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# UNDERSTANDING THE RELATIONSHIPS AMONG LOW LEVEL METAL INFLUX, REMEDIATED SEDIMENTS, AND BIOLOGICAL RECEPTORS

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A challenge to all sediment remediation technologies is the continued influx of contaminants from uncontrolled sources. However, contaminants deposited on sediments remediated with chemically active sequestering agents (such as those in active caps) may be affected by the sequestering agents resulting in reduced impacts. We conducted mesocosm studies designed to evaluate the effectiveness of in situ remediation technologies (active and passive caps) subjected to continued low level, metal influxes (e.g., arsenic (As), cadmium (Cd), copper (Cu), zinc (Zn), and lead (Pb) from uncontrolled sources and better understand relationships among remediation methods, low level influxes of contaminants, bioturbation, and effects on biological receptors. Task 1 examined recontamination without bioturbation, Task 2 examined recontamination coupled with bioturbation, and Task 3 developed numerical models for assessing the long–term effectiveness of remedial methods based on results from Task 1.

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# TABLE OF CONTENTS

LIST OF ACRONYMS ..... vi
LIST OF TABLES ..... i
LIST OF FIGURES ..... v
LIST OF PICTURES ..... xii
ABSTRACT ..... 1
EXECUTIVE SUMMARY ..... 2
1.0 OBJECTIVES ..... 12
2.0 BACKGROUND ..... 13
3.0 MATERIALS AND METHODS ..... 17
3.1 TASK 1. LINKAGES BETWEEN CONTAMINANT LOADING AND RECONTAMINATION OF REMEDIATED SEDIMENTS – FLOW THROUGH MESOCOSMS WITH CONTINUOUS METAL INFLUX ..... 17
3.1.1 SUBTASK 1.1. DISSOLVED METAL INFLUX ..... 17
3.1.1.1 Experimental setup - construction of mesocosms ..... 17
3.1.1.2 Sample collection ..... 27
3.1.1.3 Toxicity testing ..... 28
3.1.1.4 Bioaccumulation assessment ..... 28
3.1.1.5 Sediment ..... 28
3.1.1.6 Diffusive gradients in thin films (DGT) probes ..... 29
3.1.2 SUBTASK 1.2 LOW-LEVEL DISSOLVED METAL INFLUX AND METAL INTERACTIONS ..... 31
3.1.2.1 Experimental mesocosms ..... 31
3.1.2.2 Surface water and sediment sampling ..... 32
3.1.2.3 Effect of amendments on toxicity and bioaccumulation of Cu and other elements ..... 32
3.1.2.4 Diffusive gradients in thin films (DGT) probes for assessing bioavailability of Cu and other elements ..... 33
3.1.2.5 Statistical analysis ..... 34
3.2 TASK 2. UNDERSTANDING RELATIONSHIPS AMONG REMEDIATION METHODS, LOW LEVEL INFLUXES OF CONTAMINANTS, AND BIOLOGICAL RECEPTORS – COMPREHENSIVE STUDY ..... 34
3.2.1 Experimental design ..... 35
3.2.2 Addition of bioturbating organisms ..... 39
3.2.3 Pore and surface water sampling ..... 40
3.2.4 Assessment of bioaccumulation and survival ..... 40
3.2.5 Bioavailability assessment by diffusive gradients in thin films (DGT) probes. 41
3.2.6 Data analysis ..... 42
3.3 TASK 3. PREDICTION OF LONG-TERM RELATIONSHIPS AMONG THE LOW LEVEL OF INFLUX OF CONTAMINANTS, BIOLOGICAL RECEPTORS, AND REMEDIATED SEDIMENTS. ..... 43
3.3.1 Model review ..... 43
3.3.1.1 Data availability for modelling of mesocosms ..... 43
3.3.2 Development and evaluation of final model ..... 44
4.0 RESULTS AND DISCUSSION ..... 46

**4.1 TASK 1. LINKAGES BETWEEN CONTAMINANT LOADING AND RECONTAMINATION OF REMEDIATED SEDIMENTS – FLOW THROUGH MESOCOSMS WITH CONTINUOUS METAL INFLUX ..... 46**
**4.1.1 SUBTASK 1.1. DISSOVED METAL INFLUX ..... 46**
**4.1.1.1 Pore water properties and metal concentrations ..... 46**
**4.1.1.2 Surface water properties ..... 53**
**4.1.1.3 Effect of ongoing contaminant influx on metal concentrations in surface water ..... 60**
**4.1.1.4 Toxicity and bioaccumulation ..... 66**
**4.1.1.5 Assessment of cap effectiveness by diffusive gradients in thin films (DGT) probes ..... 70**
**4.1.1.6 Conclusions ..... 75**
**4.1.2 SUBTASK 1.2. LOW LEVEL METALS AND METAL INTERACTIONS ... 77**
**4.1.2.1 Pore water properties and metal conentrations ..... 77**
**4.1.2.2 Surface water properties ..... 84**
**4.1.2.3 Effect of amendments on metals and metal interactions in surface water .... 87**
**4.1.2.4 Toxicity and bioaccumulation assessment ..... 93**
**4.1.2.5 Bioavailability assessment by diffusive gradients in thin films (DGT) probes ..... 97**
**4.1.2.6 Conclusions ..... 102**
**4.2 TASK 2. UNDERSTANDING RELATIONSHIPS AMONG REMEDIATION METHODS, LOW LEVEL INFLUXES OF CONTAMINANTS, AND BIOLOGICAL RECEPTORS – COMPREHENSIVE STUDY ..... 104**
**4.2.1 Introduction ..... 104**
**4.2.2 Effects of bioturbation on contaminated sediment layer ..... 105**
**4.2.3 Pore water properties and metal concentrations ..... 109**
**4.2.4 Surface water properties ..... 113**
**4.2.5 Effects of incoming contaminant load on element level in surface water ..... 123**
**4.2.6 Toxicity ..... 132**
**4.2.7 Effect of bioturbation on bioaccumulation ..... 134**
**4.2.8 Bioavailability assessment by diffusive gradients in thin films (DGT) ..... 144**
**4.2.8.1 Water DGT ..... 144**
**4.2.8.2 Sediment DGT ..... 150**
**4.2.9 Conclusions ..... 158**
**4.3 TASK 3. PREDICTION OF LONG-TERM RELATIONSHIPS AMONG THE LOW LEVEL OF INFLUX OF CONTAMINANTS, BIOLOGICAL RECEPTORS, AND REMEDIATED SEDIMENTS ..... 159**
**4.3.1 Model review ..... 159**
**4.3.1.1 Sediment Flux Model (SFM) ..... 159**
**4.3.1.2 TICKET model ..... 181**
**4.3.2 Development and evaluation of final model ..... 192**
**4.3.2.1 Evaluating long-term performance of caps ..... 192**
**4.3.2.2 Recommendation for modeling framework ..... 198**
**4.3.3 SFM-TICKET simulation results ..... 199**
**4.3.4 Conclusions ..... 209**
**5.0 REFERENCES ..... 210**

**APPENDIX 1 – ADDITIONAL DATA..... 218**
**APPENDIX 2- PUBLICATIONS..... 356**
**APPENDIX 3 - TRANSITION PLAN ..... 361**

# LIST OF ACRONYMS

A – apatite
A-MS – apatite cap with metal spike solution
AC-MS – activated carbon treatment with metal spike solution
ANOVA – one-way analysis of variance
As – arsenic
AVG - average
B – treatments with bioturbation
BG - background
C – control with no sediment or spike solution
C-CuS – control with Cu spike solution but no sediment
C-MS – control with metal spike solution but no sediment
Cd – cadmium
$C_{DGT}$ – metal concentration measured by DGT probes
CL – contaminated layer
Co - cobalt
Cr- chromium
Cu - copper
CuS- copper spike solution
DGT – diffusive gradients in thin films
DI – deionized water
DO – dissolved oxygen
DOC – dissolved organic carbon
DoD – Department of Defense
EC – electrical conductivity
EDTA – ethylenediaminetetraacetic acid
ER – environmental restoration
Hg - mercury
HOCs – hydrophobic organic compounds
$K_d$ – partition coefficient
ICP-MS – inductively coupled plasma – mass spectrometry
LSM = least square mean
NB – treatments without bioturbation
MAAC or MC – multiple amendment active cap or mixed amendment cap
MC-CuS – multiple amendment cap with copper spike solution
MNR – monitored natural recovery
MRM – organoclay from CETCO company
MS – multiple metal spike solution
NCA – North Carolina apatite
Ni – nickel
NTU – turbidity unit
O – organoclay
ORP – oxidation reduction potential
PAHs – polycyclic aromatic hydrocarbons
Pb – lead
PCBs – polychlorinated biphenyls

POC – particulate organic carbon
PW – pore water
S – sand
SC – sand cap
Se – selenium
SED-CuS – uncapped sediment with copper spike solution
SED-MS – uncapped sediment with multiple metal spike solution
SFM – sediment flux model
SRNL – Savannah River National Laboratory
SRS – Savannah River Site
STDEV – standard deviation
TC – total carbon
TIC – total inorganic carbon
TICKET – tableau input coupled kinetic equilibrium transport model
TICKET-UWM – tableau input coupled kinetic equilibrium transport model-unit world model
TOC – total organic carbon
TSS – total suspended solids
VBA – visual basic for applications
WHAM – Windermere Humic Aqueous Model
ZOI – zone of influence
Zn – zinc

# LIST OF TABLES

Table 1. Experimental design showing the number of aquaria for each combination of three factors: active material a, passive material b, and cap thickness. ..... 21
Table 2. Experimental design. ..... 35
Table 3. Metal concentrations in sediment layers within the experimental mesocosms. ..... 37
Table 4. Pore water properties. Samples collected on 12/5/2014 before addition of spike solution. ..... 47
Table 5. Pore water properties. Samples collected on 3/4/2015 after collection of DGT probes and at 6-day test with *Lumbriculus variegates*. ..... 48
Table 6. Pore water properties. Samples collected on 3/24/2015 at the end of pumping of the spike solution at 2520 h. ..... 49
Table 7. Metal concentrations in pore water samples collected on 12/5/2014 before addition of spike solution (raw data). ..... 50
Table 8. Metal concentrations in pore water samples collected on 3/4/2015 after collection of DGT probes and at 6 day test with *Lumbriculus variegates*. ..... 51
Table 9. Metal concentrations in pore water samples collected on 3/24/2015 at the end of pumping of the spike solution at 2520 hours. ..... 52
Table 10. Average metal concentrations in Asian clams (soft tissues) after 10-day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals. Mesocosm treatments included spike solution only, uncapped sediment, sediment with passive caps (sand), and sediment with active caps [clay; apatite; activated carbon (AC); organoclay (MRM); and a mixture of activated carbon, apatite, and MRM]. BG represents background concentrations; i.e., concentrations measured in Asian clams before testing. ..... 70
Table 11. Average metal concentrations (µg/l) measured by water DGT probes ($C_{DGT}$)..... 71
Table 12. Average (AVG) and standard deviation (STDEV) of pore water quality parameters in Experiment I and II. Samples were collected on 2/1/2017 before addition of spike solutions. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS)..... 78
Table 13. Average (AVG) and standard deviation (STDEV) of pore water quality parameters in Experiment I and II. Samples were collected on 4/11/2017 at 1536 hours. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS). ..... 79
Table 14. Average (AVG) and standard deviation (STDEV) of pore water quality parameters in Experiment I and II. Samples were collected on 6/6/2017 at 2880 hours. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS). ..... 80
Table 15. Average (AVG) and standard deviation (STDEV) of metal concentrations in pore water samples collected on 2/1/2017 before addition of spike solutions. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active

caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS). ..... 81
Table 16. Average (AVG) and standard deviation (STDEV) of metal concentrations in pore water samples collected on 4/11/2017 at 1536 h. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS). . 82
Table 17. Average (AVG) and standard deviation (STDEV) of metal concentrations in pore water samples collected on 6/6/2017 at 2880 h. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS). . 83
Table 18. Average (Avg) and standard deviation (Stdev) of total Cu concentrations (n = 3) in surface water in Experiments I and II from time 0 to 2880 h. Each value is an average of three samples. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). ..... 90
Table 19. Average and standard deviation of total As, Cd, Pb, and Zn concentrations (n = 3) in surface water in mesocosms with multiple element spike solution (Experiment I): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS) from time 0 to 2880 h. ..... 91
Table 20. Metal concentrations (μg $kg^{-1}$) measured by sediment DGT probes (CDGT) in cap materials and individual layers of sediment (layer A: 0.0-2.5 cm, layer B: 2.5-5.0 cm, and layer C: 5.0-7.5 cm). Each value is an average of three samples. Experiment I (multiple element spike solution): uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS)..... 100
Table 21. Properties of pore water collected at the end of experiment (time, 696 hours); NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 109
Table 22. Two-way ANOVAs of pore water metal concentrations in the experimental mesocosms. Main effects were treatment (apatite caps vs. sediment only) and bioturbation (presence vs. absence). ..... 111
Table 23. Raw data and average values of surface water pH for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 114

Table 24. Raw data and average values of surface water electrical conductivity (EC, μS $cm^{-1}$) for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A – apatite. ..... 115
Table 25. Raw data and average values of surface water turbidity (in NTU) for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 116
Table 26. Raw data and average values of surface water dissolved oxygen (in mg $L^{-1}$) for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 117
Table 27. Two-way analysis of variance (ANOVA) of As in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction. ..... 138
Table 28. Two-way analysis of variance (ANOVA) of Cd in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction. ..... 139
Table 29. Two-way analysis of variance (ANOVA) of Cu in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction. ..... 140
Table 30. Two-way analysis of variance (ANOVA) of Ni in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction. ..... 141
Table 31. Two-way analysis of variance (ANOVA) of Pb in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction. ..... 142
Table 32. Two-way analysis of variance (ANOVA) of Zn in blackworm tissues. ..... 143
Table 33. Two-way analysis of variance (ANOVA) of DGT-Cd water data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions and for main effects if not part of a significant interaction. ..... 146
Table 34. Two-way analysis of variance (ANOVA) of DGT-Ni water data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions and for main effects if not part of a significant interaction. ..... 147
Table 35. Two-way analysis of variance (ANOVA) of DGT-Cu water data. ..... 148

Table 36. Two-way analysis of variance (ANOVA) of DGT-Pb water data..... 149
Table 37. Three-way analysis of variance (ANOVA) of DGT-Cu sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant main effects..... 154
Table 38. Three-way analysis of variance (ANOVA) of DGT-Cd sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions..... 155
Table 39. Three-way analysis of variance (ANOVA) of DGT-Ni sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for the 3-way interaction. ..... 156
Table 40. Three-way analysis of variance (ANOVA) of DGT-Pb sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions..... 157
Table 41. Distribution coefficients (Kd, log(L $kg^{-1}$)) for sediment and cap materials. ..... 163

# LIST OF FIGURES

Figure 1. Mesocosm experimental design. ..... 18
Figure 2. Diagram of experimental mesocosms. ..... 36
Figure 3. Temporal changes in surface water electrical conductivity (EC) for each treatment. Each value is an average of three samples. ..... 54
Figure 4. Average surface water electrical conductivity (EC) for each treatment; error bars are standard deviations. ..... 54
Figure 5. Average surface water turbidity for each treatment; error bars are standard deviations. ..... 55
Figure 6. Temporal changes in surface water pH for each treatment. Each value is an average of three samples. ..... 56
Figure 7. Average surface water pH for each treatment; error bars are standard deviations. ..... 56
Figure 8. Average surface water dissolved oxygen for each treatment. Error bars are standard deviations. ..... 57
Figure 9. Average surface water temperature for each treatment; error bars are standard deviations. ..... 58
Figure 10. Hardness of surface water (mg $L^{-1}$) for each treatment at 2520 h; spike solution only (C), uncapped sediment (SED), sediment with passive sand caps (S-1: 2.5 cm, S-2: 5 cm), and sediment with several types of active caps (SC: 2.5 cm silty clay, A-1: 2.5, A-2: 5.0 cm apatite, AC: activated carbon treatment, MRM: 2.5 cm organoclay, and MC: 2.5 cm mixture of active amendments). ..... 59
Figure 11. Average surface water concentrations of metals in mesocosms with no sediment, spike solution only (C), uncapped sediment (SED), sediment with passive sand caps (S-1: 2.5 cm cap, S-2: 5 cm cap), and sediment with several types of active caps (SC: 2.5 cm silty clay cap, A-1: 2.5 cm apatite cap, A-2: 5.0 cm apatite cap, AC: activated carbon treatment, MRM: 2.5 cm organoclay cap, and MC: 2.5 cm mixed amendment cap) at 2520 h. ..... 61
Figure 12. Average surface water concentrations of dissolved Cd and Zn in mesocosms with passive caps (n=6 for 2.5 cm sand cap and 5.0 cm sand cap), active caps (n=12 for the 2.5 cm apatite cap, 5.0 cm apatite cap, activated carbon treatment, and 2.5 cm mixed amendment cap), and without caps or sediment (control) (n=2) over 2520 h. ..... 62
Figure 13. Average surface water concentrations of dissolved mercury in mesocosms with passive caps, active caps, and without caps or sediment (control). ..... 64
Figure 14. Average surface water concentrations of particle-bound mercury in mesocosms with passive caps, active caps, and without caps or sediment (control). ..... 64
Figure 15. Average surface water concentration of mercury in mesocosms with no sediment (Control), uncapped sediment (SED), sediment with passive sand caps, and sediment with several types of active caps after 144, 1008, and 2520 h. ..... 65
Figure 16. Average survival of *Lumbriculus variegatus* after 10-day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals. Mesocosm treatments included spike solution only (C), uncapped sediment (SED), sediment with sand caps (S-1: 2.5 cm and S-2: 5 cm), and sediment with active caps (SC: 2.5 cm silty clay, A-1: 2.5 cm apatite, AC: activated carbon, MRM: 2.5 cm organoclay, and MC: 2.5 cm mixture of active amendments). Error bars are standard deviations (n=3). ..... 67
Figure 17. Analysis of variance of differences in *Lumbriculus variegatus* metal concentrations (whole body, 10-day exposure) among sediment treatments (BG =background, AC: activated carbon, SC: silty clay cap, A: apatite cap (2.5 cm thick), MRM: organoclay MRM cap, MC:

mixture of active amendments, SED: untreated sediment). Geometric means connected by the same line are not significantly different at $p<0.05$. ..... 68
Figure 18. Average mortality of Asian clams after 10-day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals. Mesocosm treatments included spike solution only, uncapped sediment, sediment with passive caps (sand), and sediment with active caps [clay; apatite; activated carbon (AC); organoclay (MRM); and a mixture of activated carbon, apatite, and MRM]. Error bars are standard deviations. ..... 69
Figure 19. Cadmium (Cd) and cobalt (Co) concentrations ($\mu g\ kg^{-1}$) measured by sediment DGT probes (CDGT) in cap materials and layers of sediment beneath the cap (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm). Treatments: uncapped sediment (SED), sediment with passive sand caps (S – 1: 2.5 cm thick cap and S – 2: 5 cm thick cap) and sediment with several types of active caps (2.5 cm thick) (apatite A-1; silty clay - SC; activated carbon, no cap - AC; organoclay – MRM:, and mixture of active amendments – MC) at 2040 h. ..... 73
Figure 20. Pearson correlations between metal concentrations in *Lumbriculus variegatus* (whole body, 10-day exposure) and metal concentrations in sediment measured by sediment DGT probes. ..... 74
Figure 21. Average pH values (n = 3) in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm) at 2520 hours; uncapped sediment (SED), sediment with passive sand caps (S-1: 2.5 cm, S-2: 5 cm), and sediment with several types of active caps (SC: 2.5 cm silty clay, A-1: 2.5 cm apatite, A-2: 5.0 cm apatite, AC: activated carbon treatment, MRM: 2.5 cm organoclay, and MC: 2.5 cm mixture of active amendments). ..... 75
Figure 22. Average hardness of surface water ($mg\ L^{-1}$) (n = 21) for each treatment in both experiments. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). ..... 85
Figure 23. Temporal changes in surface water electrical conductivity (EC), pH, dissolved oxygen (DO), and turbidity for each treatment. Each value is an average of three samples. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). ..... 86
Figure 24. Average Cu concentrations in surface water in Experiments I and II from time 0 to 2880 h. Each value is an average of three samples. Experiment I (multiple element spike solution): control with no sediment, uncapped sediment, sediment with multi-amendment caps. Experiment II (Cu spike solution): control with no sediment, uncapped sediment, and sediment with multiple amendment active caps..... 92
Figure 25. Average dissolved and particulate surface water concentrations of As, Cd, Pb, and Zn in Experiment I mesocosms at 2880 h. Each value is an average of three samples; multiple element spike solution (MS), control mesocosms with multiple element spike solution and

no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). ..... 93
Figure 26. Average mortality of *Lumbriculus variegatus* after ten-day toxicity tests conducted in mesocosms receiving water spiked with metals (MS) and copper only (CuS). Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). Groups represented by different letters are significantly different ($p<0.05$, ANOVA followed by Student-Newman-Keuls method for multiple comparison). ..... 95
Figure 27. Analysis of variance of differences in *Lumbriculus variegatus* element concentrations (whole body, 10-day exposure) among treatments. Geometric means connected by the same line are not significantly different at $\alpha<0.05$. Experiment I: background (BG), mesocosms with multiple element spike solution and no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II: mesocosms with Cu spike solution and no sediment (C-CuS), uncapped sediment (SED-CuS), sediment with mixed amendment active caps (MC-CuS), and background (BG). ..... 96
Figure 28. Analysis of variance of differences in *Lumbriculus variegatus* Cu concentrations (whole body, 10-day exposure) among treatments in Experiment I and Experiment II. Geometric means connected by the same line are not significantly different at $\alpha<0.05$. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), sediment with mixed amendment active caps (MC-CuS), and background (BG). ..... 97
Figure 29. Average Cd, Cu, Pb, and Zn concentrations ($\mu g\ L^{-1}$) measured by water DGT probes. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). Groups represented by different letters are significantly different ($\alpha<0.05$, ANOVA followed by Student-Newman-Keuls method for multiple comparison). 99
Figure 30. Average pH values (n = 3) in cap materials and individual layers of sediment (layer A: 0.0-2.5 cm, layer B: 2.5-5.0 cm, and layer C: 5.0-7.5 cm) at 2880 h; Experiment I (multiple element spike solution): uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): uncapped sediment (SED-CuS) and sediment with mixed amendment caps (MC-CuS). ..... 101

Figure 31. Regression of metal concentrations in *Lumbriculus variegatus* (whole body) and metal concentrations in sediment measured by sediment DGT probes ($C_{DGT}$, depth 0.0-2.5 cm). Experiment I (multiple element spike solution): uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): uncapped sediment (SED-CuS) and sediment with mixed amendment active caps (MC-CuS). ..... 102
Figure 32. Average pore water pH for each treatment (time, 696 h). NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 110
Figure 33. Average pore water electrical conductivity (EC) for each treatment (time, 696 h). NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 110
Figure 34. Arsenic, Cd, Cu, Ni, Pb, and Zn concentrations in pore water collected at the end of experiment (time, 696 h). ..... 112
Figure 35. Average values of surface water pH for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 118
Figure 36. Average values of surface water turbidity (in NTU) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 118
Figure 37. Average values of surface water electrical conductivity (EC) for all 8 samplings of surface water collected from time 0 to 696 hours. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 119
Figure 38. Average values of surface water electrical conductivity (EC) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 119
Figure 39. Average values of surface water electrical conductivity (EC) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 120
Figure 40. Average values of surface water electrical conductivity (EC) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 121
Figure 41. Average values of surface water dissolved oxygen for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 121
Figure 42. Average values of surface water dissolved oxygen for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite. ..... 122
Figure 43. Surface water concentrations of As in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate As, other colors dissolved As. ..... 124
Figure 44. Surface water concentrations of Cd in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B),

and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Cd, other colors dissolved Cd. ..... 125
Figure 45. Surface water concentrations of Cu in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Cu, other colors dissolved Cu. ..... 126
Figure 46. Surface water concentrations of Mn in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Mn, other colors dissolved Mn..... 127
Figure 47. Surface water concentrations of Ni in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (SED-B) and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Ni, other colors dissolved Ni..... 128
Figure 48. Surface water concentrations of Zn in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (SED-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Zn, other colors dissolved Zn..... 129
Figure 49. Surface water concentrations of Pb in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (SED-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Pb..... 130
Figure 50. Least square mean (LSM) metal concentrations (error bars = LSM standard error) for mesocosms with apatite caps or untreated sediment with or without bioturbation..... 131
Figure 51. Asian clam mortality in treatments with bioturbation over time; B – treatments with bioturbation, SED – sediment, A - apatite. ..... 132
Figure 52. Average Asian clam mortality in treatments with bioturbation; B – treatments with bioturbation, SED – sediment, A – apatite, A and B indicate significant differences at p=0.011 (Student's t-test). ..... 133
Figure 53. Average *Lumbriculus variegatus* mortality; NB - treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A – apatite, A and B indicate significant differences at p=0.011 (one-way ANOVA). ..... 133
Figure 54. Average element concentrations (whole body, 10-day exposure) in *Lumbriculus variegatus* among treatments: apatite- sediment with apatite active cap subjected to bioturbation (black), no bioturbation (red), sediment – sediment only, subjected to bioturbation (black), no bioturbation (red), background (green). ..... 135
Figure 55. Average element concentrations in Asia clams among treatments: apatite- sediment with apatite active cap subjected to bioturbation (black), sediment – sediment only, subjected to bioturbation (red), and background (green). Groups represented by different letters are significantly different ($p<0.05$, ANOVA)..... 136

Figure 56. Metal concentrations measured by DGT in the water of experimental mesocosms with untreated sediment (SED) and with sediment treated with apatite active caps (AC). ..... 145
Figure 57. Metal concentrations measured by DGT in the sediment of experimental mesocosms with untreated sediment (SED) and with sediment treated with apatite active caps (AC). Three sediment layers are represented: surficial contaminated layer (CL), cap layer (for mesocosms with cap, CAP), sediment layer beneath the cap or surficial contaminated layer (A), and deeper sediment layer (B). ..... 152
Figure 58. Average pH values (n = 3) in cap materials and individual layers of sediment (CL: contaminated layer, layer A: 0.0-2.5 cm, layer B: 2.5-5.0 cm) in treatments with bioturbation (B) and without bioturbation (NB) at 696 h. ..... 153
Figure 59. Conceptual process diagram for original Sediment Flux Model. ..... 160
Figure 60. Time series of turbidity observations for 5.1 cm sand cap mesocosms. ..... 165
Figure 61. Vertical profile of dissolved metal concentrations on 3/5/15 for sand (2.54 cm) cap: top panel – As, middle panel – Cd, bottom panel – Ni ..... 168
Figure 62. Vertical profile of dissolved metal concentrations on 3/5/15 for NCA (2.54 cm) cap: top panel – As, middle panel – Cd, bottom panel – Ni. ..... 169
Figure 63. Vertical profile of dissolved metal concentrations on 3/5/15 for organoclay MRM cap: top panel – As, middle panel – Cd, bottom panel – Ni. ..... 170
Figure 64. Vertical profile of dissolved metal concentrations on 3/5/15 for activated carbon cap: top panel – As, middle panel – Cd, bottom panel – Ni. ..... 171
Figure 65. Vertical profile of dissolved metal concentrations on 3/5/15 for MAAC: top panel – As, middle panel – Cd, bottom panel – Ni. ..... 172
Figure 66. Vertical profile results for Kd sensitivity simulations for activated carbon cap for dissolved Cd (top panel) and dissolved Ni (bottom panel). ..... 175
Figure 67. Vertical profile results for Kd sensitivity simulations for NCA 2.54 cm cap for dissolved Cd (top panel) and dissolved Ni (bottom panel). ..... 176
Figure 68. Vertical profile results for diffusion rate sensitivity simulations for sand 2.54 cm cap for dissolved Cd (top panel) and dissolved Ni (bottom panel). ..... 177
Figure 69. Vertical profile results for diffusion rate sensitivity simulations for NCA 2.54 cm cap for dissolved Cd (top panel) and dissolved Ni (bottom panel). ..... 178
Figure 70. Vertical profile results for resuspension/deposition rate sensitivity simulations for sand (2.54 cm) cap for dissolved Cd (top panel) and dissolved Ni (bottom panel). ..... 179
Figure 71. Vertical profile results for resuspension/deposition rate sensitivity simulations for NCA (2.54 cm) cap for dissolved Cd (top panel) and dissolved Ni (bottom panel). ..... 180
Figure 72. TICKET-simulated vertical profile of dissolved Ni on 3/5/15 for generic sand cap case (including observed concentrations). ..... 186
Figure 73. TICKET-simulated vertical profiles of dissolved and total Ni on 3/5/15 for..... 187
Figure 74. TICKET-simulated vertical profiles of dissolved Ni on 3/5/15 for baseline simulation and sensitivity run for diffusion rate. ..... 188
Figure 75. TICKET-simulated vertical profiles of dissolved Ni on 3/5/15 for baseline simulation and sensitivity run for resuspension/settling rate. ..... 188
Figure 76. TICKET-simulated vertical profiles of dissolved Ni on 3/5/15 for baseline simulation and sensitivity run for initial salicylate concentration in the sand cap layers. ..... 189
Figure 77. Vertical profile comparison for sand (2.54 cm) and NCA (2.54 cm) cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after five years. ..... 194

Figure 78. Vertical profile comparison for sand (2.54 cm) and NCA (2.54 cm) cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after 10 years. ..... 195
Figure 79. Vertical profile comparison for sand (2.54 cm) and NCA (2.54 cm) cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after 20 years. ..... 196
Figure 80. Vertical profile comparison for sand (2.54 cm) and NCA (2.54 cm) cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after 50 years. ..... 197
Figure 81. Time series of total metal concentrations in water column for control/native sediment case (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 201
Figure 82. Time series of dissolved metal concentrations in water column for control/native sediment case (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 202
Figure 83. Time series of total metal concentrations in water column for the apatite cap case (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 203
Figure 84. Time series of dissolved metal concentrations in water column for the apatite cap case (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 204
Figure 85. Water-sediment vertical profile simulated at 4/5/2017 for total metal concentrations for the apatite cap case (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 205
Figure 86. Water-sediment vertical profile simulated at 4/5/2017 for dissolved metal concentrations for the apatite cap case, with DGT comparisons (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 206
Figure 87. Water-sediment vertical profile simulated at 4/11/2017 for dissolved metal concentrations for the apatite cap case, with comparison to PW2 sampling event data (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 207
Figure 88. Water-sediment vertical profile simulated at 6/6/2017 for dissolved metal concentrations for the apatite cap case, with comparison to PW3 sampling event data (top panel – Cu, middle panel – Cd, bottom panel – Zn). ..... 208

# LIST OF PICTURES

Picture 1. Sediment placed in mesocosms. ..... 19
Picture 2. Construction of sippers for collection of pore water. ..... 20
Picture 3. Sippers being installed in mesocosms. ..... 20
Picture 4. Placement of cap materials over saturated sediment following Table 1. ..... 22
Picture 5. Thirty mesocosms representing different cap compositions, cap thicknesses, controls with sediment but without caps, and controls without sediment or caps. ..... 25
Picture 6. Saturating cap materials and filling flow-through mesocosms with DI water (16.5 L). Drain lines from the mesocosms enter carboys. ..... 25
Picture 7. Tanks ready to receive metal spike solution (0.5 mg $L^{-1}$ of each element). Drain and sipper tubes are visible. ..... 26
Picture 8. Collection of baseline pore water samples before addition of the spike solution. ..... 26
Picture 9. Overview of mesocosms showing suspension of particulate matter. ..... 27
Picture 10. Setting up the experiment: pumping synthetic water into tanks to saturate sediment and cap. ..... 38
Picture 11. A layer (1.5 cm) of contaminated sediment was added after six weeks of equilibrium, marking the beginning of the experiment (time,1 h). The addition of the sediment layer resulted in high turbidity in all mesocosms. ..... 39
Picture 12. Asian clams were added to selected mesocosms (marked by red tape) for bioturbation twenty-four hours after adding a 1.5 cm layer of contaminated sediment. ..... 40

# ABSTRACT

A challenge to all sediment remediation technologies is the continued influx of contaminants from uncontrolled sources. However, contaminants deposited on sediments remediated with chemically active sequestering agents (such as those in active caps) may be affected by the sequestering agents resulting in reduced impacts. We conducted mesocosm studies designed to evaluate the effectiveness of *in situ* remediation technologies (active and passive caps) subjected to continued low level, metal influxes (e.g., arsenic (As), cadmium (Cd), copper (Cu), zinc (Zn), and lead (Pb)) from uncontrolled sources and better understand relationships among remediation methods, low level influxes of contaminants, bioturbation, and effects on biological receptors. Task 1 examined recontamination without bioturbation, Task 2 examined recontamination coupled with bioturbation, and Task 3 developed numerical models for assessing the long–term effectiveness of remedial methods based on results from Task 1.

The main findings of Task 1 were 1) Sequestering agents in active caps bound metals from ongoing sources thereby reducing their bioavailability and protecting underlying sediments from recontamination. In contrast, metals from ongoing sources contaminated passive caps and uncapped sediment. 2) Element concentrations in *Lumbriculus variegatus* were significantly higher in mesocosms with untreated sediment than mesocosms with active caps and were related to element influx and contaminant concentrations in sediment as measured by diffusive gradients in thin films probes. 3) The toxicity of Cu mixed with other elements was greater than the toxicity of Cu alone in treatments without active caps, but the ability of active caps to control Cu was not affected by the presence of other elements in inflowing contamination.

In Task 2, contaminated sediment was deposited over apatite caps and uncapped sediment to simulate recontamination by inflowing particle-bound contaminants. Remedial effectiveness was assessed in the presence and absence of the bioturbating organism *Corbicula fluminea*. Findings were as follows: 1) The metal sequestration capacity of apatite caps was unaffected or improved by bioturbation for all elements except As. 2) The effects of bioturbation on uncapped sediment were metal specific including reductions in bioavailable Ni, Cd, and to a lesser extent, Pb, increases in bioavailable As and Cu, and little effect for Zn. 3) Bioturbation distributed metals more uniformly; differences in metal levels among sediment layers were usually significant in the absence of bioturbation but not in its presence. 4) Apatite caps reduced sediment metal levels compared with uncapped sediment in both the presence and absence of bioturbation.

Task 3 focused on review and diagnostic testing of two modeling frameworks: the Sediment Flux Model (SFM) and the Tableau Input Coupled Kinetic Equilibrium Transport (TICKET) model. The tableau approach used in the TICKET was integrated into the Sediment Flux Model (SFM) producing a combined SFM-TICKET model capable of simulating the effects of pH on free metal activity, adsorption to representative sequestering components, and competition between metal and hardness cations for ligand binding sites.

This research showed that active caps can protect remediated sediments from recontamination by reducing the pool of bioavailable elements in ongoing sources of contamination. It contributes to a better understanding of the relationships among low level metal influxes, remediated sediments, and biological receptors, which can help set more defensible cleanup goals and priorities while ensuring the protection of human health and the environment.

# EXECUTIVE SUMMARY

## Introduction

Contaminated sediments are commonly remediated by environmental dredging, which involves their removal and disposal to reduce environmental risks. However, sediment capping is sometimes preferred because it is less expensive and disruptive to the benthic environment. In passive capping, contaminated sediment is covered with a layer (cap) of clean, inert material such as sand, soil, or sediment to physically isolate the contaminants. In active capping, chemically reactive amendments are applied to the sediment surface to bind contaminants, thereby reducing pore water contaminant concentrations and bioavailability (Figure 1).

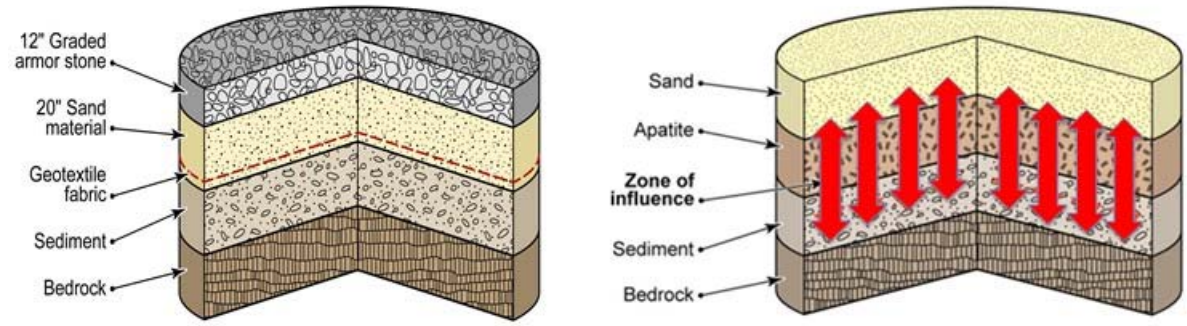



Figure 1. Passive cap (left) and active cap (right). Active caps incorporate chemically active materials that react with contaminants to reduce their bioavailability.

Remediated sediments may be exposed to continued inputs from permitted discharges, upstream contaminated sites, or stormwater discharge resulting in recontamination that can slow or reverse recovery associated with remedial efforts. The recontamination of sediments can negate expensive remedial actions by producing a polluted habitat zone that overlies the remediated sediment (Figure 2). This is a challenge to all remedial approaches, but the severity of the problem may be affected by the type of remediation that has been undertaken. Contaminant influxes can degrade the benthic environment as contaminants accumulate in areas previously remediated by environmental dredging or conventional capping with inert materials such as sand. However, remedial effectiveness may persist in areas remediated by active capping with chemically active sequestering agents because these agents interact with incoming contaminants to reduce their bioavailability and toxicity. Remedial effectiveness can be further influenced by bioturbation, the physical disturbance, restructuring, and reworking of sediments by benthic organisms. Bioturbation can mix newly deposited contaminated sediment with underlying uncontaminated sediment, which may contribute to the release of contaminants from the newly deposited contaminated sediment or, conversely, to contaminant sequestration or dilution by burial in underlying clean sediment or active capping material. In the latter case, contaminants may react with sequestering agents to reduce their toxicity and bioavailability.

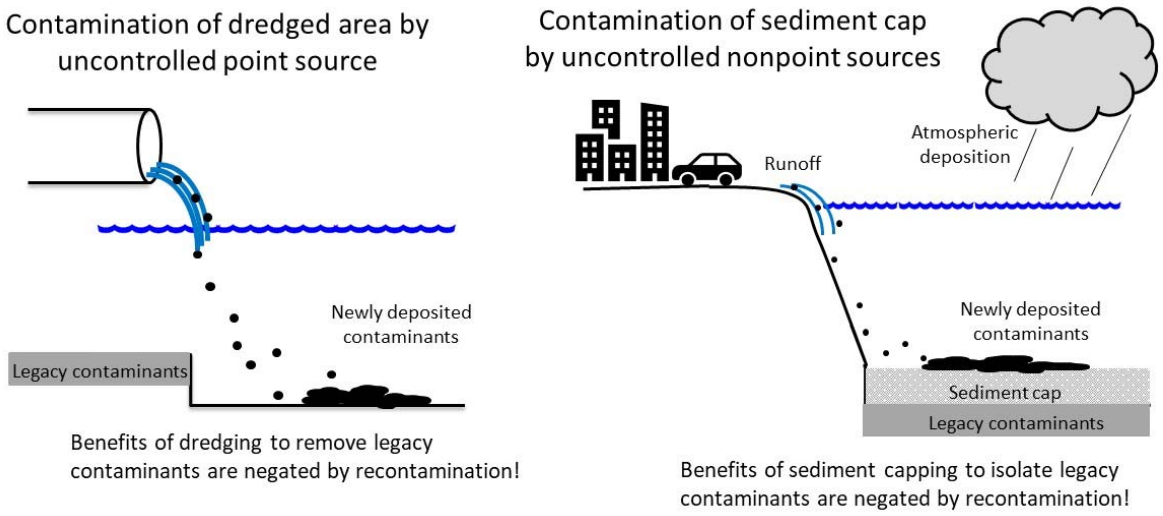



Figure 2. Remediated sediments may be exposed to contamination from uncontrolled point or nonpoint sources resulting in recontamination that reverses recovery.

Our research addressed the knowledge gap related to the effects of ongoing contamination on different sediment remediation technologies including active caps, passive caps, and sediment remediated by the removal of contaminants through environmental dredging (simulated by uncontaminated, uncapped sediment). None of these technologies have been evaluated for their effectiveness when confronted with ongoing contamination.

**Objectives**

The objectives of this project were to 1) evaluate the effects of low-level metal influxes from uncontrolled sources on passive caps, active caps, and clean, uncapped sediment in a freshwater environment, 2) assess the effects of bioturbation on an incoming particulate contaminant load deposited over underlying clean sediment or active capping material, 3) develop numerical models for assessing the long–term effectiveness of remediated sediment subjected to recontamination, and 4) improve understanding of the relationships among surface sediment recontamination, remediated contaminated sediments, and biological receptors.

**Technical Approach**

The research objectives were addressed in three tasks: Task 1 - Linkages between contaminant loading and recontamination of remediated sediments – flow through mesocosms with continuous metal influx, Task 2 - Understanding relationships among remediation methods, low level influxes of contaminants, bioturbation, and effects on biological receptors, and Task 3- Development of numerical models for predicting long-term relationships between low level contaminant influxes and remediated sediments.

Task 1 evaluated linkages between dissolved contaminant loading and recontamination of remediated sediments. Subtask 1.1 of Task 1, Dissolved Metal Influx, employed flow-through mesocosms to simulate recontamination by an inflow of dissolved contaminants. The setup included 30 flow-through mesocosms (20 x 41 x 43 cm) representing 10 treatments including uncapped sediment and different cap compositions and thicknesses (2.5 or 5.0 cm) (Figure 3). Passive caps consisted of sand. There were five types of active caps:1) apatite; 2) organoclay

(MRM from CETCO); 3) activated carbon; 4) silty clay sediment; and 5) a mixture of apatite, activated carbon, and organoclay (referred to as MAAC or MC). A single reservoir supplied a continuous inflow of spike solution with 0.5 mg $L^{-1}$ each of arsenic (As), chromium (Cr), cadmium (Cd), cobalt (Co), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn) to each mesocosm. Pore water samplers composed of fine mesh screens were buried in the mesocosm sediments. Dissolved oxygen, temperature, electrical conductivity, pH, turbidity, and calcium hardness were measured in surface waters. Total and dissolved metals in surface and pore water were measured by inductively coupled plasma-mass spectrometry (ICP-MS). Annelid worms, *Lumbriculus variegatus*, held in plastic screened cages within the sediments of the mesocosms for 10 days were weighed in aggregate before and after exposure to assess mortality, then analyzed by ICP-MS to assess element bioaccumulation. Diffusive gradients in thin films (DGT) sediment probes were deployed for 24 h to measure potentially bioavailable metals at different depths within the caps and sediment of each mesocosm, and sediment cores were taken to measure sediment pH.

Subtask 1.2 of Task 1, Low-level Dissolved Metal Influx and Metal Interactions, used the experiment setup described for Subtask 1.1, to assess the effects of low level Cu influxes, alone and in the presence of other contaminants, on different remediation methods. Competitive interactions among metals may exist at sites with co-occurring contaminants. Experiment I included Cu with other metals, and Experiment II included only Cu. Treatments in both experiments included uncapped sediment and sediment capped with 2.5 cm of 75% apatite, 5% activated carbon, and 20% MRM organoclay. Experimental methods were as in Task 1.

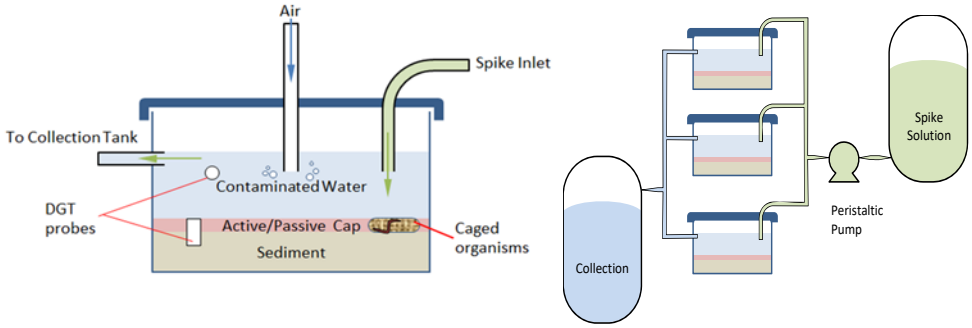



Figure 3. Experimental mesocosms.

Task 2 investigated how bioturbation affected the recontamination of uncapped clean sediments (simulating dredged sediment) and sediment remediated by apatite caps. Contaminated sediment was deposited directly over the remediated sediment to simulate the influx of contaminants bound to particulates. There were 12 mesocosms divided into four groups: apatite caps with bioturbation, apatite caps without bioturbation, uncapped sediment with bioturbation, and uncapped sediment without bioturbation. Contaminated sediment was manually added to produce a 1.5 cm thick top layer over a bottom layer of uncontaminated sediment or uncontaminated sediment with an overlying apatite cap. Levels of Cu, As, Ni, and Cd in the contaminated sediment were typical of polluted sediments; levels of Zn, and Pb were above those in the uncontaminated layer. The bioturbating organisms, Asian clams *Corbicula fluminea*, burrowed to a depth of about 2.5 cm and remained in the mesocosms for 28 days. Other experimental methods were as described previously.

Task 3 evaluated the long-term effectiveness of remedial methods through modeling that synthesized results from Task 1. It developed numerical models for the prediction of long-term relationships among low level influxes of metals and remediated sediments, thereby providing a basis for the selection of remediation strategies that exhibit long-term effectiveness in the face of ongoing contaminant influxes.

**Results and Discussion**

*Task 1, Subtask 1.1*

The concentrations of most elements in surface water remained significantly lower in mesocosms with apatite and mixed amendment active caps than mesocosms with passive caps (sand) or uncapped sediment. By the end of the 2520 h experiment, average Cd concentrations in surface water were 100 µg $L^{-1}$ in the mesocosms with active caps compared with 300 µg $L^{-1}$in mesocosms with passive caps and 500 µg $L^{-1}$ in control mesocosms (Figure 4). Like Cd, average dissolved Zn increased over time in the control mesocosms and mesocosms with passive caps, reaching 500 µg $L^{-1}$ in the former and nearly 200 µg $L^{-1}$ in the latter but remained under 10 µg $L^{-1}$ in most active cap treatments (Figure 4). Similar results were observed for other elements, especially divalent metals.

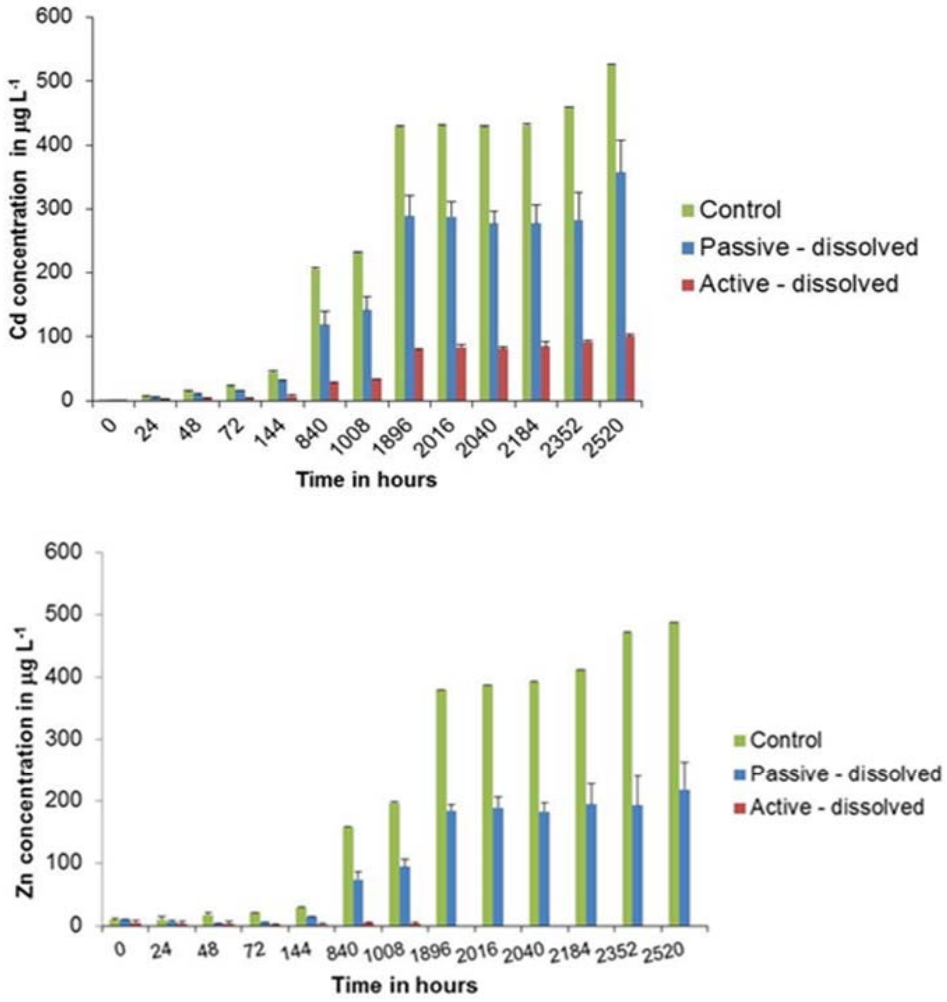



Figure 4. Average surface water concentrations of dissolved Cd and Zn in mesocosms with active caps, passive caps, and controls (i.e., multiple element spike solution).

Average percent survival of *Lumbriculus* was higher in mesocosms with active caps (65-80%) than mesocosms with uncapped sediment and sand caps (0-10%). Higher water hardness in the active cap mesocosm likely contributed to this higher survival because the acute toxicity of many metals diminishes as hardness increases. Whole-body concentrations of most metals in surviving *Lumbriculus* differed significantly among mesocosms, with lower concentrations in mesocosms with active caps (Figure 5). Although all active caps reduced metal uptake, there were differences among cap types, with the most effective caps varying among metals.

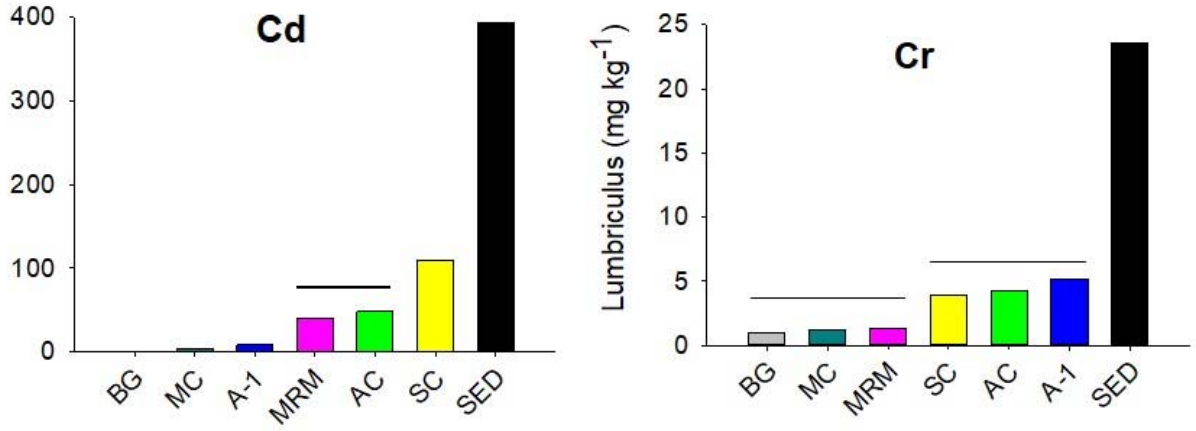



Figure 5. *Lumbriculus* metal concentrations among sediment treatments for Cd and Cr (BG=background, AC=activated carbon, SC=silty clay cap, A-1=apatite cap, MRM=organoclay MRM cap, MC=mixture of active amendments, and SED=untreated sediment. Means connected by the same line are not significantly different at $p \leq 0.05$.

The bioavailable pool of metals assessed by sediment DGT was lower in apatite caps, MC caps, and sediment treated with activated carbon than in passive sand caps, silty clay caps, and uncapped sediment. Pearson correlations between metal concentrations in *Lumbriculus* and DGT metal concentrations in the top 2.5 cm of sediment or cap were generally strong (up to 0.98) and significant ($p \leq 0.05$) for all metals except zinc (example for Co in Figure 6). These results indicated that metal concentrations in *Lumbriculus* were the result of uptake from the surrounding sediment or cap and possibly overlying water and the bioavailable pool of metals was lower in mesocosms with active caps than mesocosms with uncapped sediment or passive caps.

*Task 1, Subtask 1.2*

This task investigated the effects of Cu influxes on sediment remediated by different treatments, alone and in the presence of other elements to investigate potential competitive interactions between Cu and co-occurring contaminants. The behavior of Cu was generally similar in Experiments I (multiple metals) and II (Cu only); i.e., surface water Cu concentrations were higher in mesocosms with passive sand caps or uncapped sediment than mesocosms with apatite and mixed amendment caps. However, slightly lower surface water concentrations of Cu in Experiment I than II were visible after 528 h in mesocosms with mixed amendment caps, likely because Cd and Zn precipitated Cu and lowered average total Cu concentrations. The most

effective amendment for controlling metal influxes in Experiment I was apatite, which reduced concentrations of Pb, Cu, Cd, As, and Zn by 96, 90, 89, 76, and 63%, respectively.

DGT water probes showed that concentrations of potentially bioavailable Cu, Cd and Pb were lower ($p \leq 0.05$) in apatite, activated carbon, and MC treatments than in the control and passive sand cap treatments. However, there were no significant differences in DGT Cu concentrations between Experiments I and II for mesocosms with MC caps indicating that the presence of other elements did not influence the effectiveness of MC caps for remediating Cu. Cu concentrations in *Lumbriculus* were significantly higher in mesocosms with untreated sediment than with active caps and related to element concentrations in sediment measured by DGT probes (Figure 7). Although Cu uptake by *Lumbriculus* (indicated by tissue concentrations) differed little between Experiments I and II, the toxicity of Cu mixed with other elements (indicated by mortality) was greater than the toxicity of Cu alone in treatments with uncapped sediment (Figure 8). This was not observed in treatments with mixed amendment active caps indicating that active caps can protect remediated sediments by reducing metal toxicity in ongoing contamination by multiple metals (Figure 8).

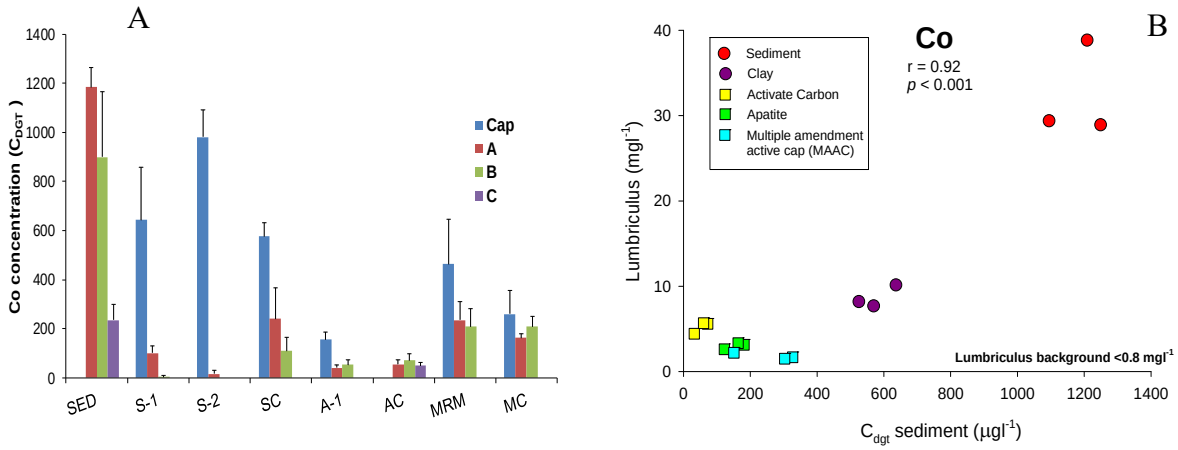



Figure 6. Graph A depicts Co concentrations (µg $kg^{-1}$) measured by sediment DGT probes ($C_{DGT}$) in cap materials and sediment beneath the cap (layer A, 0–2.5 cm; layer B, 2.5–5.0 cm; layer C, 5–7.5 cm). Treatments include uncapped sediment (SED), sediment with passive sand caps (S-1=2.5 cm thick cap and S-2=5 cm thick cap) and sediment with active caps (apatite=A-1; silty clay=SC; activated carbon= AC; organoclay=MRM; mixture of active amendments=MC). Graph B depicts Pearson correlations between metal concentrations in *Lumbriculus* and metal concentrations in sediment measured by DGT.

*Task 2*

A layer of sediment contaminated with As, Cd, Cu, Ni, Pb, and Zn was deposited over clean sediment capped with apatite, and clean uncapped sediment to simulate influxes of particle-bound contaminants on sediments remediated by active capping and dredging. The bioturbating organism, *Corbicula fluminea*, was added to half of the mesocosm to assess the effects of bioturbation on remedial effectiveness as measured by metal fluxes to sediment pore water and surface water, the distribution of mobile contaminants in surface water and sediment measured by DGT, and contaminant bioaccumulation by *Lumbriculus variegatus*.

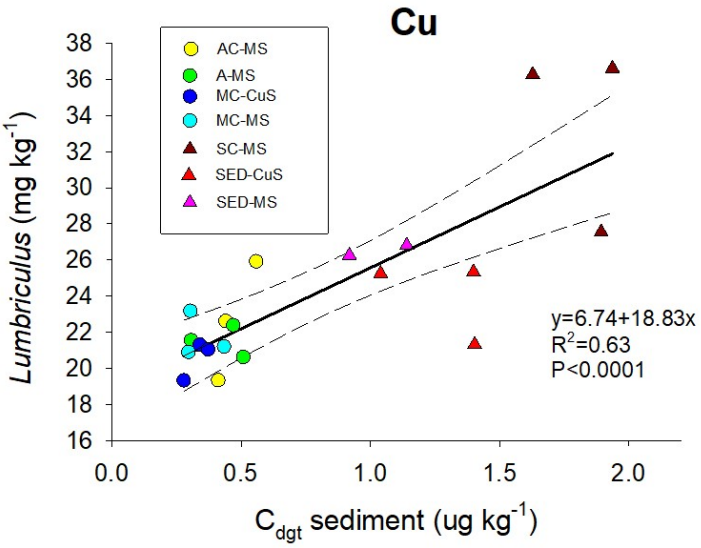



Figure 7. Regression of Cu in *Lumbriculus* on DGT Cu in sediments (see Figure 8 for explanation of legend).

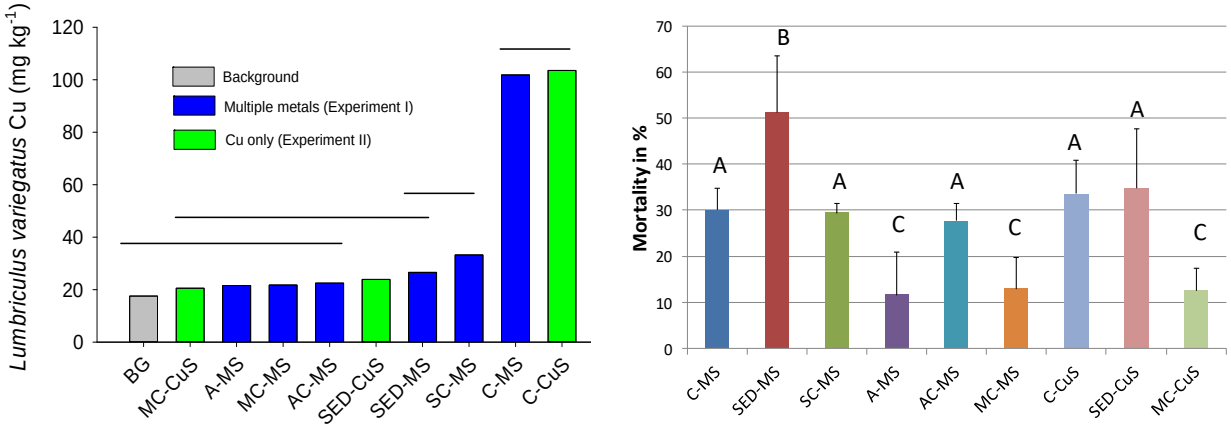
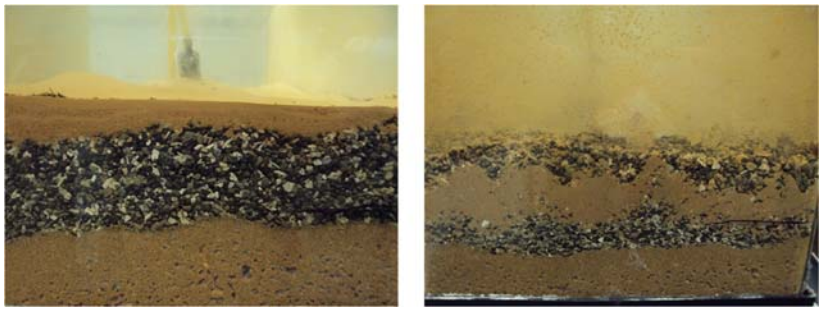



Figure 8. *Lumbriculus* Cu concentrations (left) and mortality (right) in Experiments I and II. Experiment I (multiple element): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu only): control with no sediment (C-CuS), uncapped sediment (SED-CuS), sediment with mixed amendment active caps (MC-CuS), and background (BG). Means connected by the same line or indicated by the same letter are not significantly different ($\alpha$=0.05).

Bioturbation strongly affected the vertical distribution of the layer of contaminated sediment, which was initially well consolidated and distinct but thoroughly mixed with apatite and underlying sediment after 28 days of bioturbation (Picture 1). However, the metal sequestration capacity of the apatite caps was unaffected or improved by bioturbation for all elements except As, as shown by DGT metal concentrations in sediment and metal uptake by *Lumbriculus* (Cd example in Figure 9), probably because bioturbation mixed apatite with the incoming sediment thereby enhancing chemical sequestration of the metals. Effects with uncapped sediment were



Picture 1. Before and after bioturbation of contaminated sediment deposited over an apatite cap.

metal specific including reductions in the bioavailable pool for Ni, Cd, and to a lesser extent, Pb, increases in the bioavailable pool for As and Cu, and little effect for Zn. It is likely that the reductions observed for some metals in uncapped sediment were the result of burial and dilution of the contaminated sediment combined with chemical processes such as sequestration by iron and other minerals in the clean sediment. These results show what can occur when newly dredged, uncapped sediment is challenged by a combination of recontamination and bioturbation.

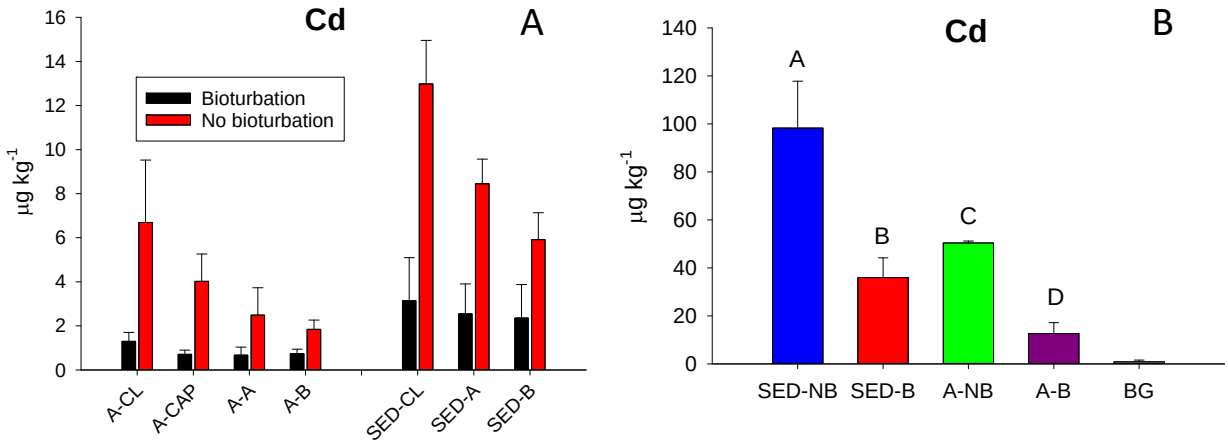



Figure 9. A) Cadmium concentrations measured by DGT in the sediment of mesocosms with untreated sediment (SED) and with apatite active caps (A). Three sediment layers are represented: surficial contaminated layer (CL), cap layer for mesocosms with cap (CAP), sediment layer beneath the cap or surficial layer (A), and deeper sediment (B). B) Mean element concentrations in *Lumbriculus variegatus* from experimental mesocosms with apatite caps (A) and uncapped sediment (SED) and bioturbation (B) or no bioturbation (NB). Means with different letters are significantly ($p<0.05$) different. Background concentrations in *Lumbriculus* (BG) are shown for comparison. Error bars are standard deviations.

*Task 3*

The Sediment Flux Model (SFM) and Tableau Input Coupled Kinetic Equilibrium Transport (TICKET) model were evaluated and compared for their ability to represent metal transport and speciation in a capped environment. The SFM provides a robust representation of transport within the sediment bed and exchange processes between the bed and the water column. However, the representation of chemical dynamics is limited to equilibrium partitioning between the dissolved phase and the particulate organic fraction. In contrast, the TICKET model contains

detailed algorithms for simulating metal speciation and precipitation via the tableau approach, but it has not been extensively used for modeling active cap performance.

Task 3 developed a modeling approach for forecasting long-term sediment conditions under different sediment treatment scenarios. It involved enhancing the SFM code by incorporating the tableau approach used in TICKET and other chemical equilibrium models into SFM producing a new framework, the SFM-TICKET, able to represent the speciation of metals and other chemicals while retaining the vertical transport capability of the SFM. The SFM-TICKET simulation of uncapped sediment reproduced both total and dissolved concentrations of the metals used in Task 1 (Zn example in Figure 10). The SFM-TICKET simulation of capped sediment differed from the uncapped sediment simulation by representing a 2.5 cm apatite cap at the top of the sediment bed. Maximum total and dissolved concentrations of Cu, Cd, and Zn observed in the experimental mesocosms with active caps were also reproduced reasonably well by SFM-TICKET (Figure 10). These and other results showed that the integrated transport-equilibrium SFM-TICKET model can simulate the effect of pH on free metal activity, adsorption to representative sequestering components, and competition between metal and hardness cations for ligand binding sites.

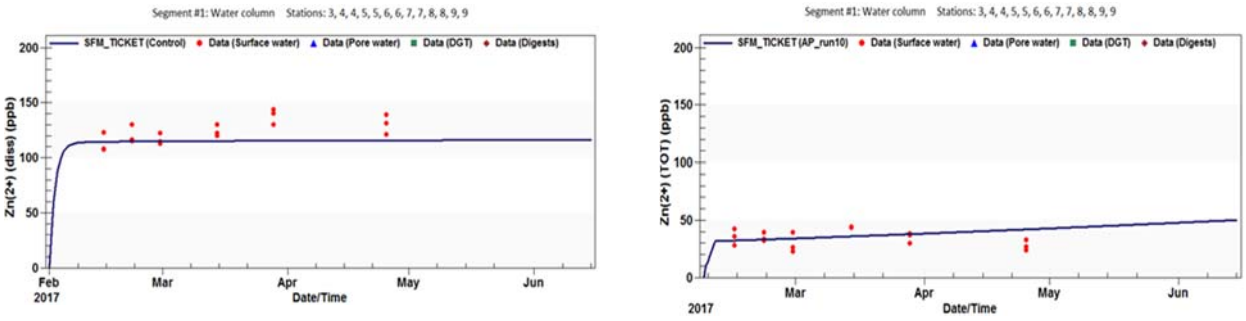



Figure 10. Time series of total metal concentrations in surface water simulated by SFM-TICKET model for uncapped sediment (left) and apatite cap (right).

**Implications for Future Research and Benefits**

We used mesocosms to investigate the effects of continuing metal influxes over uncapped sediment and sediments remediated by different types of active and passive caps, investigated competitive interactions between Cu and other elements to better understand remedial processes when contaminants co-occur, and studied the effects of bioturbation on contaminated sediment deposited over underlying clean sediment and sediment remediated by active caps. Our overarching hypothesis was that the sequestering agents in active caps can bind metals introduced from uncontrolled sources of ongoing contamination, thereby reducing their bioavailability and protecting underlying, previously remediated sediments from recontamination (Figure 11). In contrast, metals from ongoing sources have greater potential to contaminate passive caps and uncapped sediment remediated by environmental dredging.

Our results supported the preceding hypothesis. They showed that concentrations of most metals in surface waters were significantly lower in mesocosms with apatite caps, mixed amendment caps, and activated carbon treatments than mesocosms with passive sand caps and uncapped sediment. Survival was higher for *Lumbriculus* in mesocosms with active caps than

passive caps or uncapped sediment, and whole-body concentrations of most metals were lower. Regressions of metal concentrations in *Lumbriculus* on metal concentrations in sediment or cap measured by DGT were generally strong and showed reduced metal bioavailability in active cap mesocosms. Similarly, sediment DGT probes showed that ongoing contamination increased bioavailable metals in the top layer of uncapped sediment but not sediment treated with active amendments. Comparing results between multi-metal experiments and Cu-only experiments showed that the ability of active caps to control Cu contamination was not affected by the presence of other elements. Lastly, the ability of apatite active caps to reduce the bioavailability of most metals in incoming contaminated sediment was unaffected or even enhanced by bioturbation, probably because bioturbation mixed apatite with the incoming sediment, thereby enhancing sequestration of the metals. In contrast, bioturbation reduced the bioavailable pool of some metals in contaminated sediment that was deposited over uncapped clean sediment but contributed to the release of others.

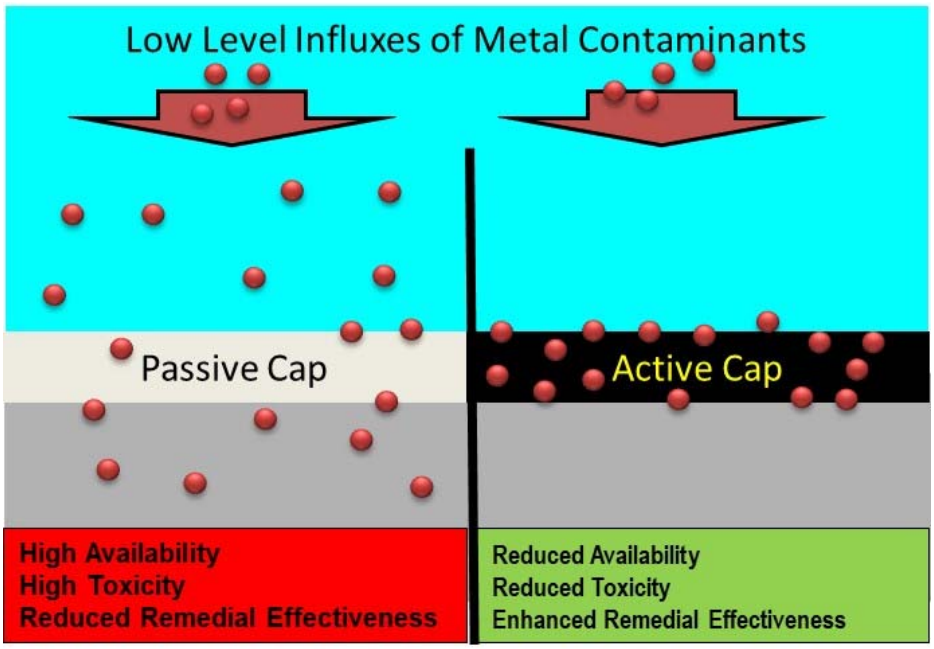



Figure 11. Conventional methods of remediating contaminated sediments may be inadequate for the protection of benthic organisms when ongoing sources of contamination exist. However, sediment caps with chemically active sequestering agents can reduce the pool of bioavailable metals in ongoing contamination (red dots), reduce toxicity, and enhance remedial effectiveness.

The remediation of contaminated sediments is an expensive process that can be negated by the continued influx of contaminants from uncontrolled sources. However, the results of this study indicate that apatite and other types of active amendments can protect remediated sediments by reducing the bioavailable pool of metals in ongoing sources of contamination. They also indicate that this ability is not affected by competitive interactions among elements nor by bioturbating organisms. This knowledge will contribute to more rigorous risk management that incorporates the resilience of remedies in the face of ongoing contamination into criteria for remedy selection.

# 1.0 OBJECTIVES

This project addressed the FY 2014 STATEMENT OF NEED ERSON-14-03 entitled "IMPROVED UNDERSTANDING OF THE IMPACT OF ONGOING, LOW LEVEL CONTAMINANT INFLUX TO AQUATIC SEDIMENT SITE RESTORATION" within the Environmental Restoration (ER) Focus Area. This research addressed the specific need to improve our understanding of the relationships among the influx of low-level metals, remediated contaminated sediments, and biological receptors in areas of concern.

A challenge to all remedial approaches is the continued influx of contaminants from uncontrolled sources following remediation. Dissolved and colloidal contaminants may gradually pollute remediated sediments until the upper several centimeters of sediment, which constitutes the habitat zone for most benthic organisms, is incapable of supporting normal benthic biodiversity. Similarly, the influx of contaminated particulate matter (e.g., contaminated sediments) that settles over remediated sediments can lead to the production of a polluted habitat zone that overlies remediated sediments, thereby negating the benefits accrued by the remedial action.

We hypothesize that the severity of the problem posed by the continued influx of contaminants on remediated sediments will be determined by the type of remediation that has been undertaken. Influxes of particulate contaminants (e.g., contaminated sediment from offsite sources) on sediments remediated by dredging or by capping with inert materials (i.e., passive capping) can be expected to degrade the remediated benthic environment at a rate proportional to the rate of contaminated sediment deposition. Remedial effectiveness will be largely negated when the deposited sediments accumulate to a depth that encompasses the habitat zone for most benthic organisms (the upper 10 cm or less of sediment). However, particulate contaminants that are deposited on sediments remediated with chemically active sequestering agents (such as those used in active caps) may be affected by the sequestering agents resulting in a subsequent reduction in the environmental impacts resulting from contaminant influx.

The main objective of the proposed research was to evaluate the effectiveness of *in situ* remediation technologies (including single amendment active caps, multiple amendment active caps, and passive caps) influenced by continued low level metal influx and to better understand the relationships among surface sediment recontamination, remediated contaminated sediments, and biological receptors. This research consisted of three tasks. Task 1, emphasized the effects of dissolved metal loading on the recontamination of sediment/remediated sediments in experimental mesocosms receiving dissolved metals from a continuous flow-through system. Specific objectives of Task 1 were to investigate (1) the effects of recontamination on different remediation technologies, 2) the effects of different concentrations of metals on remedial technologies, and (3) possible interactions among multiple metals that could influence remedial effectiveness. Task 2 emphasized the effects of particulate contaminant loading on remediated sediments. Task 2 extend the findings of Task 1 by quantifying how metal speciation and bioavailability change in incoming contaminated sediment deposited over active and passive caps and determining how these key variables are affected by bioturbating organisms. Task 2 differed from Task 1 in that contaminated sediment was deposited over the top of treated and untreated sediment. This task employed mesocosms to investigate the effects of contaminated sediment deposited over remediated sediment. Task 3 evaluated the long–term effectiveness of remedial methods through modeling that synthesized results from Task 1. Task 3 identified

inputs needed for models that predict long-term relationships among the low level of influx of metals, biological receptors, and remediated sediments. The results of this project provide a rigorous approach for the selection of remediation and risk management strategies that are resilient in the face of ongoing contaminant influxes and exhibit long-term effectiveness.

# 2.0 BACKGROUND

Clean water is a precious but limited resource that is threatened by a multitude of contaminants of anthropogenic origin. More than half of the world's animal and plant species live in water. Less than 5% is no saline (Yong, 2001), and only 0.2% and 0.3% are found in lake and rivers, respectively, and readily available for human use. Therefore, protection of water and sediment quality is highly important to ensure human and ecological health. Although part of the geoenvironment, sediments have received much less attention from researchers, policy makers, and other professionals than soil, groundwater, and surface water. Sediments are essential and valuable resources in river basins and other aqueous environments. They support a large biodiversity, and sediment organisms are ecologically important and an integral part of aquatic food webs. Because sediments are also a sink for contaminants, these organisms are often exposed to far higher concentrations of contaminants than organisms that occupy the water column.

Rapid industrialization and urbanization have led to the contamination of sediments with heavy metals and organic contaminants and created a pervasive problem worldwide. Both point and diffuse pollution sources contribute to this problem. Major sources of contaminants to the aquatic environment include agricultural and urban lands, industrial activities, spills, and accidents. Metals that enter the aquatic environment accumulate in sediments that subsequently act as a source for contaminant remobilization. Metals including arsenic (As), cadmium (Cd), cobalt (Co), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn) are often found in harbor sediments and other areas affected by anthropogenic activities. Arsenic, Cd, Cu, Pb, and Zn are the principal metals of concern at many DoD sites (SERDP and ESTCP Expert Panel Workshop Final Report, 2008). Sediments containing these contaminants act as secondary sources of contamination, posing significant direct and indirect environmental risks through bioaccumulation in aquatic organisms and incorporation into aquatic food webs that may ultimately lead to humans (NRC, 2003). Episodic physical redistribution of contaminated sediments within dynamic waterways over time can disperse such environmental risks, potentially affecting biological and water quality conditions far from the original sediment source over long periods of time (Admiral et al., 2000; Beachler et al., 2003).

In aquatic environments that are impacted by contaminated sediments, risk management strategies focus on interrupting potential exposure pathways by which contaminants can pose an ecological or human health risk over time. Conventional approaches to achieve this goal are removing contaminated sediments from the environment (dredging) or treating contaminated sediments *in situ* (e.g., capping) (NRC, 2001; Palermo et al., 1998). Although effective in some circumstances, dredging is destructive to the benthic environment, requires potentially costly disposal of contaminated dredge spoils, and may fail to achieve risk reduction goals due to sediment suspension and redeposition during dredging. *In situ* remediation techniques are usually

less energy-intensive, less expensive, and less disruptive to the benthic environment than dredging.

Capping is an *in situ* remediation technique in which the sediment is covered with a layer of material (cap) to prevent the contaminants from being released to the water column and accumulated by biota. The cap increases the path length that contaminants have to travel to diffuse out to the water, decreases the resuspension of contaminated particles, and provides a cleaner habitat for the benthic fauna. Capping may involve the physical isolation of contaminated sediments from the water column by a layer of clean inert material; e.g., clean natural substrates such as sand, soil, or sediment (passive capping) or the use of chemical amendments added to the sediment surface (active capping) that bind organic and inorganic contaminants, thereby reducing pore water contaminant concentrations and contaminant bioavailability (Dixon and Knox, 2012; Ghosh et al., 2011; Knox at al., 2008, 2012; Paller and Knox, 2010). The addition of active materials permits the use of thinner caps (Josefsson et al., 2012). Active capping involves the *in-situ* application of amendments such as activated carbon, phosphate materials (e.g., apatite), zeolite, organoclays, and bentonite. The treatment is based on the proven ability of these materials to sequester metals, or organic contaminants (Knox et al., 2012; Ghosh et al., 2011). Several amendments can be combined to treat inorganic and organic contaminants and mixed with natural substrate materials to provide filler needed to economically produce a cap that is thick enough to achieve remediation objectives and permit construction using conventional equipment and methods. The addition of natural substrate can also reduce or eliminate the potential toxicity of some amendments when used at full strength and provide a more natural substrate composition. Knox et al. (2012) referred to a cap composed of a mixture of amendments and natural substrates as a multiple amendment active cap (MAAC or MC).

Although substantially reduced in the last few decades, it is unlikely that all contaminant sources will be completely eliminated from most urban and industrial harbors, rivers, and other aquatic environments. Therefore, remediated aquatic sediments may be exposed to continued inputs from permitted discharges, upstream contaminated sites, or stormwater discharges. Recontamination from such sources can slow or even reverse recovery associated with sediment remediation efforts, and methodologies are needed to manage ongoing contaminant influx. Dissolved and colloidal contaminants may gradually enter remediated sediments until the upper several centimeters of sediment, which constitutes the habitat zone for most benthic organisms, is incapable of supporting normal benthic biodiversity. Similarly, the influx of contaminated particulate matter (e.g., contaminated sediments) that settles over remediated sediments can lead to the production of a polluted habitat zone that overlies remediated sediments, thereby negating the benefits accrued by the remedial action. Ultimately, these recontaminated sediments may once again become a source of contaminants.

The severity of the problem posed by the continued influx of contaminants on remediated sediments will be partly determined by the type of remediation that has been undertaken. Influxes of particulate contaminants (e.g., contaminated sediment from offsite sources) on sediments remediated by dredging or by capping with inert materials can be expected to degrade the remediated benthic environment at a rate proportional to the rate of contaminated sediment deposition. Remedial effectiveness will be largely negated when the deposited sediments accumulate to a depth that encompasses the habitat zone for most benthic organisms (the upper

10 cm or less of sediment). However, particulate contaminants that are deposited on sediments remediated with chemically active sequestering agents (such as those used in active caps) may be affected by the sequestering agents resulting in a subsequent reduction in the environmental impacts resulting from the contaminant influx. Knox et al. (2012) demonstrated that active caps can influence the speciation of metals located in sediments beneath the caps resulting in reduced metal mobility and potential bioavailability. They described the layer of contaminated sediment below the active caps in which contaminants were immobilized as the zone of influence (ZOI), which was usually several cm in depth. The mechanisms underpinning the formation of the ZOI was not explored but possibilities include the mixing of dissolved or solid phase cap components with underlying sediment as a result of diffusion, bioturbation, mixing of stream bed and cap material by turbulent currents (especially during flood flows), or advective movements of dissolved cap materials into the underlying sediment (e.g., as a result of cap consolidation). It is possible that a ZOI will also be formed in contaminated sediments deposited over active caps thus resulting in chemical changes to these contaminants that reduce their potential environmental impact. Similar to the situation with particulate contaminants, influxes of dissolved contaminants that contact sequestering agents used in active caps may be sequestered by these materials resulting in reduced environmental impact compared with dissolved contaminants that have the potential to contact and penetrate relatively inert materials (like those used in passive caps) via diffusion, water movements, bioirrigation, or other factors.

The influx of new contaminants on previously remediated sediment is likely to result in vertical gradients of contaminant distribution in the sediment due to the accretion of newly deposited contaminated sediment over remediated sediment and possibly to the downward migration of contaminants into remediated sediments and/or the upward migration of cap constituents into the newly deposited sediment. Vertical gradients may occur both in contaminant concentration and contaminant speciation, with the latter potentially resulting from interactions between sediment contaminants and the sequestering agents in active caps. Therefore, investigation of the influx of contaminants to remediated sediments requires methods that are sensitive to fine gradients in contaminant concentrations and speciation, especially changes in speciation that are directly related to bioavailability. Diffusive gradients in thin films (DGT) passive gel probe samplers, which were first described by Davison and co-workers (Davison and Zhang, 1994; Davison et al., 1994), are an appropriate tool for this purpose. DGT is capable of fine-scale spatial resolution and can measure steep gradients in the chemical composition of sediment pore water (Zhang et al. 1995; Stockdale et al., 2009). DGT probes can accumulate dissolved metals in a controlled fashion that permits precise measurements of trace metals. Like biota, DGT actively removes metals from water, pore water, and sediments, thus mimicking the biotic uptake while simultaneously providing quantitative measurements of the mean concentration of metals in pore water at the surface of the device. An advantage of this technology is that the thin film gels can be housed in a variety of holders or containers of different shape, and can be deployed in water, at the sediment-water interface, or into soft sediments with minimal disturbance of the sediment structure. DGT probes are constructed with two layers: a gel layer that allows diffusion of labile species into the film, and a binding layer, usually in the form of a strongly complexing resin, designed to accumulate target species (Van der Veeken et al., 2008; Van der Veeken and Van Leeuwen, 2010). Thus, DGT measures an integrated contaminant flux over the time period of deployment.

Little is known regarding relationships among the influx of low level contaminants, remediated contaminated sediments, and biological receptors. This research was designed to thoroughly investigate this topic and provide rigorous approaches/tools including conceptual and numerical models for the selection and evaluation of remediation methods that are resilient in the face of ongoing contaminant influxes and that exhibit long-term effectiveness. Ultimately, this research improved our understanding of the impact of low level, off-site contaminant loading to remediated sites and biological receptors, thereby leading to improved management strategies and better protection of human health and the environment.

# 3.0 MATERIALS AND METHODS

## 3.1 TASK 1. LINKAGES BETWEEN CONTAMINANT LOADING AND RECONTAMINATION OF REMEDIATED SEDIMENTS – FLOW THROUGH MESOCOSMS WITH CONTINUOUS METAL INFLUX

The first task consisted of two subtasks. In the first subtask we studied the effects of dissolved metal loading on the recontamination of sediment/remediated sediments in experiments employing a continuous flow-through batch reactor with fixed dissolved metal concentrations in the flow. In second subtask we utilized an improved mesocosm system that investigated lower concentrations of metals and possible competitive interactions among multiple metals.

### 3.1.1 SUBTASK 1.1. DISSOLVED METAL INFLUX

#### 3.1.1.1 *Experimental Setup - Construction of Mesocosms*

The experimental setup included flow-through mesocosms designed to test the effects of dissolved and particulate metals on selected cap materials present in different thicknesses (Figure 1). The mesocosms consisted of custom-built acrylic aquaria constructed by GlassCages.Com, LLC, Dickson TN. The dimension of each aquarium was 20 cm wide by 41 cm long, with a height (43 cm) sufficient to accommodate caps of realistic thickness. Cap thickness is important because it can affect fluxes of contaminants into and out of the caps and the potential reworking of the caps and contiguous sediments by physical processes. Cap thicknesses for Subtask 1 were 2.5 cm and 5 cm, corresponding to a range that has proven successful in field applications. Each aquarium was provided with a 6 mm acrylic lid. Outlets were drilled in each aquarium at the levels needed to maintain similar water depths in all treatments.

About 450 kg of clean sediment were collected and homogenized. A few subsamples of the homogenized sediment were analyzed for total metals, water extractable metals, pH, organic matter content, and particle size distribution. Sufficient sediment was placed in the bottom of each of 27 of the mesocosms to produce a 12.5 cm layer (Picture 1). One pore water sipper was permanently placed at a depth of about one inch in each mesocosm for the collection of sediment pore water throughout the study (Pictures 2 and 3). Sediment was not placed in three mesocosms, which acted as controls for the assessment of metal concentrations that entered the mesocosms.

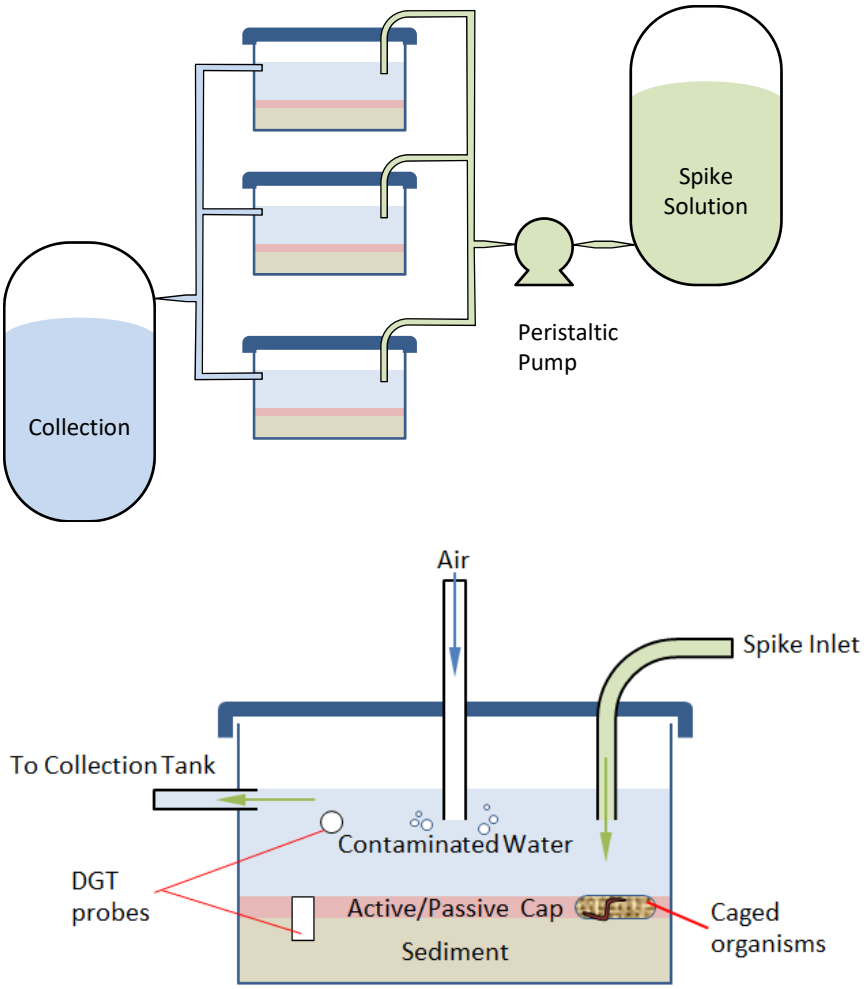



**Figure 1. Mesocosm experimental design.**

**Picture 1. Sediment placed in mesocosms.**

**Picture 2. Construction of sippers for collection of pore water.**

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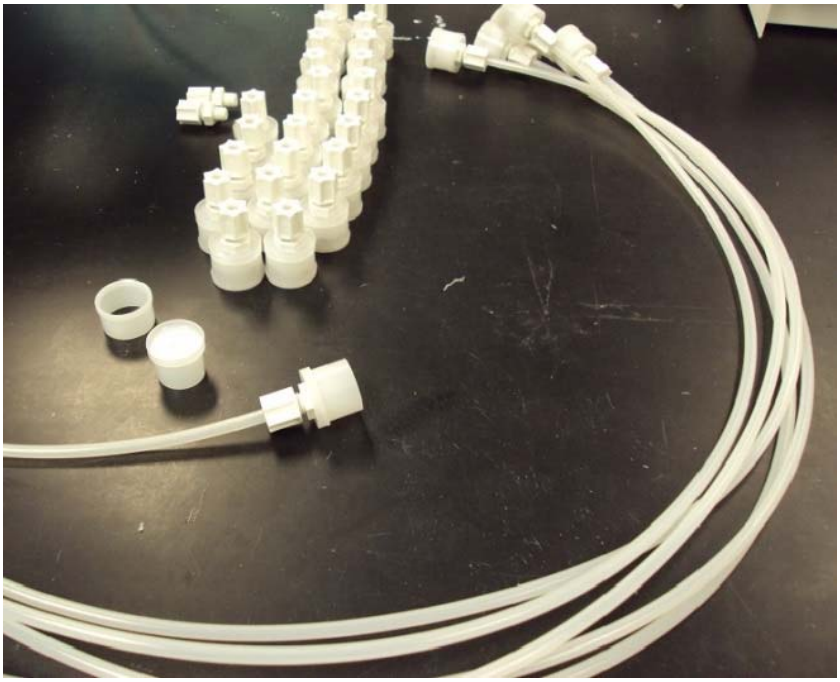

**Picture 3. Sippers being installed in mesocosms.**

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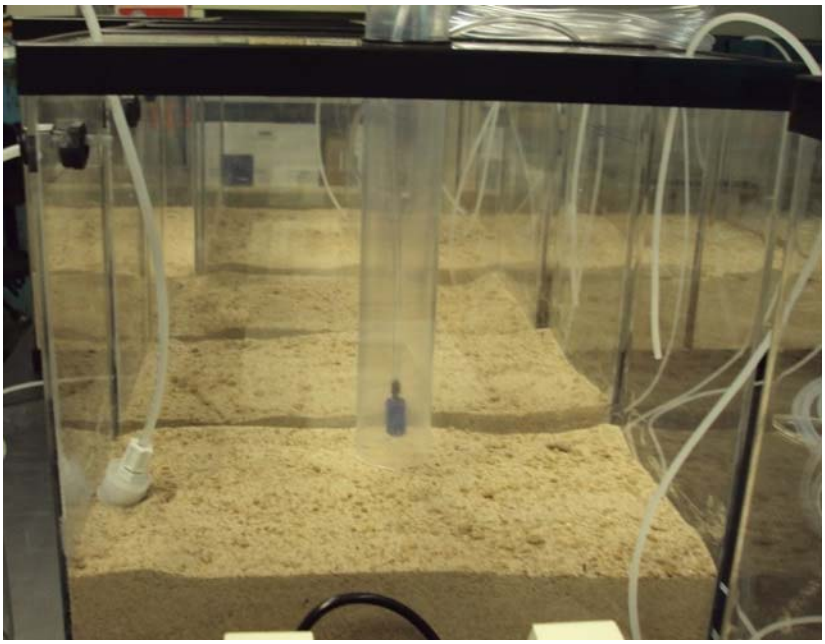


The 30 mesocosms represented different cap compositions, cap thicknesses, controls with sediment but without caps, and controls without sediment or caps (Table 1). Each treatment was represented by three replicates with treatments randomly allocated among mesocosms. The amount of active and passive cap material needed for each treatment was prepared following Table 1. Active materials include apatite (North Carolina rock phosphate), organoclay (MRM from CETCO), and activated carbon (e.g., Brimac Carbon containing both carbon and hydroxyapatite lattice surface area); passive materials include sand. The study also included locally collected, subsurface red clay sediment rich in Fe, which could act as an active material. The sediments were permitted to equilibrate for two weeks, and the cap materials were placed on top of the sediment (Pictures 4 and 5). The caps were then saturated, and the tanks filled with deionized (DI) water prior to receiving spike solution (Pictures 6 and 7). Baseline pore water samples were collected after the tanks were filled with water (Picture 8).

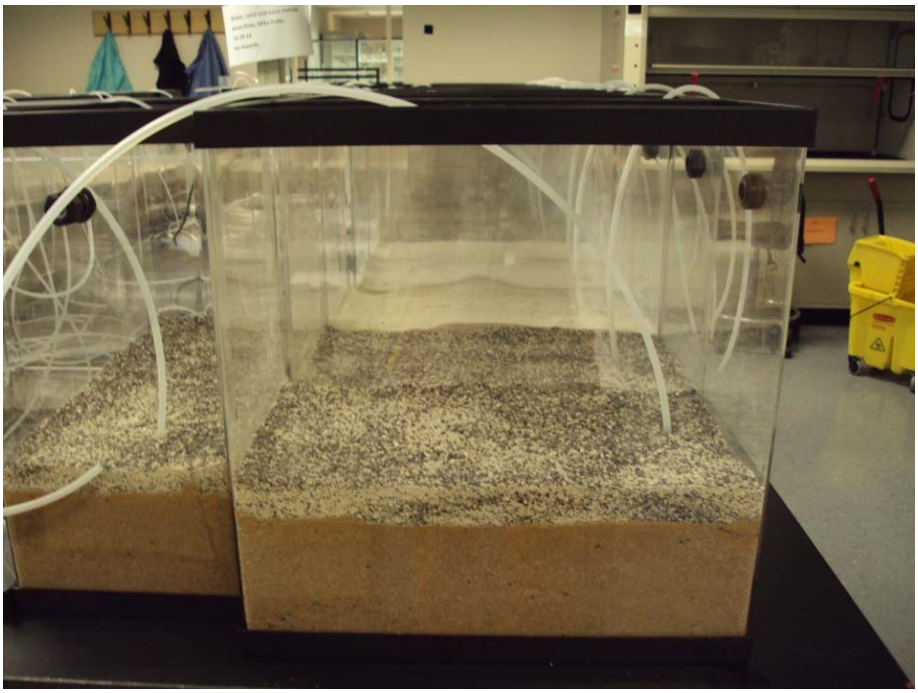
**Table 1. Experimental design showing the number of aquaria for each combination of three factors: active material a, passive material b, and cap thickness (0 –5cm).**

| Passive Materials | Active Materials | Solution (16.5L) | 0 cm | 2.5 cm | 5 cm |
|---|---|---|---|---|---|
| No | No | Yes | 3 | | |
| No | No | Yes | 3 | | |
| No | NCA | Yes | | 3 | 3 |
| No | AC | Yes | | 3 | |
| No | MRM | Yes | | 3 | |
| S | No | Yes | | 3 | 3 |
| CL | No | Yes | | 3 | |
| No | NCA/MRM/AC | Yes | | 3 | |

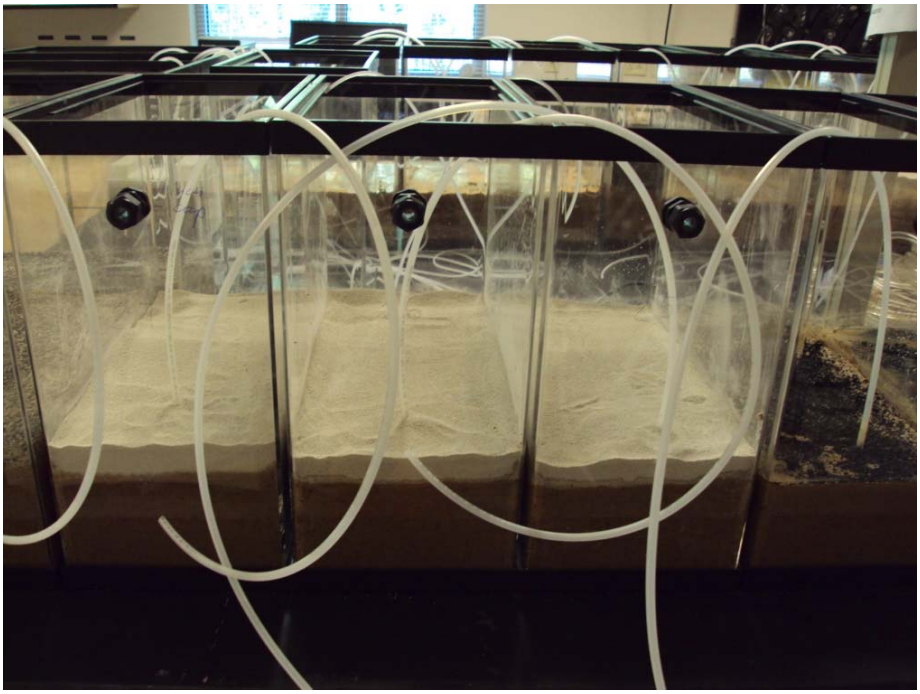
[a] No – no active material, NCA – North Carolina apatite, AC – activated carbon, MRM – organoclay from CETCO. [b] No – no passive material; S- sand, CL – silty clay.

**Picture 4. Placement of cap materials over saturated sediment following Table 1.**

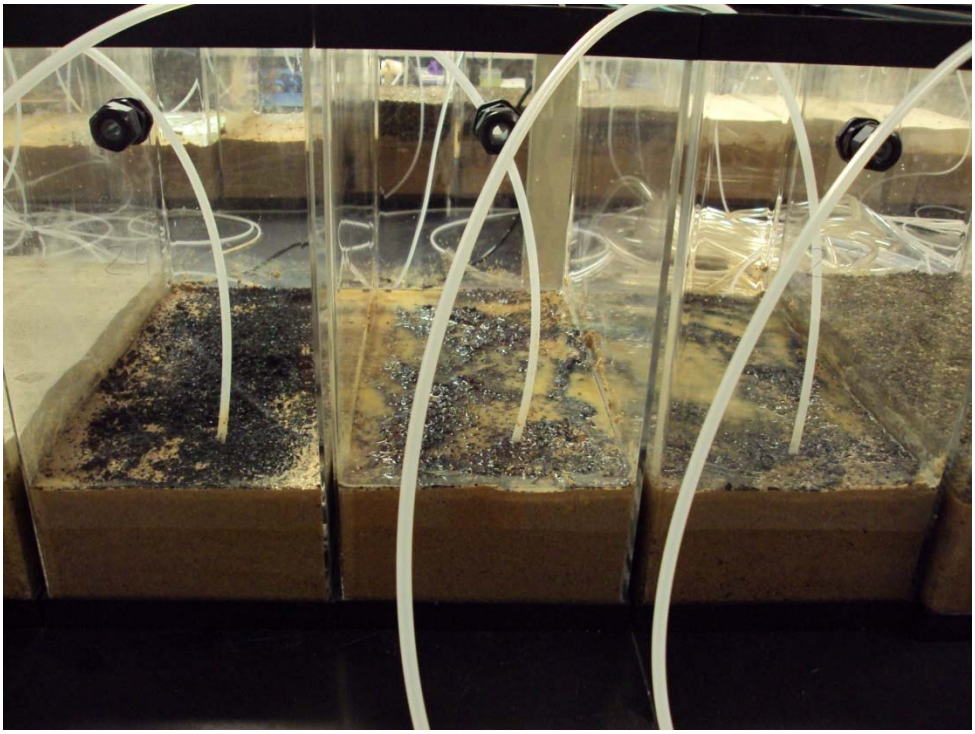
Apatite



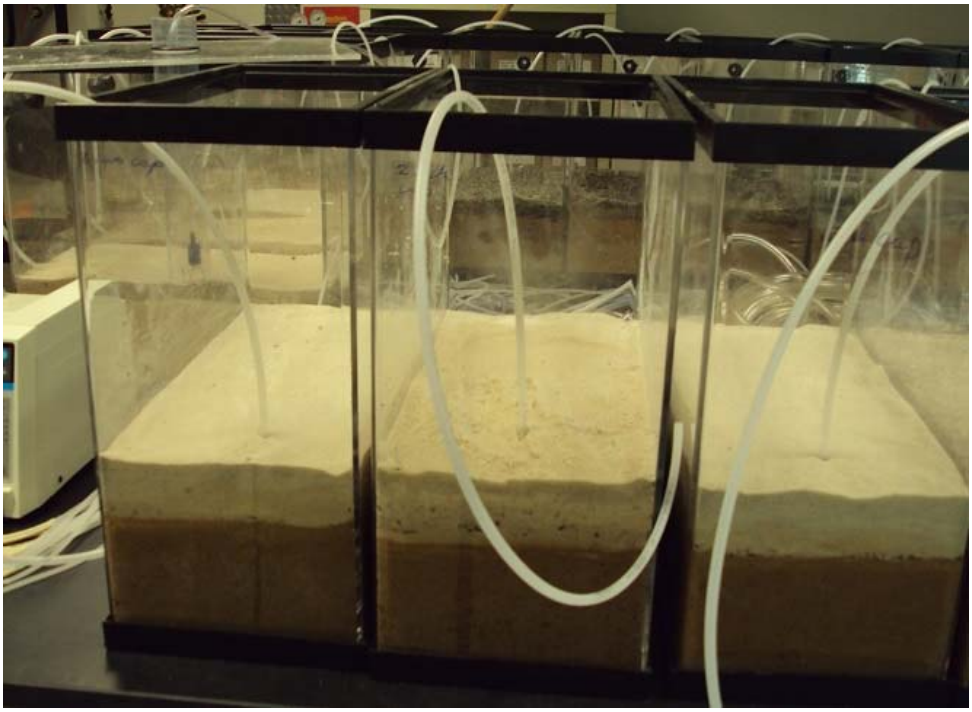
Organoclay MRM



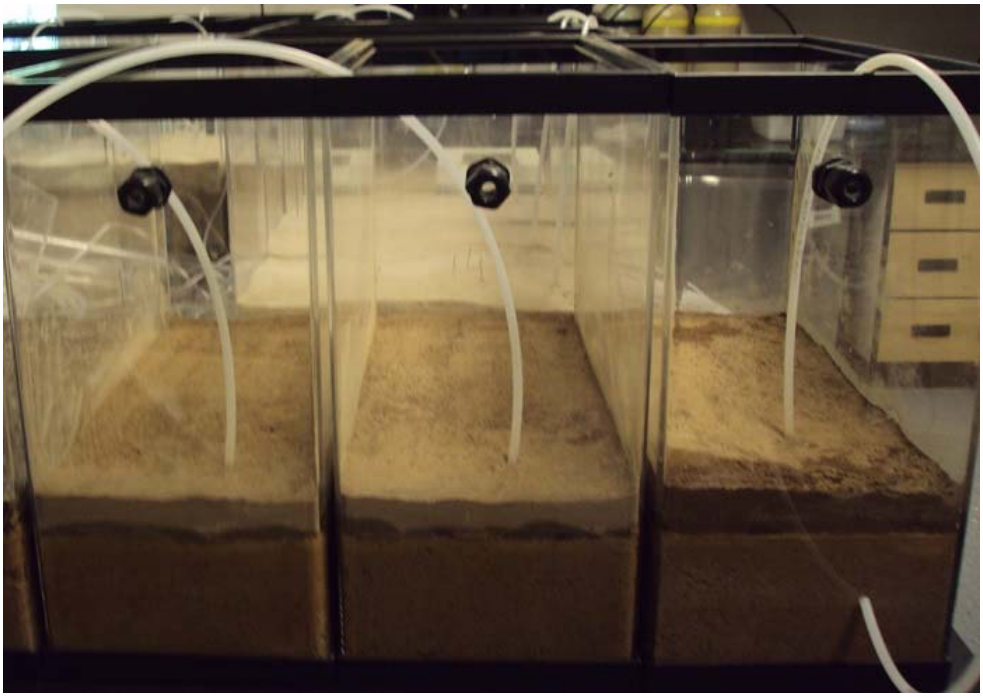
Activated carbon



Sand



Silty clay



**Picture 5. Thirty mesocosms representing different cap compositions, cap thicknesses, controls with sediment but without caps, and controls without sediment or caps.**

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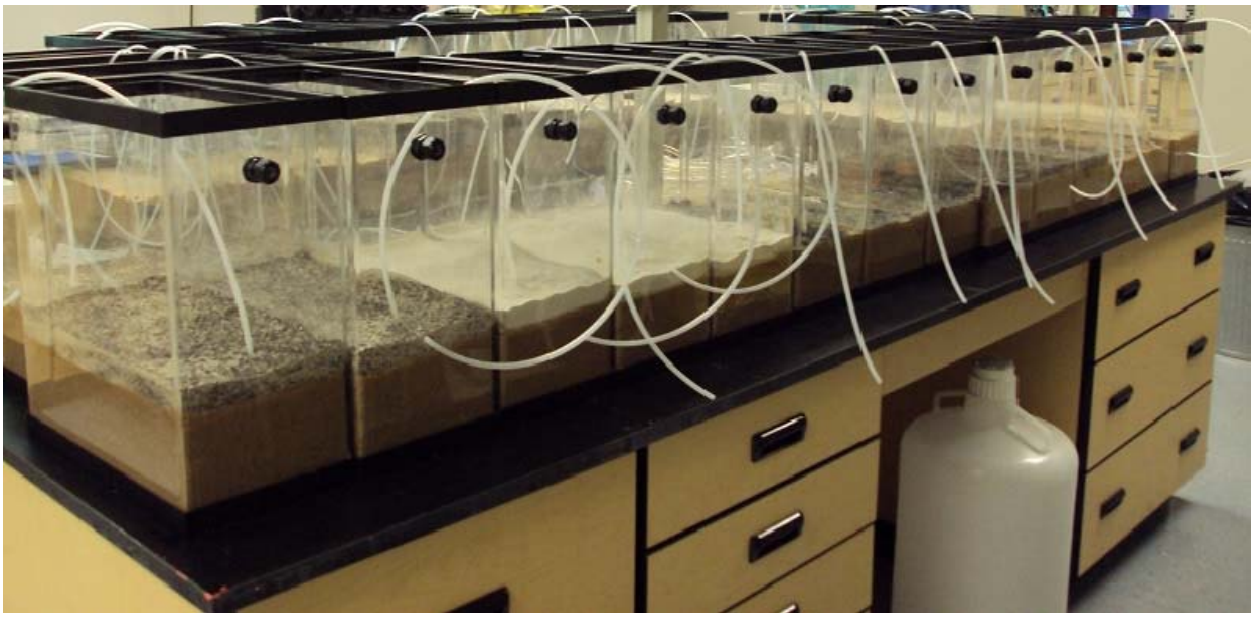
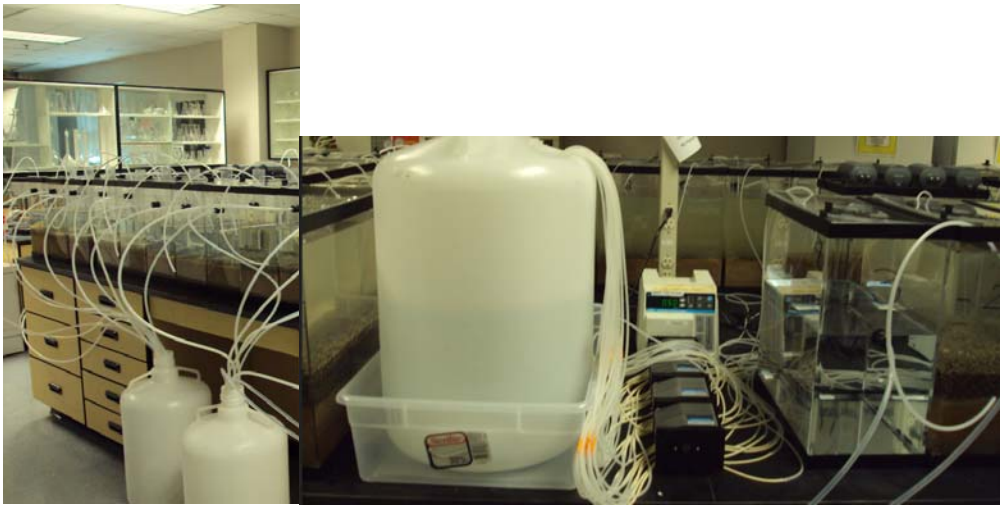


**Picture 6. Saturating cap materials and filling flow-through mesocosms with DI water (16.5 L). Drain lines from the mesocosms enter carboys.**

**Picture 7. Tanks ready to receive metal spike solution (0.5 mg $L^{-1}$ of each element). Drain and sipper tubes are visible.**

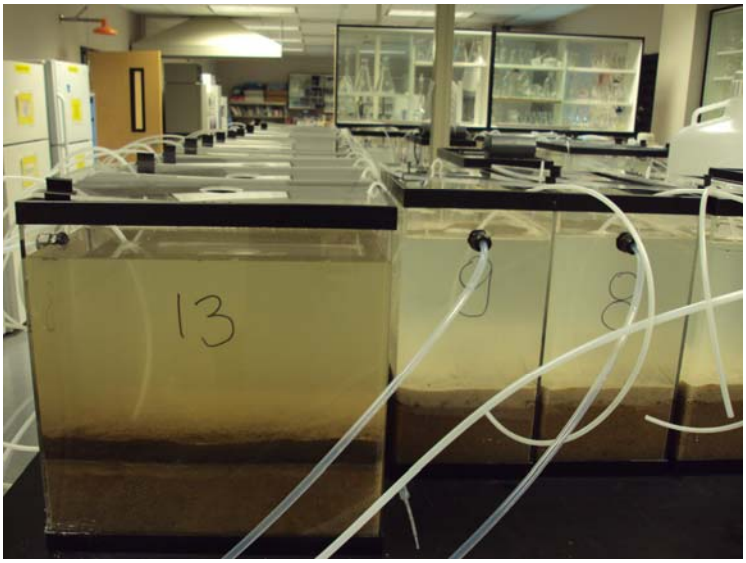


**Picture 8. Collection of baseline pore water samples before addition of the spike solution.**

A single 50-liter reservoir supplied all mesocosms with a continuous inflow (0.3 ml $minute^{-1}$) of spike solution containing 0.5 mg $L^{-1}$ of each of the following metals: As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Se, and Zn. Uniform delivery of spike solution was achieved by a single multi-channel peristaltic pump that withdrew water from the reservoir and supplied all mesocosms.

An airstone diffuser was placed in in each mesocosm to suspend particulate matter, thereby simulating field conditions in which particle-bound metals are a significant source of recontamination. Suspension of particulates was monitored by measuring turbidity within the mesocosms with a turbidity meter.

**Picture 9. Overview of mesocosms showing suspension of particulate matter.**




3.1.1.2 ***Sample Collection***

*Surface water*

Surface water samples (10 ml each) were collected daily for the first 10 days and weekly thereafter. One set of samples for dissolved metals was filtered using a 0.45 µm pore diameter membrane filter. A second set of samples for total recoverable metals was not filtered. All samples were acidified with nitric acid to pH<2. Metal concentrations in filtered and unfiltered samples were analyzed by inductively coupled plasma – mass spectrometry (ICP-MS). Surface water in all tanks was monitored daily for dissolved oxygen, temperature, electrical conductivity, pH, and turbidity. Collection of surface water samples from the mesocosms continued for 2520 h.

*Pore Water*

Pore water samplers consisted of a stainless steel wire mesh screen connected to nylon tubing. They were buried in the sediment underneath each cap to a depth of about one inch. The first set of pore water samples were collected before addition of the spike solution; i.e., 4 weeks after addition of cap materials. The second set of pore water samples were collected when the DGT probes were removed (3/4/15) in conjunction with toxicity testing of California blackworms. The third set of pore water samples was collected March 24, 2015 in conjunction with the toxicity testing of Asian clams. The pore water samples were acidified with nitric acid to pH<2 and

analyzed for metal concentrations. Measurements of pore water temperature, EC, DO, pH, ORP, and metals were recorded for all sets of pore water samples.

#### 3.1.1.3 *Toxicity testing*

The California blackworm *Lumbriculus variegates* is a common freshwater benthic oligochaete that burrows in shallow sediments. It is found throughout North America and Europe and is adapted to a broad range of temperatures. Blackworms were obtained from a commercial supplier (California Blackworm Co.). Three grams of blackworms were placed on a screen, drained of excess water, and placed in each of thirty 12 cm long 2 cm inner diameter screened cages for deployment into the experimental mesocosms. Each mesocosm received one cage, which was filled to 40-50% of maximum volume with cap material or sediment taken from just below the solid-water interface. The cages were partly (50%) buried in a horizontal position within the mesocosms. Upon retrieval, blackworms were removed from the cages by pouring the substrate into a plastic pan and agitating the pan to separate the lighter worms from the heavier substrate. Living individuals were removed from the pan with a pipette or tweezers, placed on a plastic screen to drain, and weighed in aggregate to determine percent recovery (initial weight / final weight x 100). Changes in aggregate weight between the beginning and ends of the tests were used to estimate survival and growth. Toxicity test was performed with California blackworms for 10 days of exposure.

An additional toxicity test (10 days) was performed with the Asian clam *Corbicula fluminea,* a benthic bivalve that typically lives in shallow sediments and feeds by a combination of filter and deposit feeding. Asian clams were collected from a local stream. Ten clams were placed in each of the previously described screened cages, which were subsequently deployed within the mesocosms as described for *Lumbriculus variegates.*

#### 3.1.1.4 *Bioaccumulation assessment*

Blackworms and Asian clams that remained alive after toxicity testing were analyzed for whole-body metal concentrations. Blackworms were rinsed, depurated in clean water for six hours, and drained of excess water. Asian clams were opened, and all soft tissues were removed, and rinsed. All tissues were frozen before processing. Metal analyses were conducted on fifty mg samples of freeze-dried tissue that were digested with 1 mL of $H_2O_2$ (30%) and 3 mL of $HN0_3$ at 85 °C. After digestion, the samples were analyzed by inductively coupled plasma mass spectrometry (ICP-MS) using a NexION 300X mass spectrometer (Perkin Elmer, Inc.) according to standard QA/QC protocols outlined in EPA Method 6020A (USEPA, 2007).

#### 3.1.1.5 *Sediment*

Sediment core samples were collected from each mesocosm to characterize cap and sediment chemistry after termination of the experiment. Three sediment cores were collected from each mesocosm with a push-tube coring device. The first core was used to evaluate the Zone of Influence (ZOI), the second core was a duplicate ZOI core, and the third core was archived. The

ZOI cores from sediment only and activated carbon treatments were split into three layers: A = 0-2.5 cm, B= 2.5-5 cm, and C: below 5 cm. The cores from one-inch cap treatments were split into the following layers: cap = 0-2.5 cm and sediment beneath the cap, A = 0-2.5 cm, B = 2.5-5 cm, and C = below 5 cm. The cores from the two-inch cap treatments were split into the following layers: cap A = 0-2.5 cm and cap B = 2.5-5 cm and sediment beneath the cap, A = 0-2.5 cm, B = 2.5-5 cm, and C = below 5 cm. All core samples were analyzed for pH,

#### 3.1.1.6 *Diffusive gradients in thin films (DGT) probes*

DGT passive gel probe samplers were used to determine the effects of the cap materials on the bioavailable pool of metals. The probes were purchased from DGT Research Ltd (Lancaster, UK). Two types of DGT probes were used: water and sediment.

*Water DGT probes*

Each water DGT probe consisted of a plastic housing with a 2 cm diameter window loaded with a polyethersulphone filter membrane backed by a diffusive gel layer and an ion-exchange resin gel (Chelex 100) and. Each probe was deployed by threading nylon monofilament through a small hole in the probe casing and suspending it with the open end facing down into the water. The water temperature at the time of the deployment was recorded as well as 24 h later when the unit was retrieved. The probes were rinsed with deionized water upon retrieval to remove any remaining surface water, sealed in a clean plastic bag, and stored in a refrigerator.

The internal portion of each water probe was retrieved by splitting the unit with a screwdriver and peeling away the filter and diffusive gel layers so that the bottom resin-gel layer could be removed. The resin-gel was placed in a sample tube with enough 1 M $HNO_3$ to fully immerse it. After 24 h, an aliquot of the solution was removed and diluted four times with deionized water prior to analysis by ICP-MS.

The resulting concentration from the diluted aliquot was adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution, $C_e$. The mass of metal accumulated in the resin gel layer (M) was calculated using Equation 1 for each metal:

$$M = \frac{Ce * (V_{NO_3} + V_{gel})}{f_e} \qquad \text{Eq. 1,}$$

where $V_{NO3}$ equals the amount of nitrate added (1000 µL for water probes based on the amount of nitric acid required to submerge the resin-gel layer),$V_{gel}$ equals the volume of the resin gel (150 µL), and $f_e$ is the elution factor of 0.8 (Zhang and Davison, 1995 and 2001).

The concentration of metal measured by the DGT unit ($C_{DGT}$) was calculated using Equation 2:

$$C_{DGT} = \frac{M * \Delta g}{D * t * A} \qquad \text{Eq. 2,}$$

where Δg is the thickness of the diffusive layer and filter layer (0.096 cm) (Zhang and Davison, 1995 and 2001), D is the diffusion coefficient each metal at the retrieval temperature, t is the deployment time (24 h = 86400 s), and A is the exposed area of the DGT unit (3.14 $cm^2$).

*Sediment DGT probes*

*DGT* sediment probes were sealed and refrigerated in a plastic bag with a few drops of 0.01 M $NaNO_3$, added as necessary over time to keep the units moist. The DGT sediment probes were deoxygenated before deployment. A 0.01 M NaCl solution was created with 10 grams of Chelex-100 to remove any trace metals in the NaCl solution. The NaCl solution was added to a container with enough space to cover the open windows of the DGT sediment probes with solution and accommodate plastic tubing for degassing. Nitrogen was then bubbled through the solution for 30 minutes. Immediately following the degassing, the container was placed in an anaerobic chamber to further deoxygenate the solution. The solution with probes was removed from the anaerobic chamber after 12 h, and one probe was deployed within each mesocosm.

The probes were deployed by inserting them vertically into the sediment until a mark 2 cm below the window was in line with the sediment/water interface. The sediment temperature at the time of the deployment was recorded as well as 24 h later when the unit was retrieved. Each unit was rinsed with deionized water to remove any sediment particles on the window area, sealed in a clean plastic bag, and stored in a refrigerator. The internal portion of each probe was subsequently retrieved by cutting through the window at and below the sediment/water interface using a Teflon-coated blade. The diffusive gel and filter layers were peeled away so that the bottom resin-gel layer could be removed. The resin-gel was then immersed in a sample tube with 1 M $HNO_3$. After 24 h an aliquot of the solution was removed and diluted four times with deionized water prior to analysis by ICP-MS.

The resulting concentration from the diluted aliquot was adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution, $C_e$. The mass of metal accumulated in the resin gel layer (M) was calculated using equation 3 for each metal:

$$M = \frac{Ce * (V_{NO_3} + V_{gel})}{f_e} \qquad \text{Eq. 3,}$$

where $V_{NO3}$ = amount of nitrate added (750 µL for sediment probes (based on the amount of nitric acid required to submerge the resin-gel layer), $V_{gel}$ = volume of the resin gel (810 µL), and $f_e$ = elution factor of 0.8 (Zhang and Davison, 1995 and 2001).

The concentration of metal measured by the DGT unit ($C_{DGT}$) was calculated with equation 4:

$$C_{DGT} = \frac{M * \Delta g}{D * t * A} \qquad \text{Eq. 4,}$$

where Δg = thickness of the diffusive layer and filter layer (0.096 cm) (Zhang and Davison, 1995 and 2001), D = diffusion coefficient each metal at the retrieval temperature, t = deployment time (24 h = 86400 s), and A = exposed area of the DGT unit.

## 3.1.2 SUBTASK 1.2 LOW-LEVEL DISSOLVED METAL INFLUX AND METAL INTERACTIONS

### *3.1.2.1. Experimental mesocosms*

The experimental setup included flow-through mesocosms as described for Subtask 1.1 designed to test the effects of Cu and other element influxes on selected cap materials. Homogenized, dry, clean sediment was placed on the bottom of each mesocosm to produce a 12.5 cm layer, which was equilibrated for two months at approximately 21°C with soft, synthetic water. The sediment was field-collected from a small creek in South Carolina, dried at ambient temperature, and ground in a porcelain mortar to pass through a No. 10 sieve (opening 2.00 mm). The mesocosms represented different passive and active cap compositions, *in situ* treatment, and uncapped sediment. The passive cap material in the mesocosms was sand; active cap materials included apatite (North Carolina rock phosphate), a mixture of amendments [apatite, organoclay (MRM from CETCO), and activated carbon (bone char)]. Activated carbon (bone char) was applied as an *in situ* treatment by mixing it with the upper 2.5 cm of sediment. In contrast, the other amendments were applied as a discrete layer (i.e., cap) over the sediments.

There were two parallel experiments: Experiment I with multiple elements and Experiment II with only Cu. Experiment II was included to address the possibility of competitive interactions between Cu and the multiple elements employed in Experiment I. Experiment I had 6 treatments: 1) control consisting of multiple element spike solution only (C-MS); 2) uncapped sediment (SED-MS); 3) 2.5 cm sand cap (SC-MS); 4) 2.5 cm apatite cap (A-MS); 5) *in situ* application of 5% by dry weight activated carbon (AC-MS); and 6) 2.5 cm cap composed of a mixture of 75% apatite, 5% activated carbon, and 20% MRM organoclay (MC-MS). Experiment II had 3 treatments: 1) control consisting of Cu spike solution only (C-CuS); 2) uncapped sediment (SED-CuS); and 3) sediment capped with a 2.5 cm cap composed of 75% apatite, 5% activated carbon, and 20% MRM organoclay (MC-CuS). Some treatments were excluded from Experiment II because it was intended to investigate element interactions rather than test treatments. Each treatment in both experiments was represented by three replicates, with treatments randomly allocated among mesocosms. A single reservoir supplied all mesocosms of Experiment I with a continuous inflow (0.5 ml minute$^{-1}$) of spike solution with multiple elements (referred to as MS), and a different single reservoir supplied all mesocosms of Experiment II with a continuous inflow (0.5 ml minute$^{-1}$) of spike solution with Cu only (referred to as CuS). The soft synthetic water was prepared according to EPA methods (EPA, 2002) and was used to equilibrate the mesocosm tanks and prepare spike solutions for both experiments. Using synthetic fresh water helped to accurately maintain target element concentrations and provided consistent physical and chemical properties.

Uniform delivery of the solution was achieved in each experiment by a single multi-channel peristaltic pump that withdrew solution from a reservoir and supplied all mesocosms.
All mesocosms were equilibrated with spike solution for two weeks after addition of the amendments, and synthetic spike solution was subsequently pumped in both experiments for a total of 2880 h. Two weeks were sufficient to reach equilibrium as indicated by previous research (Knox et al., 2008 and Knox et al., 2016). All mesocosms were kept at approximately

21ºC during both experiments. The tested elements in Experiment I were As, Cd, Cu, Pb, and Zn, and their target concentrations in the synthetic spike water were 150, 15, 30, 65, and 120 µg $L^{-1}$, respectively. The target Cu concentration in the synthetic spike water used in Experiment II was 30 µg $L^{-1}$.

#### *3.1.2.2. Surface water and sediment sampling*

Surface water samples (10 ml each) were collected daily for the first 5 days and weekly thereafter for a total of 2880 h (21 samplings). One set of surface water samples was filtered using a 0.45 µm pore diameter membrane filter for determination of dissolved elements. A second set of samples for the determination of total recoverable elements was not filtered. Each sample was acidified to 2% (v/v) with trace metal grade $HNO_3$ (pH<2) to be consistent with standard practices for water sampling and analysis.

Element concentrations in filtered and unfiltered samples were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS) using a NexION 300 (Perkin Elmer, Inc.) according to the QA/QC protocols outlined in EPA Method 6020B (USEPA, 2014). Dissolved oxygen, temperature, electrical conductivity, pH, turbidity, hardness, and dissolved organic carbon (selected samples) were measured in surface waters. Calcium hardness was measured by ethylenediaminetetraacetic acid (EDTA) titration (Hach, 2013).

Sediment core samples for measurement of sediment pH were collected from each mesocosm at 2880 h with a push-tube coring device. The cores from sediment only and activated carbon treatments were split into three layers: A: 0.0-2.5 cm, B: 2.5-5.0 cm, and C: below 5.0 cm. The cores from treatments with caps were split into a cap layer and three layers of sediment beneath the cap (A: 0.0-2.5 cm, B: 2.5-5.0 cm, and C: below 5.0 cm). The pH was determined from a 1:1 solid/water equilibrium solution.

#### *3.1.2.3 Effect of amendments on toxicity and bioaccumulation of Cu and other elements*

California blackworms *Lumbriculus variegatus* were used to assess sediment/cap toxicity and metal bioaccumulation in each treatment. The blackworms were obtained from a commercial supplier and placed in 12 cm long, 2 cm inner diameter screened (0.1 mm mesh), plastic cages for deployment in the mesocosms. Each mesocosm received one cage, which was filled to 40-50% of maximum volume with cap material or sediment taken from just below the sediment-water interface and about 5 grams of blackworms. The blackworms were drained of excess water and weighed in aggregate to the nearest hundredth of a gram before deployment in the cages. The cages were partly (50%) buried in a horizontal position within the mesocosms at hour 1176 of the experiment for a subsequent exposure period of 10 days at about 21ºC. The blackworms were not fed during this period except for organic matter naturally present in the sediment. Upon retrieval, the blackworms were removed from the cages by pouring the contents into a plastic pan and agitating the pan to separate the lighter worms from the heavier substrate. Living individuals were removed, placed on a plastic screen to drain, and weighed in aggregate to determine percent recovery (initial weight/final weight x 100). Changes in aggregate weight between the beginning

and end of the tests were used to estimate mortality rather than changes in number because blackworms can reproduce by fragmentation.

Blackworms that remained alive after toxicity testing were analyzed for whole-body element concentrations. They were rinsed, depurated in clean water for six h, drained of excess water, and frozen before processing. Element analyses were conducted on 50 mg samples of freeze-dried tissue that were digested with 1 mL of $H_2O_2$ (30%) and 3 mL of $HN0_3$ at 85°C. After digestion, the samples were analyzed using the ICP-MS methodology described above. Element levels in blackworms removed from the experimental mesocosms were compared with background element levels measured in six blackworm samples not exposed in the experimental mesocosms.

#### *3.1.2.4 Diffusive gradients in thin films (DGT) probes for assessing bioavailability of Cu and other elements*

DGT probes (purchased from DGT Research Ltd, Lancaster, UK) for water and sediment were used to determine the effects of the cap materials on the bioavailable pool of Cu and other elements. One DGT water probe was placed in each tank for 24 h one day before retrieving the California blackworms used in the 10-day toxicity/bioaccumulation test (1392 h). Each water DGT probe consisted of a plastic piston with a 2 cm window loaded with a filter paper backed by a polyacrylamide diffusive gel and a Chelex 100 ion-exchange resin gel. Fishing line was used to suspend the probes in the water with the open side facing downward. The water temperature was recorded at the time of the deployment and 24 h later when the probes were retrieved. Upon retrieval, the probes were rinsed with deionized water, the resin-gel was removed and extracted with 1 ml of 1 M $HNO_3$ for 24 h, and the diluted extract (1:4) was analyzed for elements by ICP-MS. DGT element concentrations in water were calculated as described in DGT research Ltd. specifications (Zhang, 2003).

DGT sediment probes were composed of the same materials as the water probes but were rectangular to facilitate vertical insertion in the sediments. They were deoxygenated before deployment in an anaerobic glove bag (Coy, Grass Lake, MI, USA) with ~0.5% $H_2$ and $N_2$ circulated over reduced palladium catalysts for trace $O_2$ removal. The DGT probes were in 0.01 M NaCl solution to remove any trace elements during deoxygenation. One sediment DGT probe was deployed within each mesocosm by inserting it vertically into the sediment to measure element levels in cap and sediment layers A (0.0-2.5 cm), B (2.5-5.0 cm), and C (5.0-7.5 cm). The units were rinsed upon retrieval, and the resin-gel layer from each probe was removed and divided into sections representing each previously described layer prior to analysis by ICP-MS. The resin-gel sections were extracted with 1 ml of 1 M $HNO_3$ for 24 h, and the diluted extract (1:4) was analyzed for elements by ICP-MS. The DGT concentrations of elements in the sediment ($C_{DGT}$) were calculated as shown in Zhang and Davison (1995), Zhang et al. (2001), and Zhang (2003). Blank water and sediment DGT probes were analyzed to determine background metal levels unrelated to experimental treatments.

#### *3.1.2.4 Statistical analysis*

The significance ($\alpha<0.05$) of differences in blackworm mortality, element concentrations in blackworm tissues, and DGT concentrations in water among treatments was assessed with one-way analysis of variance (ANOVA) followed by pair-wise Holm-Sidak tests. Blackworm tissue data were $\log_{10}(X+1)$ transformed to better approximate the assumptions of normality and homoscedasticity required for parametric testing. Test results for these data are presented as geometric means calculated by back-transformation. Pearson correlations were calculated between element concentrations in blackworm tissues and element concentrations in sediment measured by DGT probes.

## 3.2 TASK 2 UNDERSTANDING RELATIONSHIPS AMONG REMEDIATION METHODS, LOW LEVEL INFLUXES OF CONTAMINANTS, AND BIOLOGICAL RECEPTORS – COMPREHENSIVE STUDY

The objective of Task 2 was to assess the effects of bioturbation on an incoming particulate contaminant load deposited over underlying clean sediment or active capping material. The effects of bioturbation were evaluated based on metal fluxes from contaminated sediment to sediment pore water and overlying surface water, the distribution of dissolved and labile contaminants in the water and sediment measured by Diffusive Gradients in Thin Films (DGT), and contaminant bioaccumulation and toxicity to aquatic organisms. We hypothesized that the bioturbation of contaminated sediment deposited over active caps would increase the contact of the sediment with underlying cap materials, potentially fostering chemical sequestration processes that reduce contaminant bioavailability, toxicity, and release to the water column. Increased contact from bioturbation could result from mixing cap materials with overlying sediment or enhancement of diffusion and advection. We further hypothesized that these effects would be weaker when bioturbation occurs in contaminated sediment deposited over uncontaminated sediment, as would be the case when areas dredged for contaminant removal are subjected to recontamination.

### 3.2.1 Experimental design

In Task 2 substantial amounts of contaminated sediment was deposited over the tops of untreated, uncontaminated sediment and uncontaminated sediment treated by active capping. Task 2 employed 12 mesocosms, each consisting of a 20 cm wide, 41 cm long, 43 cm high custom-built acrylic aquarium with an acrylic lid, to investigate the effects of contaminated sediment deposited over active caps and assess the effects of bioturbation on contaminated sediment deposited over active caps and over uncapped sediment.

A single reservoir supplied the flow-through mesocosms used in Task 2 with a continuous inflow (0.5 ml minute$^{-1}$) of uncontaminated artificial water (Figure 2). Half of the mesocosms had a 2.5 cm cap composed of apatite, a chemically active material, overlying the uncontaminated sediment (Table 2). The mesocosms were divided into four groups: apatite cap with bioturbation, apatite cap without bioturbation, sediment only with bioturbation, and sediment only without bioturbation. Each group was represented by three replicates. Each mesocosm contained a bottom layer of uncontaminated sediment and overlying water (Picture 10). Cr, Mn, Ni, Cu, Zn, As, Cd, and Pb levels in the uncontaminated bottom sediment layer were below levels typically associated with polluted conditions (Table 3). Pore water samplers, consisting of a stainless-steel wire mesh screen connected to nylon tubing, were constructed and buried in the sediment within each mesocosm to a depth of about 2 cm. The mesocosms were permitted to equilibrate for six weeks after the initiation of water flow before the experiment was started by adding a thin layer of contaminated sediment to the mesocosms (Picture 10).

**Table 2. Experimental design.**

| | **Active Materials** | **Replicates** |
|---|---|---|
| No bioturbation | None (only sediment) | 3 |
| No bioturbation | NCA* cap | 3 |
| Bioturbation | None (only sediment) | 3 |
| Bioturbation | NCA cap | 3 |

*NCA = North Carolina apatite

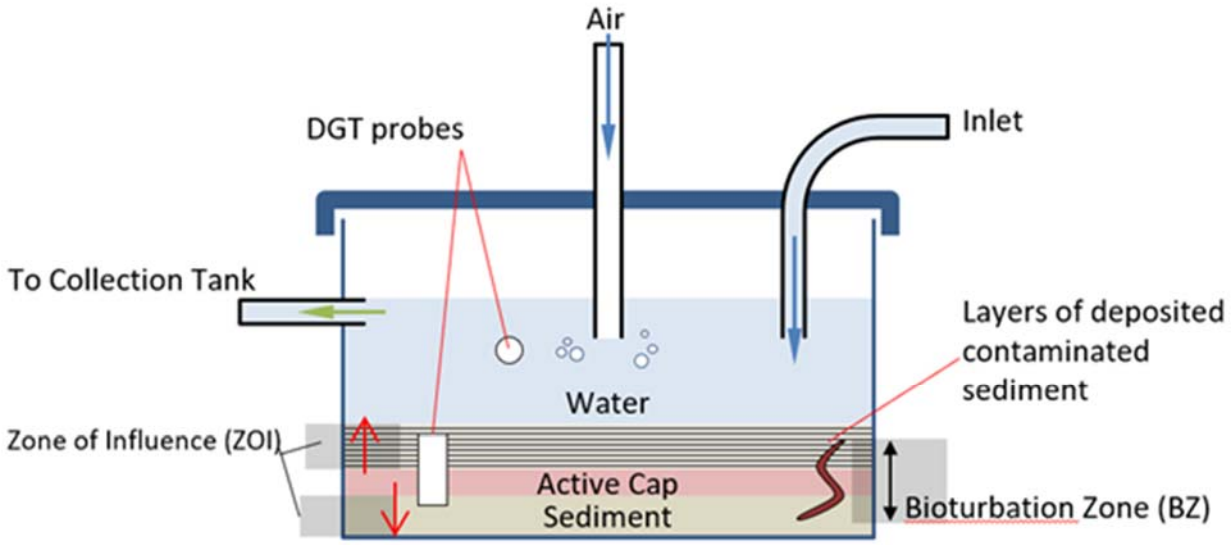



**Figure 2. Diagram of experimental mesocosms.**

**Table 3. Metal concentrations in sediment layers within the experimental mesocosms.**

| Sediment description | Mn | Fe | Ni | Cu | Zn | As | Cd | Pb |
|---|---|---|---|---|---|---|---|---|
| | mg $kg^{-1}$ | | | | | | | |
| Clean sediment – bottom layer (average; n=13) | 169.8 | 5845.8 | 7.8 | 3.7 | 7.3 | 1.0 | 0.3 | 5.4 |
| Contaminated sediment – top layer (average; n=7) | 117.5 | 8564.3 | 9.6 | 19.4 | 23.1 | 11.0 | 5.4 | 14.8 |
| Moderately polluted (EPA, 1977) | 300-500 | | 20-50 | 25-50 | 90-200 | 3-8 | | 40-60 |
| Heavily polluted (EPA, 1977) | >500 | | >50 | >50 | >200 | >8 | >6 | >60 |
| Moderate Contamination (New York DEC, 1994) | | | | 16-110 | | | 0.6-10 | |
| Significantly higher element concentrations in the top layer | | | | YES | | YES | YES | |
| Slightly higher element concentrations in the top layer | | YES | | | YES | | | YES |

**Picture 10. Setting up the experiment: pumping synthetic water into tanks to saturate sediment and cap.**

**Picture 11. A layer (1.5 cm) of contaminated sediment was added after six weeks of equilibrium, marking the beginning of the experiment (time,1 h). The addition of the sediment layer resulted in high turbidity in all mesocosms.**

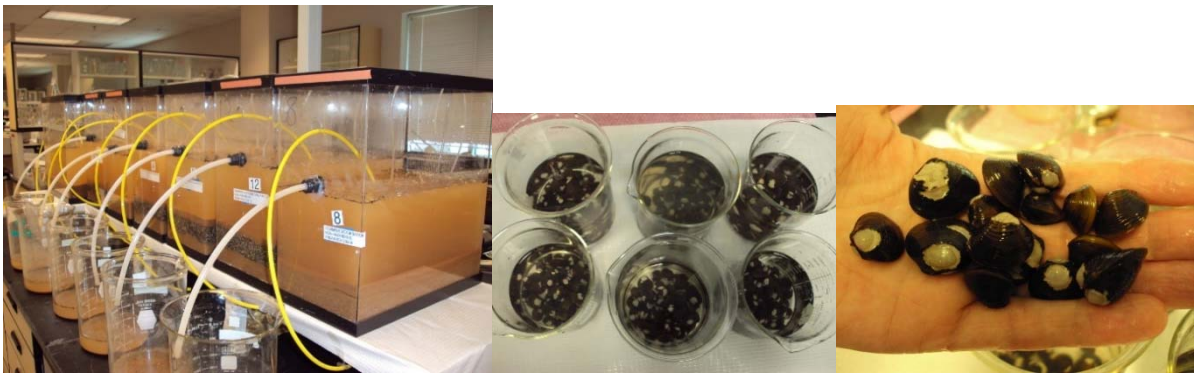
The experiment was initiated by adding contaminated sediment to all treatments after the six-week equilibration period (Picture 11). The contaminated sediment was characterized by levels of Cu, As and Cd within the range typical of polluted sediments (Table 3). Levels of Cr, Fe, Zn, and Pb in the sediment were elevated compared with levels in the uncontaminated layer of bottom sediment but did not reach levels recognized by the U.S. EPA (1977) as characteristic of polluted conditions. The contaminated sediment was dried at room temperature, and thoroughly homogenized to ensure the uniform distribution of contaminants. Contaminated sediment was gradually added by hand to each of the mesocosm to produce a layer about 1.5 cm thick over the uncontaminated sediments (controls) or apatite caps. The intent of this procedure was to simulate a remediated benthic ecosystem in which contaminated sediment is introduced from contaminated offsite sources through episodic disturbances such as runoff from storms or upstream construction activities.

### 3.2.2 Addition of bioturbating organisms

Asian clams *Corbicula fluminea* were added to half of the control and treatment mesocosms 24 h after the addition of the contaminated sediment (Table 2, Picture 12). Preliminary experiments showed that Asian clams are active organisms that burrow to a depth of 2 cm or more and significantly affect sediment porosity and vertical zonation. The addition of Asian clams permitted us to assess the effects of bioturbation, which may mix overlying contaminated sediment with underlying cap material, or sediment. One hundred and twenty clams were added to each mesocosm producing a density of 1,463 individuals per $m^2$, which simulated natural

densities and resulting bioturbation to an extent realistic in rivers with moderate to high densities of Asian clams (Sousa et al., 2008). The clams remained in the mesocosms for 28 days before the experiment was ended. Clams that died during this period were replaced with new clams marked to distinguish them from original clams in the mesocosms for the entire 28-day exposure period. Visual observations of the caps and sediment through the transparent mesocosm walls were used to assess the effects of bioturbation on the sediment and cap layers.

**Picture 12. Asian clams were added to selected mesocosms (marked by red tape) for bioturbation twenty-four hours after adding a 1.5 cm layer of contaminated sediment.**



### 3.2.3 Pore and surface water sampling

Pore water samplers were constructed using a stainless-steel wire mesh screen connected to nylon tubing. They were buried in the sediment to a depth of about 2.5 cm. Pore water samples were collected at the end of experiment at time 696 h (28 days). The samples were acidified with nitric acid to pH<2 and analyzed for metal concentrations by ICP-MS. Pore water temperature, EC, DO, pH, and ORP were also measured.

Surface water samples (10 ml each) were collected 8 times during the experiment: 0, 1, 24, 96, 264, 432, 600, and 696 h. One set of samples for determination of dissolved metals was filtered using a 0.45 µm pore diameter membrane filter. A second set of samples for the determination of total recoverable metals was not filtered. All samples were acidified with nitric acid to pH<2. Concentrations of As, Cd, Cu, Ni, Pb, and Zn were determined by inductively coupled plasma-mass spectrometry (ICP-MS) using a NexION 300 (Perkin Elmer, Inc.) according to the QA/QC protocols outlined in EPA Method 6020B (USEPA, 2014). Dissolved oxygen, temperature, electrical conductivity, pH, turbidity, and hardness were measured in surface waters. Calcium hardness was measured by ethylenediaminetetraacetic acid (EDTA) titration (Hach, 2013).

### 3.2.4 Assessment of bioaccumulation and survival

Eighteen days after the addition of the clams, fine-mesh screen cages (as previously described) containing an average of 5 g of the burrowing annelid *Lumbriculus variegates* were embedded within the top layer of sediment to directly assess metal bioavailability. The organisms were

obtained from a commercial supplier (California Blackworm Co.). After 10 days of exposure, they were removed from the cages, weighed in aggregate, and transferred to beakers containing uncontaminated water for depuration of sediment from the intestinal tract. Survival of the annelids was estimated based on changes in aggregate weight in each cage between the beginning and end of the exposure period. Whole animals removed from the cages were rinsed with deionized water and dried to a constant weight. Approximately 0.5 g of freeze-dried tissue or an equivalent wet tissue were digested with 1 mL of $H_2O_2$ (30%) and 3 mL of $HN0_3$ at 85 °C. Control samples consisting of worms that were not exposed in the mesocosms were also analyzed. Metals in the extracts were analyzed by inductively coupled plasma mass spectrometry (ICP-MS) using a NexION 300X mass spectrometer (Perkin Elmer, Inc.) according to standard QA/QC protocols outlined in EPA Method 6020A (USEPA, 2014).

The experiment was concluded after removal of the worm cages (i.e., at the end of the 28-day bioturbation period). At this time, all Asian clams were also removed from the mesocosms and counted to assess survival. Clams that were present in the mesocosms from the beginning of the bioturbation experiment were dissected to remove their soft tissues, which were rinsed and frozen before processing. Tissues from 30 clams were combined to make a single composite sample representing soft tissue metal levels in each mesocosm. Background soft tissue metal levels were represented by composite samples of 30 clams taken directly from the Savannah River. Metal analyses were conducted on a 50 mg subsample of freeze-dried tissue from each composite. The subsample was digested with 1 mL of $H_2O_2$ (30%) and 3 mL of $HN0_3$ at 85 °C. After digestion, the samples were analyzed by ICP-MS using a NexION 300X mass spectrometer (Perkin Elmer, Inc.) (USEPA, 2014).

### 3.2.5 Bioavailability assessment by diffusive gradients in thin films (DGT) probes

DGT water and sediment probes were deployed for 24 h in each mesocosm to measure metal levels in the water column and assess the effects of bioturbation on the vertical distribution of sediment contaminants. DGT permitted the measurement of fine-scale vertical profiles of contaminants that developed in the sediments and caps in each of the mesocosms. The probes were purchased from DGT Research Ltd (Lancaster, UK).

DGT water probes were placed in each tank (one per tank) for 24 h one day before retrieving the California black worms used in the 10-day survival/bioaccumulation test. Each water DGT probe consisted of a plastic piston loaded with a diffusive gel layer backed by an ion-exchange resin gel (Chelex 100). The probes were suspended in the water with the open side facing downward. The water temperature was recorded at the time of the deployment and 24 h later when the probes were retrieved. Upon retrieval, the probes were rinsed with deionized water, sealed in a clean plastic bag, and stored in a refrigerator for later analysis.

DGT sediment probes were deoxygenated and deployed within the mesocosms near the end of *Lumbriculus variegates* exposure period, by inserting them vertically into the sediment. The sediment temperature was recorded at the time of the deployment as well as 24 h later when the probes were retrieved. Upon removal from the sediment, the probes were rinsed with deionized water to remove any particles left on the window area. They were then sealed in a clean plastic bag and stored in a refrigerator until analysis. Prior to analysis, the internal portions of the sediment probes were removed and divided into sections corresponding to cap layer (CAP),

surficial contaminated layer (CL), underlying sediment layer (A), and deep sediment layer (B) to assess the vertical distribution of sediment contaminants.

Resin-gels from the DGT probes were placed in small sample tubes with enough 1 M $HNO_3$ to immerse the resin-gels. After 24 hours, an aliquot of the solution was removed from each tube and diluted with deionized water prior to analysis by ICP-MS. The resulting concentration from the diluted aliquot was adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution, $C_e$. DGT element concentrations were calculated as described in DGT research Ltd. specifications (Zhang, 2003).

Core samples for measurement of sediment pH were collected from each mesocosm at 696 h with a push-tube coring device. The cores from uncapped sediment were divided into a contaminated sediment layer (CL), an A layer (0.0-2.5 cm beneath the contaminated layer), and a B layer (2.5-5.0 cm beneath the contaminated layer). The cores from apatite cap treatments were split into four layers: CL, cap layer (C), A layer (0.0-2.5 cm beneath the cap) and B layer (2.5-5.0 cm beneath the cap). The pH was determined from a 1:1 solid/water equilibrium solution.

### 3.2.6 Data analysis

Two-way, factorial analysis-of-variance (ANOVA) was used to assess the significance of differences in surface water metal concentrations, pore water metal concentrations, blackworm whole-body metal concentrations, and DGT surface water concentrations among experimental groups. The main effects in each test were treatment (apatite cap vs uncapped sediment) and bioturbation (presence vs absence). The dependent variable for each metal in the surface water tests was the average concentration in each mesocosm beginning at 264 hours after the introduction of the contaminated sediment and continuing to the end of the experiment, thus eliminating the initial period when metals levels were fluctuating. The dependent variable for each metal in the blackworm tests was the average concentration in the composite samples from each treatment (N=3 for apatite-bioturbation, N=2 for apatite-no bioturbation [the blackworm cage in one mesocosm was damaged], N=3 for sediment-bioturbation, and N=3 for sediment-no bioturbation). Sample size for each surface water, DGT surface water, and pore water test was three per treatment corresponding to the three replicate mesocosms for each treatment (total of 12 for four treatments).

One-way ANOVA was used to assess the significance of differences in soft tissue metal concentrations among clams held in the bioturbation mesocosms. There were three groups: apatite mesocosms, sediment mesocosms, and clams taken from the field (i.e., background samples). Data points were the composite samples representing each group (N=3 for apatite, N=3 for sediment treatments, and N=6 for background).

Three-way ANOVA was used to analyze DGT sediment metal concentrations with the main effects of treatment (sediment vs. apatite cap), bioturbation (presence/absence), and sediment/cap layers as previously described. The cap layer, which was present only in the apatite cap treatment, was excluded to maintain a balanced design. Average blank concentrations were subtracted when calculating the DGT concentration for each element.

All ANOVA results were considered significant at $\alpha = 0.05$. Most data satisfied tests for normality (Shapiro-Wilk) and equal variance (Brown-Forsythe) making transformations unnecessary. Holm-Sidak pair-wise, multiple comparisons tests (overall $\alpha = 0.05$) were used to assess differences among individual least square means following overall significance in the ANOVAs. Means in statistical tables are least square means (LSMs) derived from linear models, which may differ slightly from observed means (i.e., averages) because of differences in sample size. Separate tests were conducted for As, Cu, Cd, Ni, and Zn. DGT results are not presented for As because Chelex probes are inappropriate for this element, nor for Zn because blank DGT Zn concentrations often exceeded Zn concentrations in the mesocosms.

## 3.3 TASK 3. PREDICTION OF LONG-TERM RELATIONSHIPS AMONG THE LOW LEVEL OF INFLUX OF CONTAMINANTS, BIOLOGICAL RECEPTORS, AND REMEDIATED SEDIMENTS.

### 3.3.1 Model review

Two candidate frameworks, the Sediment Flux Model (SFM) and Tableau Input Coupled Kinetic Equilibrium Transport (TICKET) model (Farley et al. 2008, 2011) were evaluated and compared with respect to their capabilities for representing metals transport and speciation in a capped environment. The SFM provides a robust and well-tested representation of transport within the bed (i.e., particle mixing and porewater diffusion) and exchange processes between the bed and the water column (i.e., porewater diffusion, resuspension, settling). However, the representation of chemical dynamics is limited to equilibrium partitioning between the dissolved phase and the particulate organic fraction in the sediment bed or water column. While this approach is standard for hydrophobic organic compounds (HOCs), it does not provide the capability to represent the more complex speciation of metals. In contrast, the TICKET model (Farley et al. 2008, 2011) contains detailed algorithms to dynamically simulate metal speciation and precipitation via the tableau approach, but it has not been extensively used for modeling the performance of different active caps.

At the request of SERDP, we developed a comparative evaluation of the SFM and TICKET models based on the application of these models to simulate the cap conditions represented in the mesocosm experiments. Initial model assessment, model modification and calibration, and diagnostic testing was conducted with both models within the context of the mesocosm experiments that were carried for Task 1, Subtask 1.1. This assessment included the following:

1) Evaluation of the data requirements of each model relative to the data collected during the mesocosm experiments
2) Configuration and calibration of each model (including model enhancements) for the mesocosm experiments
3) Comparison of initial diagnostic testing results for each model including an assessment of model limitations and concerns
4) Assessment of model sensitivity to parameter assumptions.

#### 3.3.1.1 *Data availability for modelling of mesocosms*

A summary of the data (Task 1, Subtask 1.1) used for modeling is provided below:

- Water column analysis of conventional parameters (32 samples) and total and dissolved metals (18 samples);
- Pore water analysis (for 3 samples collected via pore water sipper positioned one inch below the cap within the "base"/parent bed);
- Diffusive gradients in thin films (DGT) results for the water column and within the cap and "base" sediment layer; and
- Major cation concentrations analyzed for the "base" sediment used in all of the non-control mesocosms and also for the clay cap material.

In addition, measurements of inorganic and organic carbon were made for selected water column and pore water samples collected during the experiment. However, except for the sand cap, no observations of total organic carbon (TOC) were available for cap or "base" sediment material.

Schematics depicting the general design and sampling design for the mesocosm cap experiments are provided in previous sections of this report. Water column and pore water metal concentration results and water/sediment DGT results for the mesocosm experiments were compiled in a Microsoft Access database and connected to an existing LimnoTech data visualization tool. This allowed for efficient visualization of the data via automated generation of vertical profiles and time series profiles.

The monitoring efforts described above produced a considerable quantity of data for the mesocosm experiments, and these data were sufficient to configure and apply the "Sediment Flux Model" to reproduce the individual mesocosms. However, use of the mesocosm data within the context of the TICKET modeling effort highlighted significant data gaps with respect to fully applying that framework. Example key data gaps include:

- Total organic carbon content in the various cap materials (excluding the sand cap) and the "base" sediment used for the experiments;
- Characteristics and concentrations of adsorptive capacity for solids (e.g., hydroxides) and organic materials/coatings in the matrix of cap materials; and
- Sulfide content; i.e., as could be quantified by simultaneously extracted metals/acid-volatile sulfide (SEM-AVS).

### 3.3.2 Development and evaluation of final model

Based on the comparative evaluations described above, we developed a specific modeling approach for use in supporting field experimental work and forecasting long-term sediment conditions under different sediment treatment scenarios. This approach involved enhancement of the SFM code by incorporating the tableau approach used in TICKET and other chemical equilibrium models (e.g., MINEQL) into SFM producing an SFM framework capable of representing speciation of metals and other chemical components while retaining the vertical transport components from the original version of the SFM.

Simplified test cases were developed with the SFM-TICKET framework and evaluated against TICKET results to verify that the tableau-based equilibrium algorithms functioned as expected.

Following initial testing, simulations were developed to represent several of the mesocosm cases from Task 1, Subtask 1.2 (Experiment 1), including the control case, sand cap case, and apatite cap case. Four of the metals included in Task 1, Subtask 1.2 (Experiment 1) were simultaneously simulated: Cu, Cd, Pb, and Zn. (Arsenic was not included in the simulations because DGT probes cannot evaluate this element due to lack of a diffusion coefficient.) The SFM-TICKET simulations were configured in a manner generally consistent with the original simulations developed for the separate SFM and TICKET frameworks, which are discussed later in this report. The segmentation scheme included a single cell to represent the water column and multiple cells/layers to represent the sediment bed. The water column was assumed to have a constant volume of 10 L, based on the aquarium surface area of 825.8 $cm^2$ and a water depth of approximately 12 cm. A constant inflow and outflow of 0.030 L $h^{-1}$ was specified. The inflow represented the total concentrations of Cu (30 µg $L^{-1}$), Cd (15 µg $L^{-1}$), Pb (65 µg $L^{-1}$), and Zn (120 µg$L^{-1}$) consistent with the experimental design. The initial thickness of the individual sediment layers was defined as 1.27 cm, which allowed for each 2.54 cm cap layer to be represented by two discrete sediment cells/layers in the model. The top 7.5 cm of the "base" (i.e., parent) sediment were represented as six (6) discrete layers in the model. For example, a 2.54 cm sand cap case was represented by a total of 9 layers, including one water column layer, two layers representing the sand cap, and six layers representing the "base"/subsurface sediment.

Sequestering agents, including organic carbon and inorganic phosphate compounds (i.e., for apatite), were represented in the model by a single humic acid (HA) component for the purpose of simulating the adsorption of free Cu, Cd, Pb, and Zn ions to those agents. Humic acid and metal-HA complexes were represented in the model as a particulate phase, as were solid precipitates that might potentially form during a simulation. Resuspension of sediment bed material results in transferring both dissolved and particulate species into the water column; however, deposition processes only transfer particulate species, e.g., metal-HA complexes, from the water column to the sediment bed. Similarly, pore water diffusive exchange between the water column and the surficial bed layer (as well as between bed layers) only transports dissolved species and not the metal-HA or other solid species. Therefore, the use of a humic acid component to represent sequestering agent behavior appeared to be reasonable. A more detailed treatment of these agents would require a very extensive sediment chemistry datasets, which was cost-prohibitive. Modification of the HA initial concentration and the equilibrium constants (*K*) for the individual metal-HA complexes provided similar control over the metal adsorption behavior relative to modifying organic carbon fraction and the "$K_d$" values in the original SFM model.

# 4.0 RESULTS AND DISCUSSION

## 4.1 TASK 1. LINKAGES BETWEEN CONTAMINANT LOADING AND RECONTAMINATION OF REMEDIATED SEDIMENTS – FLOW THROUGH MESOCOSMS WITH CONTINUOUS METAL INFLUX

### 4.1.1 SUBTASK 1.1. DISSOVED METAL INFLUX

The treatments were evaluated based on the following criteria: 1) pore and surface water properties, 2) dissolved and particulate metal concentrations in surface water, 3) toxicity to *Lumbriculus,* 4) *b*ioaccumulation of metals by *Lumbriculus,* and 5) metal concentrations measured by diffusive gradients in thin films (DGT) probes.

#### 4.1.1.1 *Pore water properties and metal concentrations*

The addition of cap materials influenced pore water chemistry, especially pH, EC, and the ORP (Tables 4 - 6). The pH of pore water from all tanks increased slightly after cap placement (Tables 4 - 6) and remained higher than in pore water collected before cap placement (Tables 4 - 6). The highest EC values in pore water were observed in treatments with organoclay MRM and mixed amendment active caps (MAAC, which also contained MRM (Tables 4 - 6). The EC in pore water beneath the organoclay MRM caps decreased from about 10000 µS $cm^{-1}$ (time 0 h) to 5000 µS $cm^{-1}$ by the end of experiment (after 2520 h) (Tables 4 - 6).

The caps contributed to changes in the ORP of pore water in sediment under the caps as indicated by three sets of samples (Tables 4 - 6). Generally, the ORP value decreased beneath the caps in comparison to the control treatments (Tables 4 - 6).

Pore water metal concentrations differed among treatments with the lowest concentrations for most elements in the mesocosms with apatite and activated carbon caps (Tables 7 - 9). Metal concentrations in pore water collected at 2040 and 2520 h were significantly lower than concentrations in pore water collected at time zero (Tables 7 - 9). These changes very likely reflect changes in redox potential of the sediment beneath the caps.

**Table 4. Pore water properties. Samples collected on 12/5/2014 before addition of spike solution.**

| Treatment | Treatment description | Replicates | TEMP (°C) | DO (mg/L) | EC (µS/m) | pH | ORP |
|---|---|---|---|---|---|---|---|
| II | Sediment | 4 | 21.1 | 1.8 | 95 | 5.7 | 135 |
| | | 5 | 21.1 | 1.6 | 95 | 5.6 | 130 |
| | | 6 | 21.1 | 1.6 | 91 | 5.5 | 140 |
| III | Sand - 1 inch | 7 | 21.2 | 2.0 | 80 | 5.7 | 138 |
| | | 8 | 21.6 | 1.6 | 81 | 5.7 | 132 |
| | | 9 | 21.6 | 1.7 | 81 | 5.6 | 145 |
| IV | Sand - 2 inches | 10 | 21.2 | 2.0 | 90 | 5.6 | 139 |
| | | 11 | 20.9 | 1.8 | 80 | 5.7 | 137 |
| | | 12 | 21.1 | 1.8 | 86 | 5.6 | 137 |
| V | Silty clay | 13 | 21.7 | 2.0 | 95 | 5.6 | 136 |
| | | 14 | 21.7 | 1.8 | 98 | 5.7 | 134 |
| | | 15 | 21.7 | 1.9 | 108 | 5.7 | 145 |
| VI | Apatite - 1 inch | 16 | 21.4 | 2.0 | 300 | 5.4 | 123 |
| | | 17 | 21.2 | 1.8 | 252 | 5.5 | 125 |
| | | 18 | 21.4 | 2.0 | 324 | 5.3 | 130 |
| VII | Apatite - 2 inches | 19 | 21 | 1.9 | 600 | 5.2 | 120 |
| | | 20 | 21.1 | 2.2 | 549 | 4.7 | 123 |
| | | 21 | 21 | 2.3 | 470 | 5.2 | 124 |
| VIII | Activated carbon | 22 | 21.4 | 1.6 | 121 | 5.8 | 148 |
| | | 23 | 21.5 | 2.0 | 111 | 5.9 | 150 |
| | | 24 | 21.2 | 1.9 | 116 | 5.9 | 145 |
| IX | Organoclay MRM | 25 | 21.4 | 1.9 | 10180 | 4.7 | 125 |
| | | 26 | 21.4 | 1.9 | 10240 | 4.7 | 130 |
| | | 27 | 21.4 | 1.9 | 11380 | 4.4 | 134 |
| X | NCA60/MRM35/AC5 | 28 | 21.6 | 1.1 | 4650 | 5.0 | 110 |
| | | 29 | 21.3 | 1.9 | 4650 | 4.7 | 110 |
| | | 30 | 21.4 | 2.0 | 4655 | 4.7 | 124 |

**Table 5. Pore water properties. Samples collected on 3/4/2015 after collection of DGT probes and at 6-day test with *Lumbriculus variegates*.**

| Treatment | Treatment description | Replicates | TEMP (ºC) | DO (mg/L) | EC (µS/m) | pH | ORP |
|---|---|---|---|---|---|---|---|
| II | Sediment | 4 | 17.1 | 3.8 | 81 | 5.9 | 35 |
| | | 5 | 17.0 | 3.5 | 79 | 6.0 | 45 |
| | | 6 | 17.1 | 3.8 | 67 | 6.0 | 45 |
| III | Sand - 1 inch | 7 | 17.2 | 3.8 | 64 | 6.0 | 12 |
| | | 8 | 17.3 | 3.8 | 96 | 5.9 | 15 |
| | | 9 | 17.5 | 4.6 | 72 | 6.0 | 20 |
| IV | Sand - 2 inches | 10 | 17.6 | 4.1 | 91 | 5.8 | -15 |
| | | 11 | 17.5 | 3.8 | 85 | 6.0 | -20 |
| | | 12 | 17.6 | 3.9 | 75 | 5.9 | -20 |
| V | Silty clay | 13 | 17.0 | 3.8 | 104 | 6.1 | -25 |
| | | 14 | 17.6 | 3.6 | 118 | 5.9 | -35 |
| | | 15 | 17.6 | 3.4 | 114 | 5.9 | -35 |
| VI | Apatite - 1 inch | 16 | 17.5 | 4.5 | 413 | 5.4 | 10 |
| | | 17 | 17.6 | 4.2 | 392 | 5.2 | 5 |
| | | 18 | 17.5 | 4.2 | 422 | 5.2 | 12 |
| VII | Apatite - 2 inches | 19 | 17.6 | 4.1 | 650 | 5.4 | -10 |
| | | 20 | 17.7 | 3.5 | 660 | 5.0 | -15 |
| | | 21 | 17.6 | 3.9 | 673 | 5.4 | -20 |
| VIII | Activated carbon | 22 | 17.6 | 3.8 | 98 | 6.1 | 10 |
| | | 23 | 17.5 | 3.2 | 99 | 6.0 | 20 |
| | | 24 | 17.7 | 3.6 | 126 | 5.9 | 10 |
| IX | Organoclay MRM | 25 | 17.7 | 4.0 | 5086 | 5.1 | 5 |
| | | 26 | 17.6 | 3.8 | 6139 | 5.2 | 12 |
| | | 27 | 17.6 | 3.8 | 6090 | 4.6 | 16 |
| X | NCA60/MRM35/AC5 | 28 | 17.6 | 3.6 | 3110 | 5.7 | 10 |
| | | 29 | 17.6 | 4.1 | 3423 | 5.7 | 11 |
| | | 30 | 17.5 | 3.5 | 3351 | 5.1 | 12 |

**Table 6. Pore water properties. Samples collected on 3/24/2015 at the end of pumping of the spike solution at 2520 h.**

| Treatment | Treatment description | Replicates | TEMP (ºC) | DO (mg/L) | EC (µS/m) | pH | ORP |
|---|---|---|---|---|---|---|---|
| II | Sediment | 4 | 18.5 | 3.5 | 79 | 6.1 | 25 |
| | | 5 | 18.6 | 3.3 | 80 | 6.3 | 20 |
| | | 6 | 18.5 | 3.6 | 71 | 6.1 | 15 |
| III | Sand - 1 inch | 7 | 18.5 | 3.6 | 62 | 6.0 | 15 |
| | | 8 | 18.5 | 3.4 | 84 | 5.9 | 23 |
| | | 9 | 18.5 | 3.4 | 73 | 6.0 | 18 |
| IV | Sand - 2 inches | 10 | 18.5 | 4.1 | 93 | 5.9 | 6 |
| | | 11 | 18.5 | 3.9 | 87 | 6.0 | -10 |
| | | 12 | 18.5 | 4.1 | 69 | 6.0 | -20 |
| V | Silty clay | 13 | 18.6 | 3.3 | 128 | 6.1 | -17 |
| | | 14 | 18.7 | 3.3 | 128 | 5.9 | -23 |
| | | 15 | 18.6 | 3.4 | 122 | 5.9 | -37 |
| VI | Apatite - 1 inch | 16 | 18.5 | 4.3 | 445 | 5.6 | -6 |
| | | 17 | 18.3 | 4.2 | 414 | 5.2 | 5 |
| | | 18 | 18.5 | 4.1 | 449 | 5.2 | 13 |
| VII | Apatite - 2 inches | 19 | 18.5 | 4.1 | 890 | 5.5 | -10 |
| | | 20 | 18.4 | 3.9 | 602 | 5.7 | -19 |
| | | 21 | 18.5 | 4.0 | 693 | 6.1 | -24 |
| VIII | Activated carbon | 22 | 18.4 | 3.5 | 140 | 6.6 | 11 |
| | | 23 | 18.5 | 3.4 | 118 | 6.7 | 17 |
| | | 24 | 18.6 | 3.6 | 132 | 6.7 | 20 |
| IX | Organoclay MRM | 25 | 18.5 | 4.0 | 4494 | 5.1 | -10 |
| | | 26 | 18.6 | 3.9 | 5467 | 5.2 | -13 |
| | | 27 | 18.5 | 3.7 | 6037 | 4.7 | 14 |
| X | NCA60/MRM35/AC5 | 28 | 18.6 | 3.9 | 2490 | 5.9 | -10 |
| | | 29 | 18.6 | 4.1 | 3065 | 5.7 | 15 |
| | | 30 | 18.6 | 3.7 | 3182 | 5.8 | 25 |

**Table 7. Metal concentrations in pore water samples collected on 12/5/2014 before addition of spike solution (raw data).**

| Treatments | Replicates | Elements | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | As | Cd | Co | Cr | Cu | Mo | Pb | Se | Zn | Hg* |
| | | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | µg/l |
| | 4 | 0.835 | 0.012 | 0.018 | 0.024 | 0.032 | 0.112 | 0.355 | 0.315 | 0.060 | 0.620 |
| Sediment | 5 | 0.365 | 0.007 | 0.009 | 0.004 | 0.020 | 0.054 | 0.166 | 0.153 | 0.085 | 1.066 |
| | 6 | 0.388 | 0.000 | 0.014 | 0.006 | 0.025 | 0.063 | 0.183 | 0.136 | 0.045 | 0.629 |
| | 7 | 0.528 | 0.007 | 0.009 | 0.014 | 0.028 | 0.076 | 0.205 | 0.197 | 0.043 | 0.479 |
| Sand - 1 | 8 | 0.544 | 0.000 | 0.015 | 0.015 | 0.031 | 0.076 | 0.253 | 0.197 | 0.037 | 0.469 |
| | 9 | 0.482 | 0.007 | 0.014 | 0.012 | 0.036 | 0.076 | 0.205 | 0.152 | 0.044 | 0.512 |
| | 10 | 0.815 | 0.005 | 0.016 | 0.024 | 0.042 | 0.123 | 0.365 | 0.249 | 0.088 | 0.472 |
| Sand - 2 | 11 | 0.432 | 0.002 | 0.011 | 0.011 | 0.013 | 0.058 | 0.189 | 0.165 | 0.032 | 0.311 |
| | 12 | 0.537 | 0.007 | 0.012 | 0.012 | 0.013 | 0.080 | 0.243 | 0.184 | 0.034 | 0.298 |
| | 13 | 0.200 | 0.012 | 0.009 | 0.004 | 0.020 | 0.041 | 0.099 | 0.087 | 0.015 | 0.185 |
| Silty Clay | 14 | 0.327 | 0.005 | 0.008 | 0.006 | 0.015 | 0.058 | 0.141 | 0.119 | 0.021 | 0.137 |
| | 15 | 0.223 | 0.002 | 0.006 | 0.001 | 0.004 | 0.024 | 0.086 | 0.081 | 0.017 | 0.123 |
| | 16 | 0.126 | 0.000 | 0.032 | 0.007 | 0.007 | 0.035 | 0.093 | 0.113 | 0.041 | 0.124 |
| Apatite -1 | 17 | 0.233 | 0.002 | 0.020 | 0.005 | 0.003 | 0.028 | 0.102 | 0.097 | 0.025 | 0.596 |
| | 18 | 0.369 | 0.002 | 0.034 | 0.010 | 0.007 | 0.058 | 0.176 | 0.178 | 0.039 | 0.290 |
| | 19 | 0.269 | 0.004 | 0.130 | 0.007 | 0.004 | 0.086 | 0.102 | 0.275 | 0.061 | 0.209 |
| Apatite -2 | 20 | 0.307 | 0.004 | 0.075 | 0.008 | 0.007 | 0.063 | 0.150 | 0.329 | 0.040 | 0.143 |
| | 21 | 0.146 | 0.002 | 0.040 | 0.008 | 0.000 | 0.032 | 0.080 | 0.200 | 0.024 | 0.105 |
| | 22 | 0.410 | 0.002 | 0.007 | 0.009 | 0.009 | 0.058 | 0.179 | 0.123 | 0.026 | 0.085 |
| Acivated Carbon | 23 | 0.259 | 0.000 | 0.008 | 0.004 | 0.004 | 0.041 | 0.102 | 0.081 | 0.019 | 0.094 |
| | 24 | 0.291 | 0.002 | 0.013 | 0.004 | 0.010 | 0.045 | 0.138 | 0.113 | 0.030 | 0.079 |
| | 25 | 0.594 | 0.122 | 0.293 | 0.101 | 0.049 | 0.222 | 0.355 | 2.357 | 0.143 | 0.426 |
| MRM | 26 | 0.676 | 0.130 | 0.322 | 0.101 | 0.057 | 0.257 | 0.407 | 2.596 | 0.156 | 0.328 |
| | 27 | 0.500 | 0.178 | 0.645 | 0.158 | 0.071 | 0.365 | 0.615 | 2.862 | 0.330 | 0.210 |
| | 28 | 0.373 | 0.076 | 0.103 | 0.046 | 0.019 | 0.132 | 0.205 | 1.641 | 0.060 | 0.187 |
| MAAC | 29 | 0.515 | 0.115 | 0.336 | 0.076 | 0.028 | 0.214 | 0.304 | 1.810 | 0.054 | 0.112 |
| | 30 | 0.524 | 0.105 | 0.278 | 0.070 | 0.022 | 0.175 | 0.298 | 1.972 | 0.099 | 0.108 |

**Table 8. Metal concentrations in pore water samples collected on 3/4/2015 after collection of DGT probes and at 6 day test with *Lumbriculus variegates*.**

| Treatments | Replicates | Elements | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | As | Cd | Co | Cr | Cu | Ni | Pb | Se | Zn | Hg* |
| | | µg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | µg/l | mg/l | µg/l |
| Sediment | 4 | 0.73 | 0.000 | 0.015 | 0.008 | 0.038 | 0.007 | 0.023 | 3.77 | 0.220 | 0.16 |
| | 5 | 0.90 | 0.000 | 0.013 | 0.007 | 0.028 | 0.005 | 0.021 | 3.38 | 0.279 | 0.18 |
| | 6 | 0.30 | 0.000 | 0.005 | 0.004 | 0.015 | 0.003 | 0.011 | 1.95 | 0.259 | 0.28 |
| Sand - 1 | 7 | 0.08 | 0.001 | 0.004 | 0.002 | 0.021 | 0.003 | 0.006 | 1.35 | 0.333 | 0.06 |
| | 8 | 0.74 | 0.001 | 0.005 | 0.002 | 0.016 | 0.003 | 0.005 | 3.41 | 0.368 | 0.02 |
| | 9 | 0.72 | 0.001 | 0.003 | 0.002 | 0.010 | 0.002 | 0.008 | 3.43 | 0.261 | 0.09 |
| Sand - 2 | 10 | 0.85 | 0.001 | 0.003 | 0.002 | 0.012 | 0.001 | 0.004 | 3.82 | 0.333 | 0.05 |
| | 11 | 0.56 | 0.001 | 0.003 | 0.002 | 0.006 | 0.002 | 0.006 | 3.50 | 0.268 | 0.01 |
| | 12 | 0.24 | 0.001 | 0.005 | 0.003 | 0.007 | 0.003 | 0.009 | 1.45 | 0.361 | 0.06 |
| Silty Clay | 13 | 1.25 | 0.001 | 0.006 | 0.002 | 0.004 | 0.002 | 0.001 | 4.38 | 0.283 | 0.00 |
| | 14 | 1.03 | 0.000 | 0.005 | 0.001 | 0.005 | 0.003 | 0.004 | 3.29 | 0.269 | 0.01 |
| | 15 | 1.48 | 0.001 | 0.003 | 0.001 | 0.000 | 0.002 | 0.001 | 3.87 | 0.204 | 0.01 |
| Apatite -1 | 16 | 0.73 | 0.000 | 0.046 | 0.002 | 0.000 | 0.005 | 0.001 | 1.92 | 0.285 | 0.00 |
| | 17 | 0.81 | 0.000 | 0.036 | 0.001 | 0.004 | 0.006 | 0.005 | 2.11 | 0.246 | 0.00 |
| | 18 | 0.86 | 0.000 | 0.046 | 0.001 | 0.003 | 0.007 | 0.000 | 2.54 | 0.236 | 0.00 |
| Apatite -2 | 19 | 0.72 | 0.000 | 0.092 | 0.005 | 0.001 | 0.014 | 0.008 | 2.12 | 0.264 | 0.00 |
| | 20 | 1.07 | 0.000 | 0.062 | 0.003 | 0.020 | 0.009 | 0.008 | 4.13 | 0.346 | 0.00 |
| | 21 | 1.05 | 0.000 | 0.066 | 0.003 | 0.000 | 0.009 | 0.008 | 3.43 | 0.268 | 0.00 |
| Acivated Carbon | 22 | 0.60 | 0.000 | 0.004 | 0.002 | 0.007 | 0.003 | 0.004 | 1.68 | 0.280 | 0.00 |
| | 23 | na | na | na | na | na | na | na | na | na | na |
| | 24 | 0.73 | 0.000 | 0.008 | 0.006 | 0.009 | 0.005 | 0.010 | 3.05 | 0.250 | 0.04 |
| MRM | 25 | 1.45 | 0.000 | 0.128 | 0.007 | 0.000 | 0.021 | 0.008 | 2.64 | 0.233 | 0.00 |
| | 26 | 2.04 | 0.000 | 0.184 | 0.010 | 0.000 | 0.020 | 0.022 | 1.78 | 0.289 | 0.03 |
| | 27 | 1.52 | 0.000 | 0.317 | 0.033 | 0.004 | 0.127 | 0.025 | 3.64 | 0.459 | 0.11 |
| MAAC | 28 | 1.27 | 0.001 | 0.006 | 0.008 | 0.000 | 0.006 | 0.008 | 4.80 | 0.271 | 0.10 |
| | 29 | 0.98 | 0.000 | 0.192 | 0.007 | 0.000 | 0.020 | 0.017 | 2.09 | 0.299 | 0.11 |
| | 30 | 1.20 | 0.000 | 0.167 | 0.004 | 0.000 | 0.014 | 0.019 | 4.19 | 0.299 | 0.06 |

**Table 9. Metal concentrations in pore water samples collected on 3/24/2015 at the end of pumping of the spike solution at 2520 hours.**

| Treatments | Replicates | Elements | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | As | Cd | Co | Cr | Cu | Ni | Pb | Se | Zn | Hg* |
| | | µg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | µg/l | mg/l | µg/l |
| Sediment | 4 | 0.70 | 0.000 | 0.008 | 0.006 | 0.037 | 0.004 | 0.011 | 5.42 | 0.248 | 1.263 |
| | 5 | 0.30 | 0.000 | 0.005 | 0.004 | 0.026 | 0.002 | 0.011 | 3.67 | 0.198 | 1.100 |
| | 6 | 0.34 | 0.000 | 0.004 | 0.004 | 0.020 | 0.001 | 0.012 | 3.78 | 0.270 | 0.402 |
| Sand - 1 | 7 | 0.22 | 0.000 | 0.002 | 0.002 | 0.017 | 0.000 | 0.002 | 4.05 | 0.243 | 0.056 |
| | 8 | 0.08 | 0.000 | 0.004 | 0.002 | 0.016 | 0.001 | 0.007 | 3.33 | 0.166 | 0.054 |
| | 9 | 0.00 | 0.000 | 0.002 | 0.001 | 0.013 | 0.001 | 0.001 | 2.78 | 0.165 | 0.021 |
| Sand - 2 | 10 | 0.32 | 0.000 | 0.002 | 0.001 | 0.014 | 0.002 | 0.003 | 3.64 | 0.248 | 0.041 |
| | 11 | 0.30 | 0.000 | 0.001 | 0.001 | 0.007 | 0.001 | 0.002 | 3.94 | 0.177 | 0.001 |
| | 12 | 0.00 | 0.000 | 0.004 | 0.002 | 0.011 | 0.002 | 0.002 | 2.07 | 0.195 | 0.053 |
| Silty Clay | 13 | 1.25 | 0.000 | 0.004 | 0.001 | 0.004 | 0.000 | 0.000 | 3.75 | 0.193 | 0.009 |
| | 14 | 1.32 | 0.000 | 0.003 | 0.000 | 0.004 | 0.001 | 0.000 | 3.66 | 0.221 | 0.000 |
| | 15 | 1.67 | 0.000 | 0.002 | 0.000 | 0.003 | 0.000 | 0.002 | 5.39 | 0.170 | 0.005 |
| Apatite -1 | 16 | 0.74 | 0.000 | 0.047 | 0.001 | 0.003 | 0.004 | 0.005 | 3.21 | 0.197 | 0.000 |
| | 17 | 1.18 | 0.000 | 0.037 | 0.001 | 0.005 | 0.004 | 0.003 | 4.40 | 0.182 | 0.000 |
| | 18 | 0.67 | 0.000 | 0.042 | 0.002 | 0.002 | 0.004 | 0.000 | 4.42 | 0.185 | 0.000 |
| Apatite -2 | 19 | 0.93 | 0.000 | 0.080 | 0.001 | 0.000 | 0.010 | 0.007 | 4.17 | 0.261 | 0.000 |
| | 20 | 0.34 | 0.000 | 0.038 | 0.002 | 0.004 | 0.005 | 0.002 | 3.64 | 0.179 | 0.002 |
| | 21 | 0.69 | 0.000 | 0.054 | 0.002 | 0.001 | 0.006 | 0.002 | 3.98 | 0.199 | 0.000 |
| Acivated Carbon | 22 | 0.47 | 0.000 | 0.003 | 0.001 | 0.014 | 0.001 | 0.005 | 3.32 | 0.152 | 0.000 |
| | 23 | na | na | na | na | na | na | na | na | na | na |
| | 24 | 0.39 | 0.000 | 0.005 | 0.002 | 0.010 | 0.002 | 0.001 | 3.37 | 0.178 | 0.055 |
| MRM | 25 | 2.12 | 0.000 | 0.120 | 0.008 | 0.001 | 0.021 | 0.007 | 2.91 | 0.209 | 0.083 |
| | 26 | 1.51 | 0.000 | 0.152 | 0.007 | 0.000 | 0.027 | 0.012 | 2.91 | 0.203 | 0.101 |
| | 27 | 2.01 | 0.000 | 0.280 | 0.040 | 0.000 | 0.062 | 0.022 | 4.68 | 0.329 | 0.148 |
| MAAC | 28 | 2.90 | 0.000 | 0.012 | 0.002 | 0.000 | 0.005 | 0.012 | 6.46 | 0.191 | 0.185 |
| | 29 | 1.30 | 0.000 | 0.129 | 0.004 | 0.000 | 0.012 | 0.009 | 5.11 | 0.212 | 0.018 |
| | 30 | 1.42 | 0.000 | 0.131 | 0.002 | 0.000 | 0.010 | 0.012 | 4.82 | 0.307 | 0.073 |

#### 4.1.1.2 *Surface water properties*

The concentration of each metal (As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Se, and Zn) in the spike solution was about 0.5 mg $L^{-1}$ as indicated by ICP-MS. Maintaining these concentrations required keeping the pH of the spike solution at or below 7.0 to prevent metals from precipitating and declining in concentration.

Electrical conductivity (EC) trends were consistence throughout the 2520 h experiment. Average conductivity was relatively constant over time and was highest in the mesocosms with MRM caps followed by the mesocosms with MAAC caps, which contained MRM, apatite, and activated carbon (Figures 3 - 4 and Appendix 1; Tables A1.1 – A1.32).

Surface water turbidity was the highest in the mesocosms with sediment, activated carbon, and silty clay because these materials contained fine particles that were easily suspended (Figure 5 and Appendix 1; Tables A1.1 – A1.32).

Surface water pH was affected by the pH of the spike solution and nature of the cap materials. The highest pH values were observed in treatments with activated carbon caps followed by apatite and MAAC caps (Figures 6 and 7 and Appendix 1; Tables A.1.1 – A1.32). Average pHs in these mesocosms were higher than in the mesocosms with sand caps and untreated sediment. Only the treatment with organoclay MRM showed significant changes in pH during the 2520 h test period. Surface water pH in this treatment decreased after 600 h from about 6.6 to about 4.0 (Figures 6 and 7).

Surface water dissolved oxygen concentrations were similar among treatments and were consistent during the test period of 2520 h (Figure 8 and Appendix 1; Tables A1.1 – A1.32).

Average temperatures were similar among treatments and were stable throughout the experiment (about 18ºC) (Figure 9 and Appendix 1; Tables A1.1 – A1.32).

Some amendments (e.g., apatite and MRM) increased the water calcium carbonate hardness from less than 5 (control and sand cap treatments) to about 180 mg $L^{-1}$ (Figure 10).

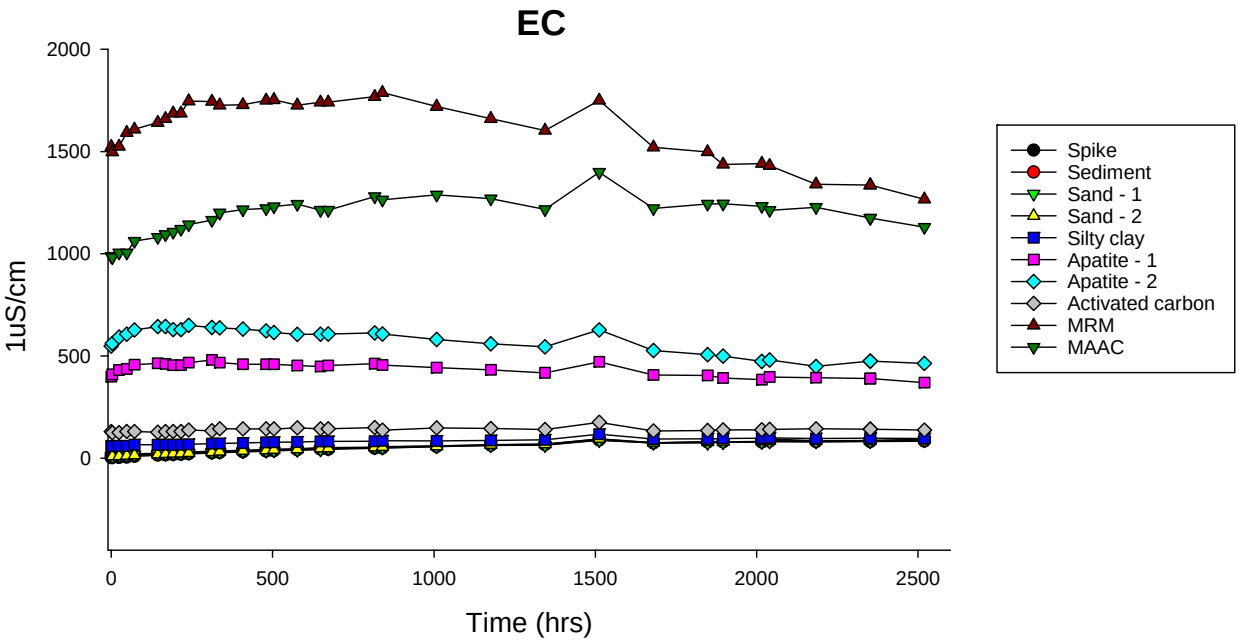



**Figure 3. Temporal changes in surface water electrical conductivity (EC) for each treatment. Each value is an average of three samples.**

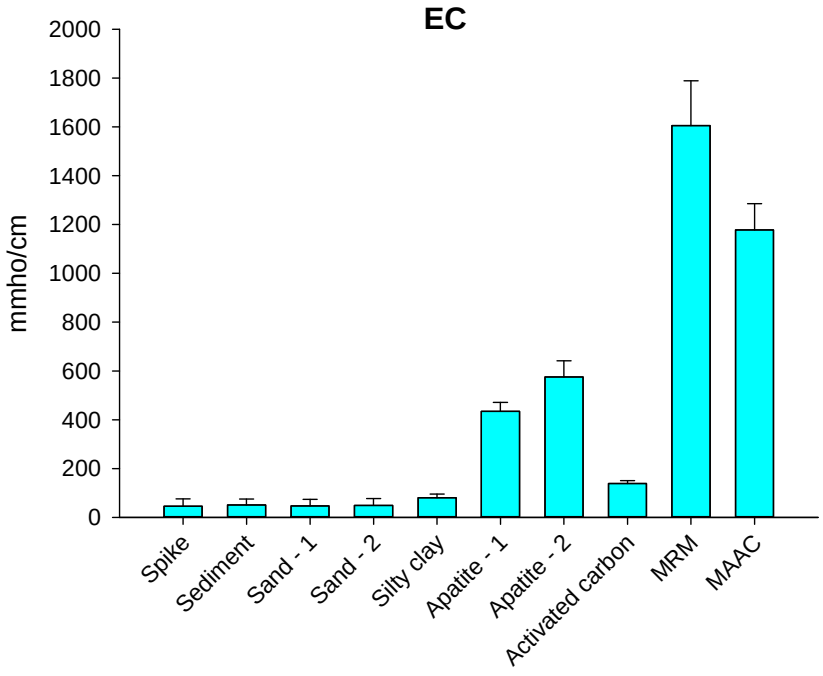



**Figure 4. Average surface water electrical conductivity (EC) for each treatment; error bars are standard deviations.**

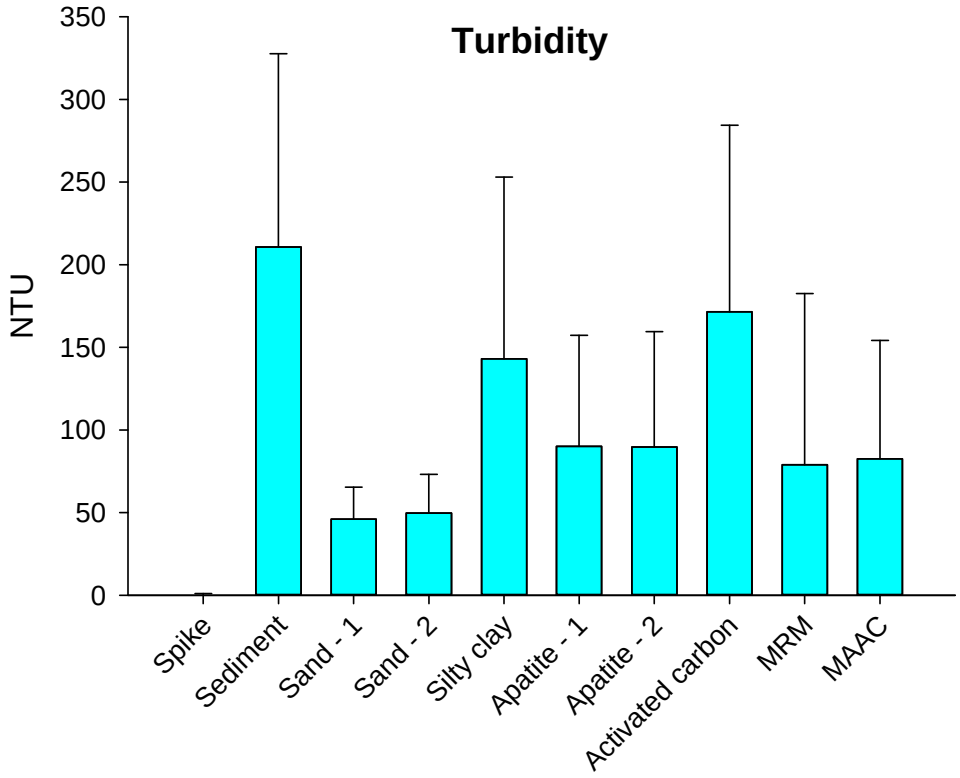



**Figure 5. Average surface water turbidity for each treatment; error bars are standard deviations.**

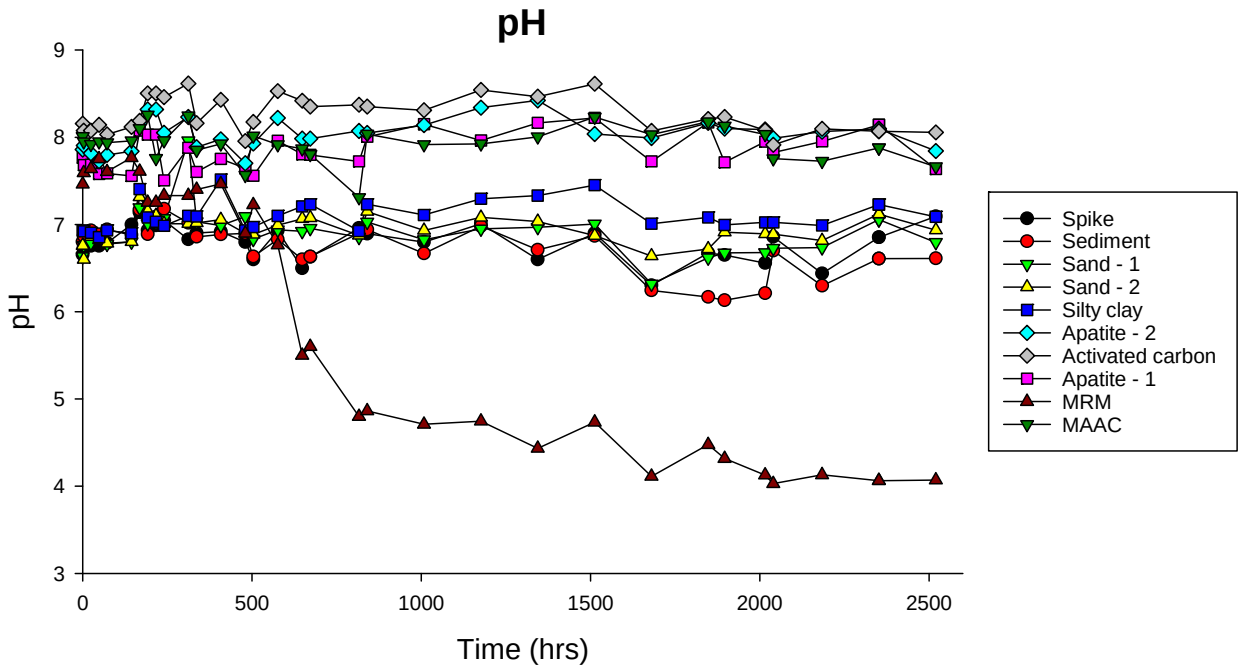



**Figure 6. Temporal changes in surface water pH for each treatment. Each value is an average of three samples.**

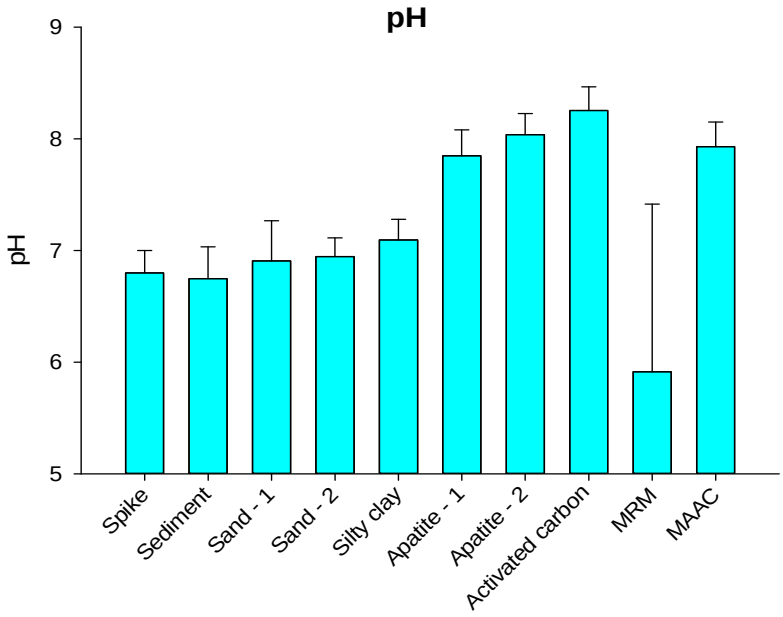



**Figure 7. Average surface water pH for each treatment; error bars are standard deviations.**

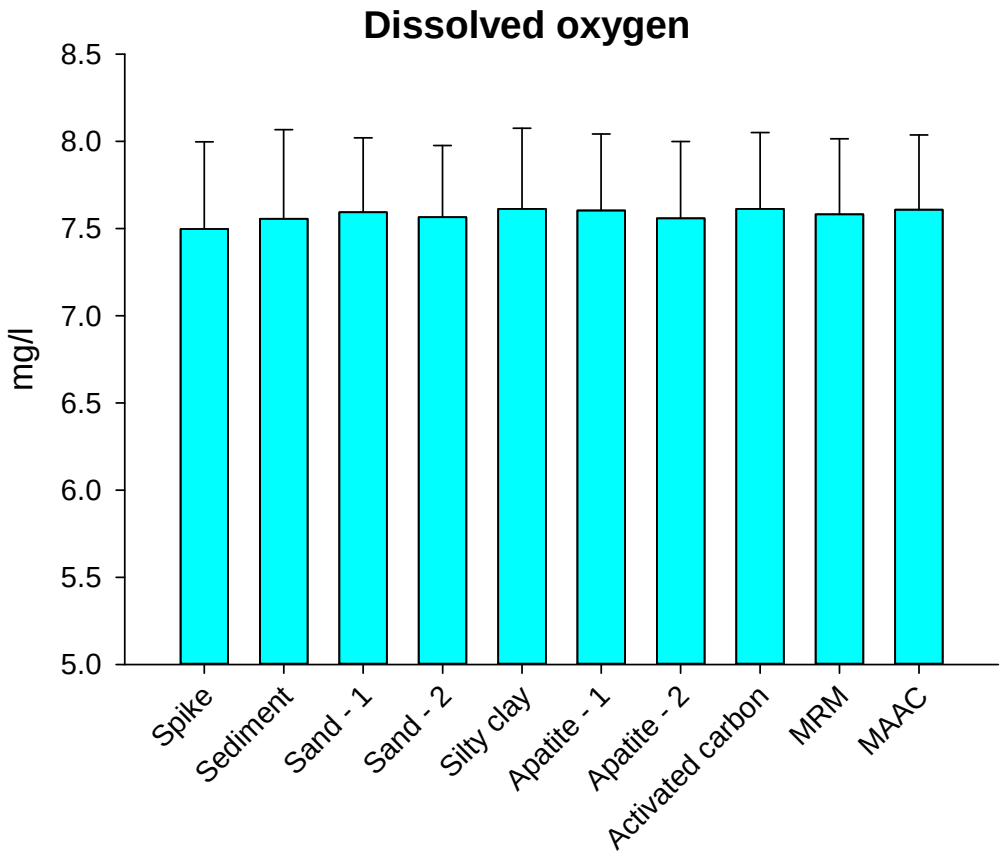



**Figure 8. Average surface water dissolved oxygen for each treatment. Error bars are standard deviations.**

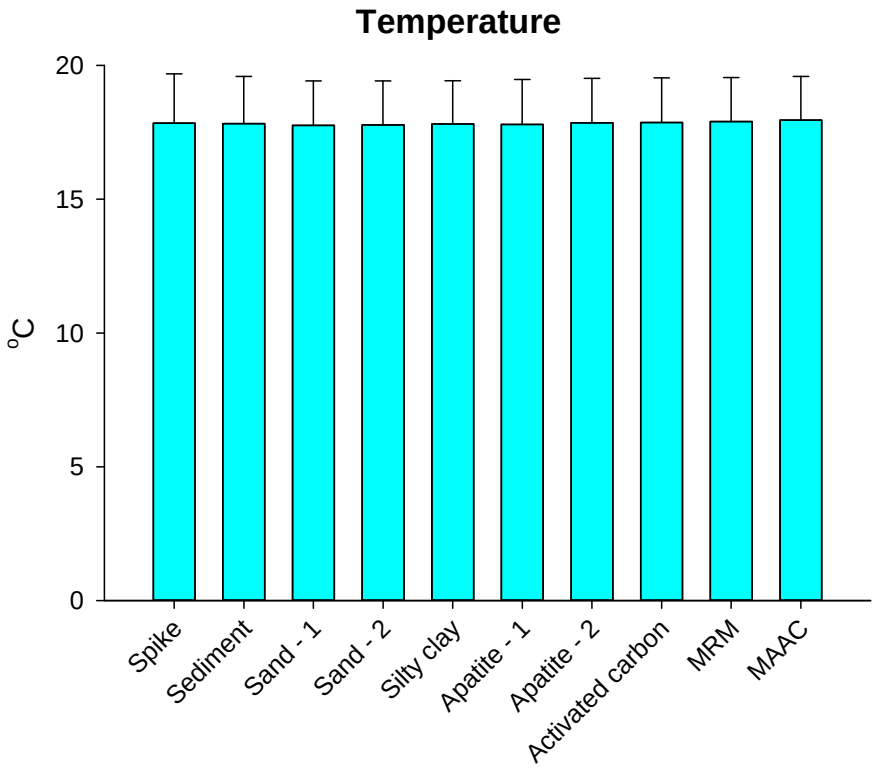



**Figure 9. Average surface water temperature for each treatment; error bars are standard deviations.**

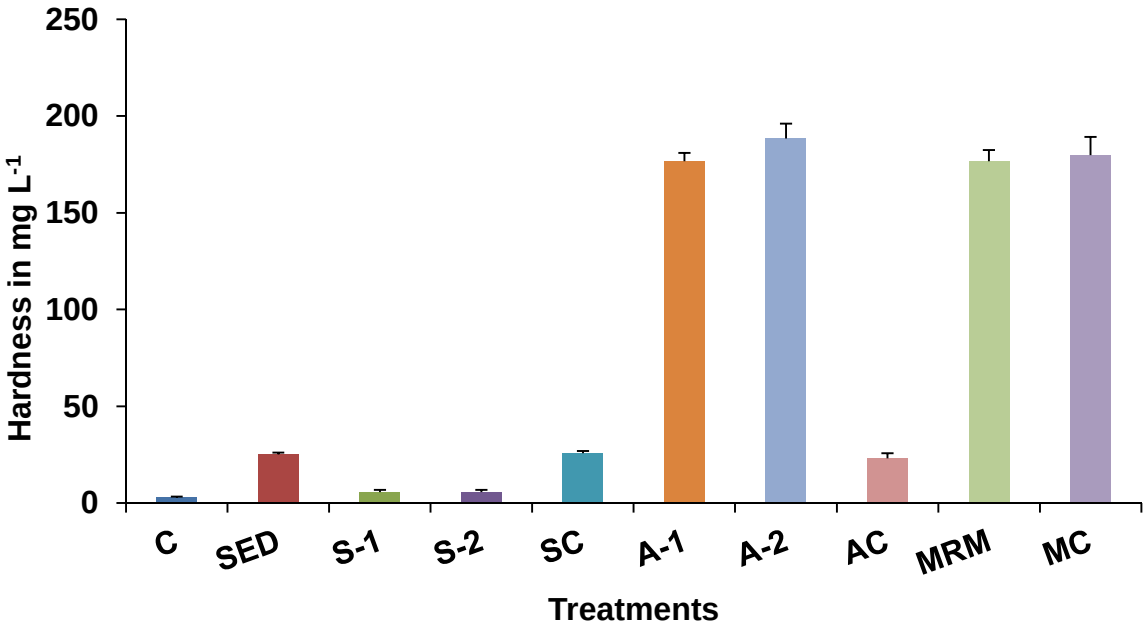



**Figure 10. Hardness of surface water (mg $L^{-1}$) for each treatment at 2520 h; spike solution only (C), uncapped sediment (SED), sediment with passive sand caps (S-1: 2.5 cm, S-2: 5 cm), and sediment with several types of active caps (SC: 2.5 cm silty clay, A-1: 2.5, A-2: 5.0 cm apatite, AC: activated carbon treatment, MRM: 2.5 cm organoclay, and MC: 2.5 cm mixture of active amendments).**

#### 4.1.1.3 *Effect of ongoing contaminant influx on metal concentrations in surface water*

The concentration of each metal in the spike solution was about 0.5 mg $L^{-1}$ as indicated by ICP-MS. Maintaining these concentrations required keeping the pH of the spike below 7.0 to prevent metals from precipitating. The effects of the treatments on metal concentrations in surface water are shown in Figures 11 – 15 and Tables A1.33 – A1.49 (Appendix 1). Electrons neutralize protons (i.e., $H^+$) in many naturally-occurring reactions (Dragun, 1998), so the fixation of elements in sediment and cap materials was dependent upon Eh and pH. Because the Eh of the water column was stable for all treatments and above 0.0, dissolved and particulate metal concentrations in the water column were mostly dependent on pH. Other factors that likely affected the chemisorption of metals in this experiment included electronegativity, electrostatic forces between metal ions and sediment/cap material surfaces, surface complexation reactions, charge-to-radius ratios, and hydrolysis constants (McBride, 1994; Shi et al., 2009).

At 2520 h, the average dissolved arsenic concentration in the mesocosms with active caps was about 70 µg $L^{-1}$ compared with 250 µg $L^{-1}$ in the control mesocosms (spike solution only) and 114 µg $L^{-1}$ in the mesocosms with passive caps (Figure 11 and Appendix 1; Tables A1.33 - A1.49). Dissolved As concentrations in mesocosms with sequestering agents (especially mixed amendment cap and apatite caps) were lower than in mesocosms with passive caps and control mesocosms (Figure 11). Arsenic concentrations were about 50% lower in the control treatment than in the spike solution, likely due to As precipitation as $As_2O_3$. Dragun (1998) reported that particle bound As predominates under Ehs above 0.0 and at pH 7.

Dissolved Cd increased over time in all treatments, but the increases were much greater in the control mesocosms and mesocosms with passive caps (Figure 12 and Appendix 1; Tables A1.33-A1.49). At 2520 h, average Cd concentrations in surface water were less than 100 µg $L^{-1}$ in the mesocosms with active caps (except MRM) compared with more than 300 µg $L^{-1}$in the mesocosms with passive caps and 500 µg $L^{-1}$ in the control mesocosms (Figures 11 and 12). Total Cd concentrations were relatively high in the mesocoms with MRM caps due to low pH (Figure 7). Particle bound Cd was a small fraction of total Cd in all treatments (Figure 11). Cadmium is soluble over a wide range of pHs (Adriano, 2001), so Cd concentrations in the control treatment were similar to Cd concentrations in the spike solution (Figure 11). Also, the relatively low metal electronegativity of Cd (1.69) tended to reduce the specific adsorption of this ion resulting in a relatively high proportion of Cd being dissolved.

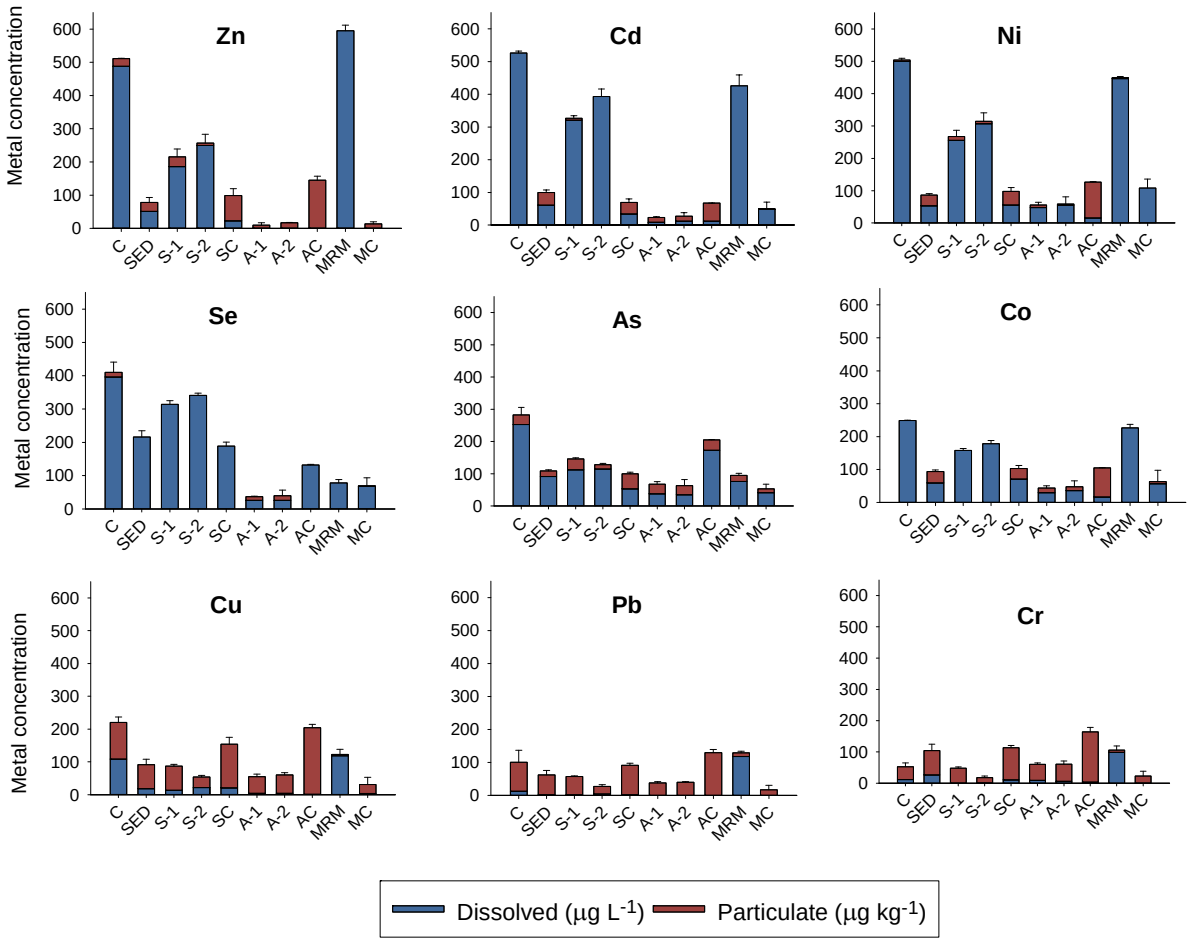



**Figure 11. Average surface water concentrations of metals in mesocosms with no sediment, spike solution only (C), uncapped sediment (SED), sediment with passive sand caps (S-1: 2.5 cm cap, S-2: 5 cm cap), and sediment with several types of active caps (SC: 2.5 cm silty clay cap, A-1: 2.5 cm apatite cap, A-2: 5.0 cm apatite cap, AC: activated carbon treatment, MRM: 2.5 cm organoclay cap, and MC: 2.5 cm mixed amendment cap) at 2520 h.**

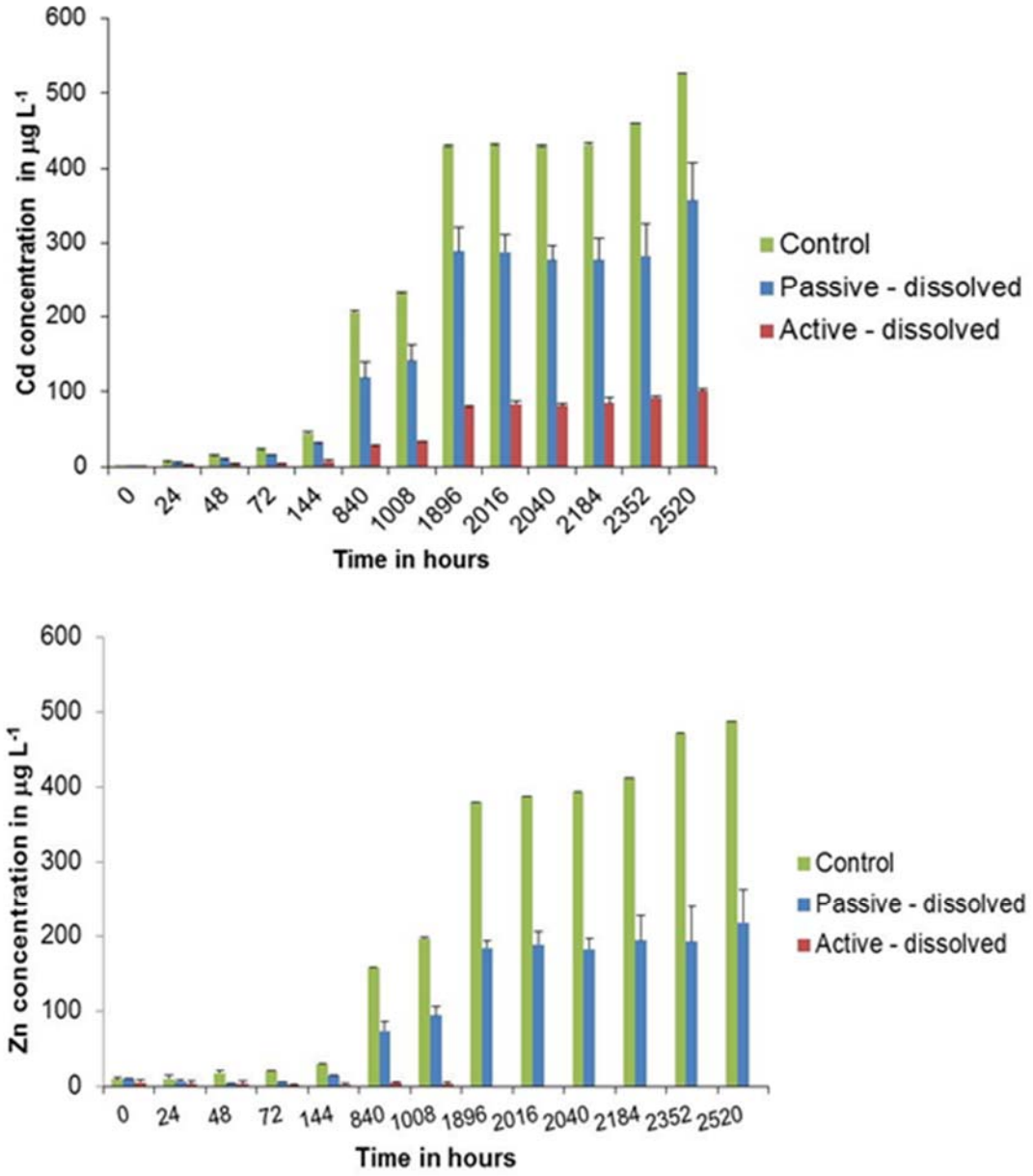



**Figure 12. Average surface water concentrations of dissolved Cd and Zn in mesocosms with passive caps (n=6 for 2.5 cm sand cap and 5.0 cm sand cap), active caps (n=12 for the 2.5 cm apatite cap, 5.0 cm apatite cap, activated carbon treatment, and 2.5 cm mixed amendment cap), and without caps or sediment (control) (n=2) over 2520 h.**

Dissolved Se in the control mesocosms was 400 µg $L^{-1}$ at 2520 h and was also relatively high in the treatments with passive sand caps (Figure 11). Levels were substantially lower in the mesocosms with active caps, especially apatite caps (under 50 µg $L^{-1}$). At 2520 h, most Se was dissolved in all treatments (Figure 11). Although relatively ineffective at removing divalent metals such as Zn, Cd, and Ni, MRM caps were about as effective as apatite caps at removing Se and As from the surface water. MRM is specifically designed for the removal of Hg and As rather than other elements (CETCO, 2012).

Like Cd, Zn is very mobile over a wide range of pHs (Adriano, 2001) and has relatively low electronegativity (1.65) (McBride, 1994); therefore, Zn concentrations in the control treatment were comparable to those in the spike solution. Average dissolved Zn increased over time in the control mesocosms and mesocosms with passive caps, reaching 500 μg $L^{-1}$ in the former and nearly 200 μg $L^{-1}$ in the latter (Figure 12). In contrast, average dissolved Zn concentrations remained under 10 μg $L^{-1}$ in most active cap treatments during the experiment (Figure 12). High dissolved Zn concentrations in the MRM treatment were likely the result of low pH (about 4.0; Figure 7) that facilitated metal dissolution. The lowest average total Zn concentrations were in mesocosms with apatite caps (A) and multiple amendment caps (MC). Most of the Zn in these mesocosms was particle-bound, and very little was in the more bioavailable dissolved phase (Figure 11). Ma et al. (1995) and Wright et al. (1995) have reported that the interaction between apatite and metals in solution is controlled by the precipitation of various phosphate phases, soption, and isomorphic substitution.

Average dissolved mercury concentrations in surface water were lower at 2520 h than at 144 or 1008 h (Figures 13 - 15 and Appendix 1; Tables A1.33 – A1.49). However, particulate-bound Hg increased with time, especially after 1008 hours, and was highest at the end of experiment. The Hg chemistry in this experiment was probably affected more by other elements, especially selenium (Dang and Wang 2011), than by the treatments. In support of this hypothesis, the treatments with higher Se concentrations in surface water also had the highest particulate-bound Hg (Figure 15 and Appendix 1; Tables A1.33 – A1.49). It is well known that Hg and Se interact strongly. Cuvin-Aralar and Furness (1991) showed that these interactions include the effects of selenium on mercury toxicity in organisms, "protective action" of selenium against mercury toxicity, and synergism between the two elements. Dang and Wang (2011) reported that selenium (Se) shows protective effects against mercury (Hg) bioaccumulation and toxicity, but the underlying effects of Se chemical speciation, concentration, and administration method are poorly known.

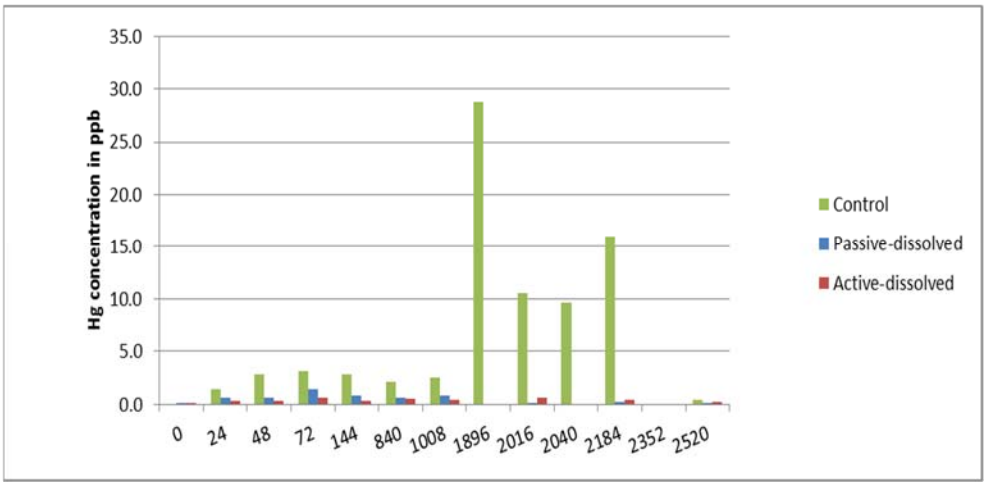



**Figure 13. Average surface water concentrations of dissolved mercury in mesocosms with passive caps, active caps, and without caps or sediment (control).**

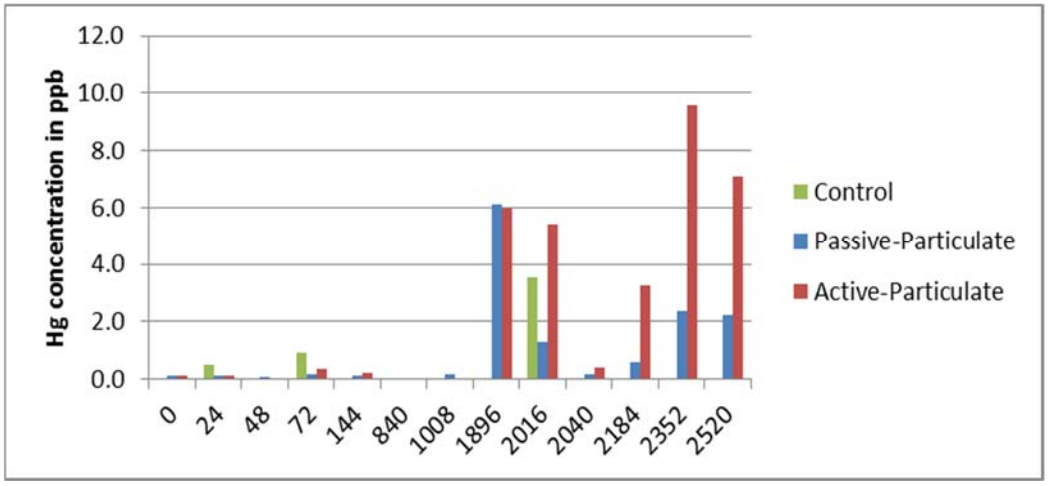



**Figure 14. Average surface water concentrations of particle-bound mercury in mesocosms with passive caps, active caps, and without caps or sediment (control).**

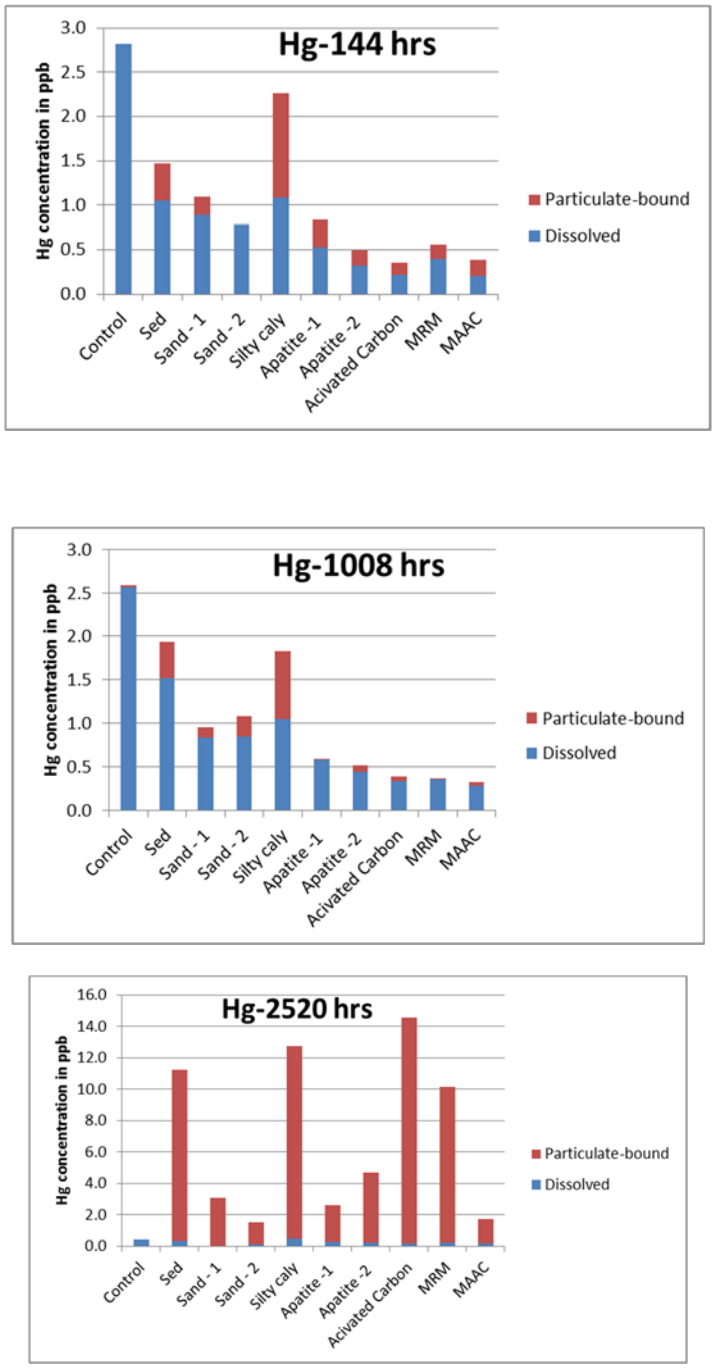



**Figure 15. Average surface water concentration of mercury in mesocosms with no sediment (Control), uncapped sediment (Sed), sediment with passive sand caps, and sediment with several types of active caps after 144, 1008, and 2520 h.**

Nickel behaved similarly to Cd, Co, Zn, and Se (Figure 11and Appendix 1; Tables A1.33-A1.48). However, Cr, Cu and Pb total concentrations in the control treatment were lower than concentrations in the spike solution (500 μg $L^{-1}$) suggesting the possibility of co-interference among these elements and solid phase partitioning through sorption and precipitation. This is consistent with other reports; e.g., Dragun (1998) reported that Pb is generally in particulate-bound forms such as $PbCO_3$ and PbO above Eh 0.0 and pH 4.

#### 4.1.1.4 *Toxicity and bioaccumulation*

Average percent survival of *Lumbriculus* for the 10-day test was 0% in the control mesocosms, 0% in the mesocosms with passive (sand) caps, 10% in the mesocosms with uncapped sediment, and 65-80% in the mesocosms with active caps suggesting that the latter can protect benthic organisms from ongoing contamination (Figure 16). High water hardness likely contributed to the relatively low mortality of test organisms in the treatments with apatite, organoclay, and MC (Figure 10). The acute toxicity of many elements (e.g., Cd, Cr, Cu, Ni, Pb, and Zn) depends on water hardness, with toxicity diminishing as hardness increases (U.S. EPA, 2016). In contrast, mortality was high in treatments with low hardness (e.g., sediment only or sand) (Figures 10 and 16). Therefore, evaluation of cap materials should be based not only on their ability to sequester metals but also on their indirect effects on water properties (e.g., hardness) that can influence metal bioavailability and toxicity.

Surviving *Lumbriculus* were analyzed for whole-body metal concentrations, which were compared with background concentrations measured in *Lumbriculus* received from the supplier. Background concentrations of Co, Cd, Cr, Ni, Pb, and Se were <2.0 mg $kg^{-1}$, similar to those reported by Piol et al. (2006) (Appendix 1; Table A1.50). Following 10 days of exposure, these metals increased to 20 - 150 mg $kg^{-1}$ in *Lumbriculus* from mesocosms with uncapped sediment but remained under 10 mg $kg^{-1}$ in *Lumbriculus* from most mesocosms with active caps (Figure 17, Appendix 1; Table A1.51). Differences between mesocosms with active caps and mesocosms with untreated sediment were statistically significant ($p<0.05$). Although all active caps were effective at reducing metal uptake, there were significant differences among cap types, with the most effective caps varying among metals (Figure 17). Differences in *Lumbriculus* tissue concentrations between active caps and untreated sediment were less prominent for As and Cu than for the previously discussed metals but were statistically significant except for Cu in the silty clay cap (Figure 17). The concentrations of most metals in *Lumbriculus* from the active cap treatments were higher than background concentrations, but these differences were not always statistically significant (Figure 17). Background levels of Zn in *Lumbriculus* (about 200 mg $kg^{-1}$) were higher than for the other metals. These levels were comparable to those in the mesocosms with active caps and significantly lower than in the mesocosms with uncapped sediment (about 700 mg $kg^{-1}$) (Figure 17). Kwon et al. (2010) reported that the sorbent material, Thiol-SAMMS, was able to reduce the uptake of Cd by *Lumbriculus* from beakers of contaminated sediment by up to 98%. These results are comparable to those in our mesocosms with apatite and mixed amendment caps (Figure 17) despite more challenging conditions of exposure involving the continuous influx of contamination via the overlying water column.

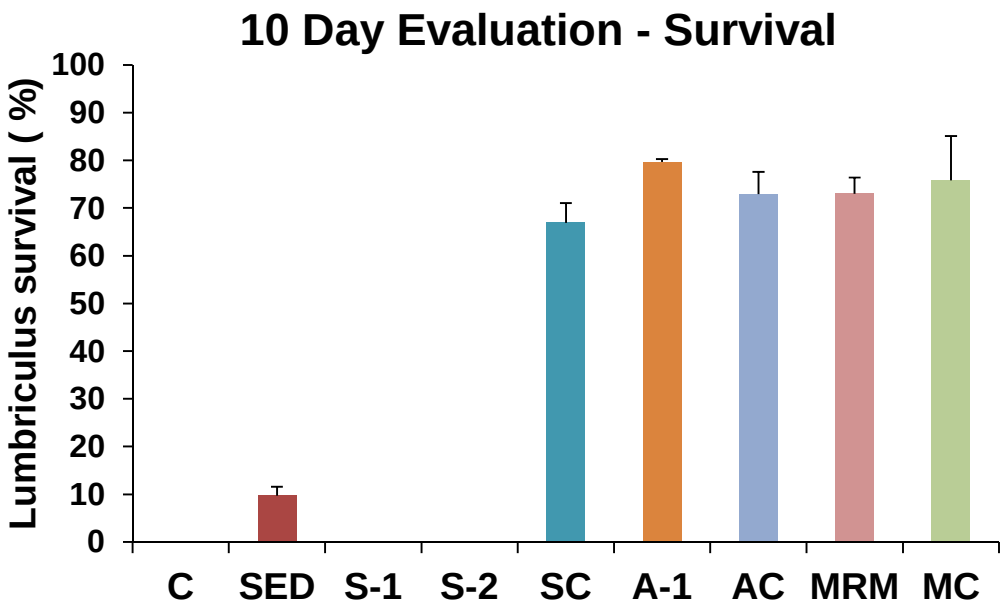



**Figure 16. Average survival of *Lumbriculus variegatus* after 10-day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals. Mesocosm treatments included spike solution only (C), uncapped sediment (SED), sediment with sand caps (S-1: 2.5 cm and S-2: 5 cm), and sediment with active caps (SC: 2.5 cm silty clay, A-1: 2.5 cm apatite, AC: activated carbon, MRM: 2.5 cm organoclay, and MC: 2.5 cm mixture of active amendments). Error bars are standard deviations (n=3).**

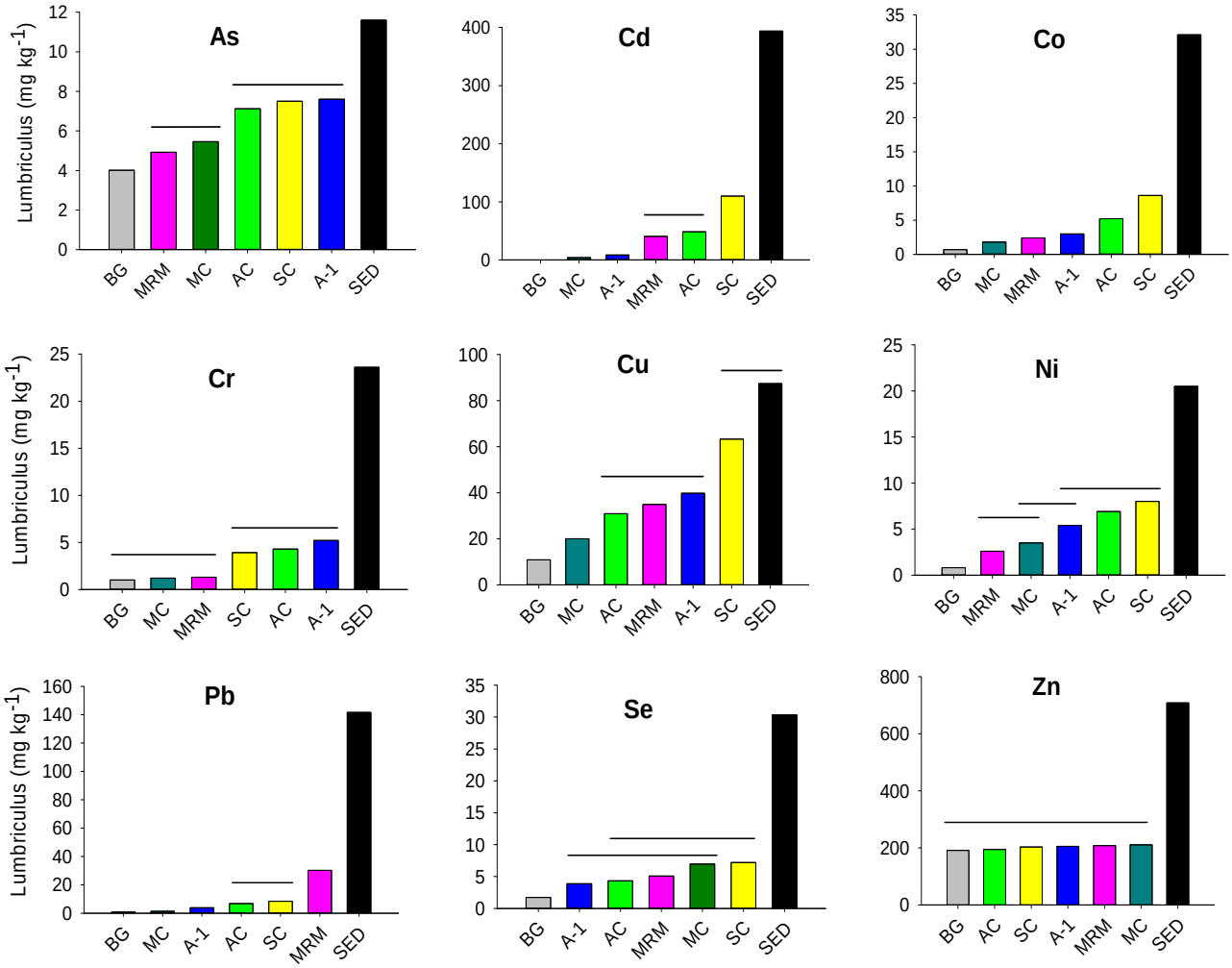



**Figure 17. Analysis of variance of differences in *Lumbriculus variegatus* metal concentrations (whole body, 10-day exposure) among sediment treatments (BG =background, AC: activated carbon, SC: silty clay cap, A: apatite cap (2.5 cm thick), MRM: organoclay MRM cap, MC: mixture of active amendments, SED: untreated sediment). Geometric means connected by the same line are not significantly different at $p<0.05$.**

The ten day exposure test conducted with caged Asian clams indicated that average mortality was 100% in mesocosms with spike solution only, over 50% in mesocosms with passive sand caps, and about 10% in mesocosms with uncapped sediment (Figure 18; Appendix A1; Table A1.52). In contrast, no mortality occurred in the mesocosms with apatite, activated carbon, and multiple amendment active caps. Mortality in mesocosms with MRM active caps averaged nearly 30%. Superior survival in the mesocosms with apatite, activated carbon, and multiple amendment active caps was likely due to lower levels of bioavailable metals in sediments and surface water as indicated by results from the DGT water and sediment probes

Metal concentrations were measured in clam tissues (whole body excluding shell) at the conclusion of the 10 day toxicity test. Concentrations were not measured in the control or sand cap treatments because all or most of clams died before 10 days in these treatments. Most metals in the remaining treatments were present at higher concentrations in clam tissues at the conclusion of the experiment than at the beginning (as represented by background concentrations in clams) regardless of treatment (Table 10; Appendix 1; Table A1.53). Concentrations of Co and Ni were higher in clams from the sediment and silty-clay treatments than in clams from treatments with active caps, but other metals did not exhibit consistent differences among treatments. This occurred despite the fact that survival was higher in clams from active cap treatments and bioavailable metal species were present at lower concentrations in these treatments (Figure 18). It is possible that survival in the presence of acutely toxic metal concentrations was governed by processes that differed from those that determined metal uptake.

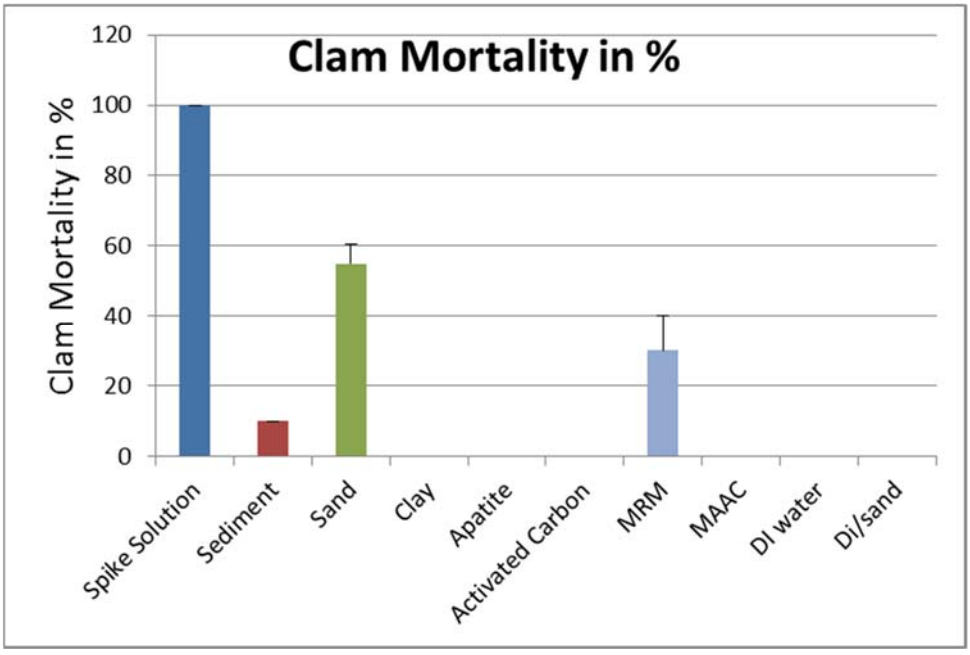



**Figure 18. Average mortality of Asian clams after 10-day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals. Mesocosm treatments included spike solution only, uncapped sediment, sediment with passive caps (sand), and sediment with active caps [clay; apatite; activated carbon; organoclay (MRM); and a mixture of activated carbon, apatite, and MRM (MAAC)]. Error bars are standard deviations.**

**Table 10. Average metal concentrations in Asian clams (soft tissues) after 10-day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals. Mesocosm treatments included spike solution only, uncapped sediment, sediment with passive caps (sand), and sediment with active caps [clay; apatite; activated carbon (AC); organoclay (MRM); and a mixture of activated carbon, apatite, and MRM (MAAC)]. BG represents background concentrations; i.e., concentrations measured in Asian clams before testing.**

| Treatments | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Pb |
|---|---|---|---|---|---|---|---|---|---|
| | AVG (mg $kg^{-1}$) | | | | | | | | |
| Sed | 15.6 | 15.5 | 20.5 | 17.4 | 130.4 | 5.1 | 4.3 | 57.5 | 4.6 |
| Silty Clay | 5.1 | 13.2 | 15.8 | 22.2 | 131.2 | 5.7 | 3.4 | 30.1 | 7.2 |
| Apatite | 8.1 | 3.6 | 5.6 | 33.8 | 101.4 | 4.4 | 3.0 | 21.5 | 3.6 |
| AC | 4.6 | 4.5 | 7.5 | 23.0 | 101.1 | 3.8 | 3.1 | 40.7 | 4.0 |
| MRM | 15.9 | 1.7 | 7.7 | 55.5 | 119.7 | 5.2 | 5.4 | 25.0 | 10.9 |
| MAAC | 6.7 | 3.9 | 2.4 | 17.5 | 107.7 | 5.2 | 2.0 | 13.0 | 8.9 |
| BG | 1.0 | 0.4 | 0.6 | 9.2 | 126.8 | 3.2 | 1.9 | 1.1 | 0.4 |
| | STDEV (mg $kg^{-1}$) | | | | | | | | |
| Sed | 1.0 | 0.8 | 1.6 | 1.0 | 5.2 | 0.4 | 0.2 | 4.0 | 0.2 |
| Silty Clay | 0.3 | 2.0 | 3.7 | 4.2 | 5.8 | 0.8 | 0.4 | 0.7 | 0.7 |
| Apatite | 1.4 | 0.5 | 0.2 | 3.2 | 3.1 | 0.2 | 0.5 | 2.4 | 0.8 |
| AC | 0.3 | 0.1 | 1.0 | 2.9 | 3.0 | 0.2 | 0.3 | 7.2 | 0.4 |
| MRM | 1.0 | 0.3 | 2.1 | 1.4 | 8.5 | 0.3 | 1.0 | 1.1 | 0.9 |
| MAAC | 1.3 | 1.0 | 0.2 | 1.9 | 5.3 | 0.3 | 0.1 | 1.4 | 1.1 |
| BG | 0.0 | 0.1 | 0.4 | 0.9 | 6.5 | 0.3 | 0.5 | 0.3 | 0.0 |

#### 4.1.1.5 *Assessment of cap effectiveness by diffusive gradients in thin films (DGT) probes*

DGT water and sediment gel probe samplers were used to determine the effects of the cap materials on the bioavailable pools of metals in the experimental mesocosms. The following discussion will be limited to Cd, Co, Cu, Ni, Pb, and Zn because only these elements can be properly measured by DGT water and sediment probes employing a chelex 100 binding resin (Figure 19 and 20; Appendix 1; Tables A1.54-A1.60).

Results from the water DGT probes showed that aqueous concentrations of dissolved and labile Cd, Cu, Co, Ni, and Pb were clearly lower in the apatite, activated carbon, and MAAC treatments than in the control and passive sand cap treatments, with the apatite treatments performing especially well (Table 11 and Appendix 1; Table A1.54). With the exception of Co, dissolved and labile metal concentrations were higher in the MRM treatments than in the apatite and mixed amendment cap (MC or MAAC) treatments, and in some cases (Ni and Pb) approached levels in the control mesocosms. Metal concentrations in the silty clay treatments were relatively low and approached levels observed in the apatite treatments. In summary, the DGT data showed that potentially bioavailable dissolved and labile concentrations of most metals were clearly lower in the surface water of mesocosms with apatite, activated carbon, and mixed amendment active caps than in mesocosms with passive sand caps or spike solution.

**Table 11. Average metal concentrations (µg $L^{-1}$) measured by water DGT probes ($C_{DGT}$).**

| Treatments | As | Cd | Co | Cr | Cu | Ni | Pb | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|
| | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | | | AVG | | | | |
| Spike | 10.2 | 1208.0 | 670.3 | 26.6 | 336.4 | 1052.3 | 193.9 | 5.8 | 1223.5 |
| Sediment | 2.6 | 133.2 | 133.8 | 3.7 | 46.7 | 124.9 | 12.7 | 1.1 | 809.1 |
| Sand - 1 | 3.2 | 789.1 | 444.1 | 2.3 | 66.9 | 789.7 | 48.9 | 1.8 | 639.6 |
| Sand - 2 | 3.1 | 878.0 | 466.0 | 3.0 | 86.8 | 866.3 | 49.8 | 2.9 | 701.5 |
| Silty Clay | 1.8 | 86.0 | 174.9 | 0.8 | 29.2 | 134.3 | 9.2 | 2.3 | 245.2 |
| Apatite -1 | 1.5 | 19.6 | 53.0 | 0.9 | 14.6 | 73.0 | 5.4 | 0.7 | 34.3 |
| Apatite -2 | 1.3 | 35.0 | 89.8 | 0.3 | 11.1 | 110.5 | 6.9 | 0.2 | 39.4 |
| Acivated Carbon | 2.6 | 41.6 | 48.0 | 0.9 | 12.8 | 52.3 | 2.6 | 1.5 | 376.1 |
| MRM | 17.7 | 362.2 | 214.3 | 44.7 | 135.8 | 709.6 | 179.9 | 6.9 | 898.9 |
| MAAC | 1.1 | 38.5 | 98.6 | 0.1 | 8.9 | 168.1 | 11.0 | 0.4 | 426.8 |
| | | | | | STDEV | | | | |
| Spike | 0.8 | 205.1 | 144.9 | 2.2 | 20.2 | 142.5 | 32.8 | 0.8 | 229.8 |
| Sediment | 0.6 | 38.9 | 39.2 | 0.6 | 27.4 | 38.7 | 6.6 | 1.0 | 634.8 |
| Sand - 1 | 0.8 | 104.8 | 71.8 | 1.0 | 20.3 | 178.2 | 15.2 | 1.8 | 118.1 |
| Sand - 2 | 0.2 | 163.4 | 79.0 | 1.1 | 23.8 | 196.4 | 18.9 | 1.9 | 139.6 |
| Silty Clay | 0.2 | 7.4 | 13.7 | 0.1 | 3.1 | 12.5 | 1.6 | 0.9 | 127.1 |
| Apatite -1 | 0.3 | 2.6 | 3.8 | 0.8 | 2.0 | 3.2 | 1.2 | 0.5 | 16.0 |
| Apatite -2 | 0.1 | 5.2 | 17.1 | 0.1 | 1.3 | 21.1 | 1.3 | 0.3 | 12.5 |
| Acivated Carbon | 0.3 | 9.0 | 8.9 | 0.4 | 2.3 | 12.0 | 0.3 | 1.3 | 521.9 |
| MRM | 4.5 | 106.0 | 24.9 | 7.4 | 32.6 | 147.5 | 34.4 | 2.7 | 299.5 |
| MAAC | 0.1 | 5.1 | 51.0 | 0.1 | 1.8 | 32.5 | 1.1 | 0.5 | 642.0 |

DGT sediment probes were used to measure concentrations of dissolved and labile metals in the sediments of the experimental mesocosms. The probes were inserted vertically and sectioned upon retrieval to measure metal levels at different sediment depths including cap, surface, middle, and lower layers. The results showed that metal concentrations in the apatite and mixed amendment cap layers and in the upper layer of sediment treated with activated carbon were very low compared with metal concentrations in the passive sand and silty clay cap layers and much lower than in the surface layer of sediment in the mesocosms without caps (Figures 19 and 20). Lower sediment metal levels in apatite, activated carbon, and mixed amendment cap treatments persisted deeper within the sediment profile, especially compared with uncapped sediment, which exhibited relatively high metals levels to a depth of 5.0 cm (examples are shown for Cd and Co, Figure 19). Metal levels, especially levels of Ni, in treatments with MRM caps were higher than in the treatments with other active caps (Figure 20), probably because of low sediment pH (Figure 21). At 2520 h the highest pH values were in mesocosms with apatite and mixed amendment caps followed by mesocosms with activated carbon (Figure 21). Mesocosms with organoclay MRM caps had the lowest pH values in the cap and the sediment below the cap (Figure 21).

The preceding results show that the potentially bioavailable pool of metals was lower in the apatite and mixed amendment caps, in the sediments with activated carbon, and in the sediment layers underlying these treatments than in uncapped sediments or passive caps. Pearson correlations between metal concentrations in *Lumbriculus* and metal concentrations in the top 2.5 cm of sediment or cap materials (measured by DGT sediment probes) were generally strong (as high as 0.98) and significant ($p<0.05$) for all metals except zinc (Figure 20). These relationships suggest that metal concentrations in *Lumbriculus* were the result of uptake from the surrounding sediment or cap and possibly the overlying water. Low metal concentrations in *Lumbriculus* from the apatite, mixed amendment, and activated carbon treatments may have resulted from metal sequestration by these amendments (Figure 17). Previous reports by Knox et al. (2012), Ghosh et al (2011), and Ma et al. (1995) indicate that active amendments (e.g., apatite and activated carbon) can reduce the bioavailable pool of contaminants in sediments. Dissolved metals that precipitate on the sediment/cap surface or that are immobilized more deeply in the sediment profile are generally biologically unavailable unless the re-enter the dissolved phase, which facilitates transport through respiratory membranes (Campbell, 1995; McGreer et al., 2002). An exception is metals that are ingested by sediment feeding organism, which may be released by interactions with digestive fluids and again become available for biological uptake within the organism (Fan and Wang, 2001).

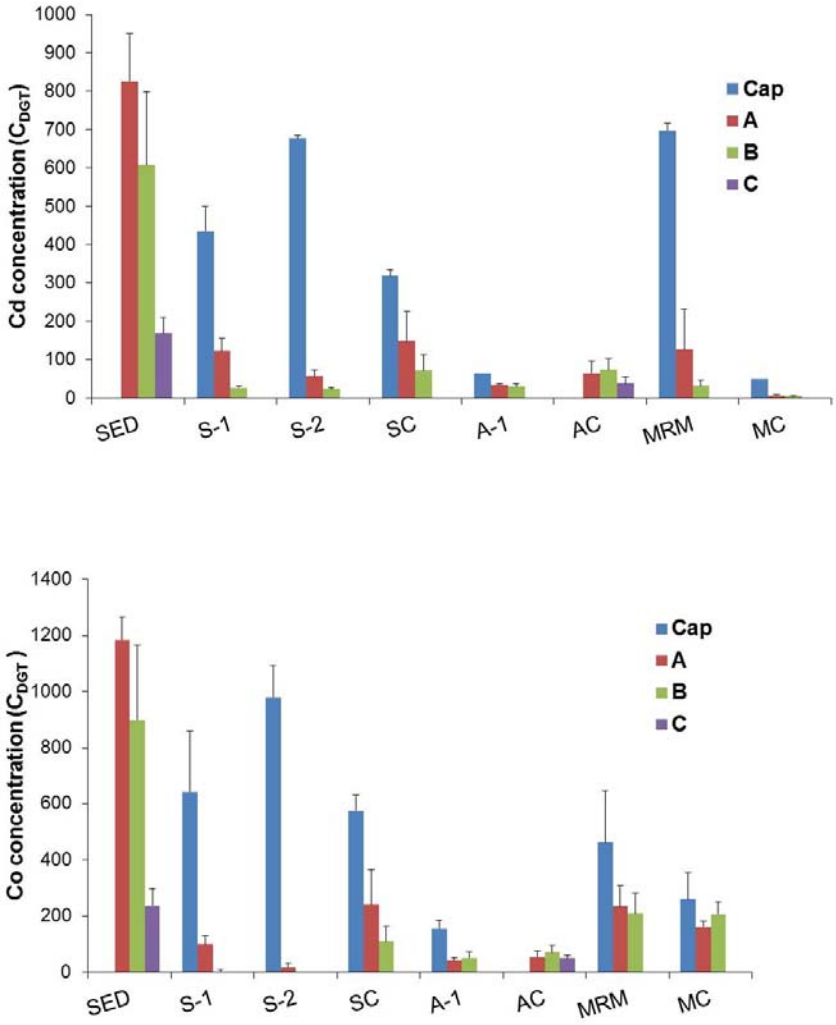



**Figure 19. Cadmium (Cd) and cobalt (Co) concentrations (μg $kg^{-1}$) measured by sediment DGT probes ($C_{DGT}$) in cap materials and layers of sediment beneath the cap (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm). Treatments: uncapped sediment (SED), sediment with passive sand caps (S – 1: 2.5 cm thick cap and S – 2: 5 cm thick cap) and sediment with several types of active caps (2.5 cm thick) (apatite A-1; silty clay - SC; activated carbon, no cap - AC; organoclay – MRM; and mixture of active amendments (MC) at 2040 h.**

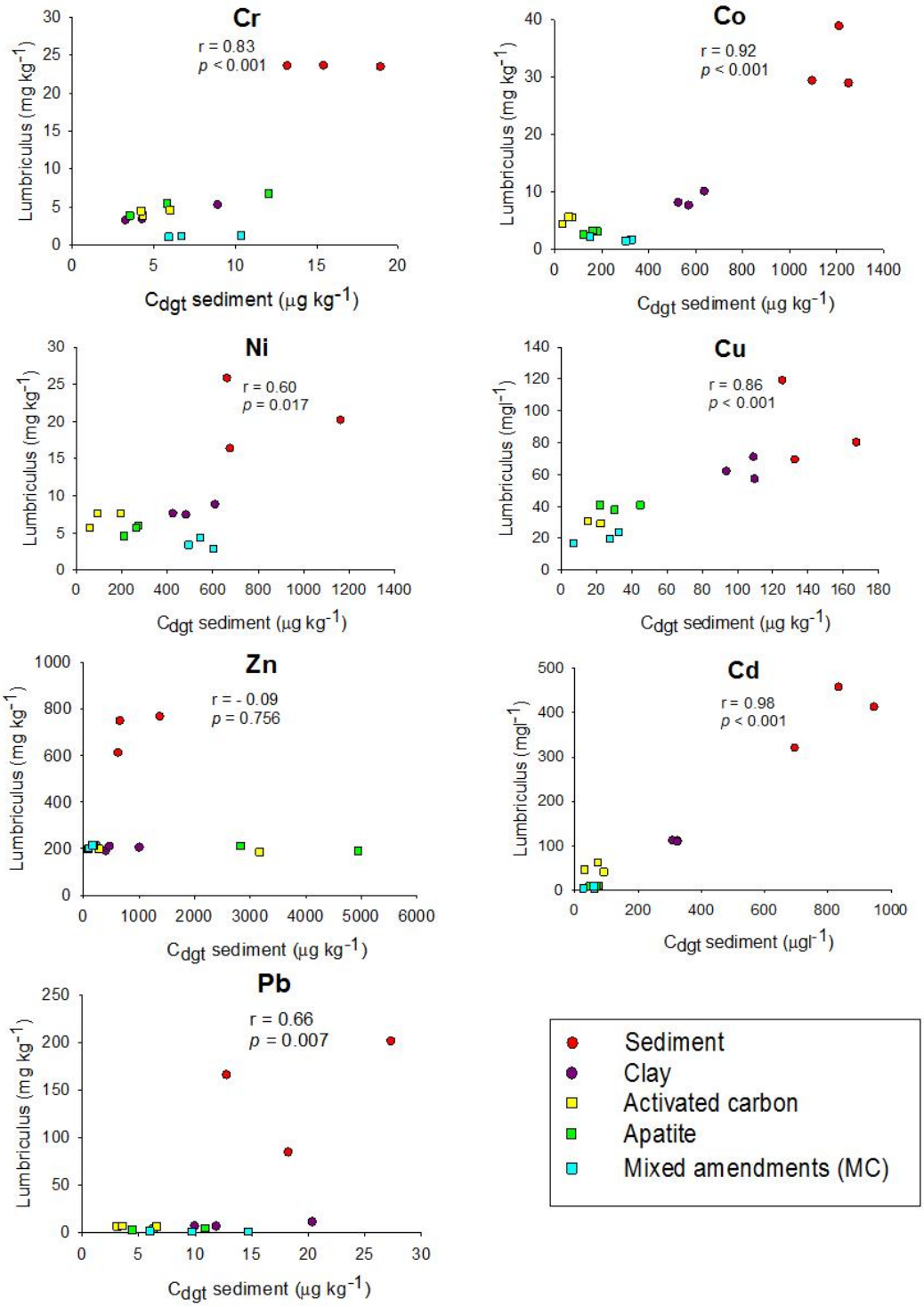



**Figure 20. Pearson correlations between metal concentrations in *Lumbriculus variegatus* (whole body, 10-day exposure) and metal concentrations in sediment measured by sediment DGT probes.**

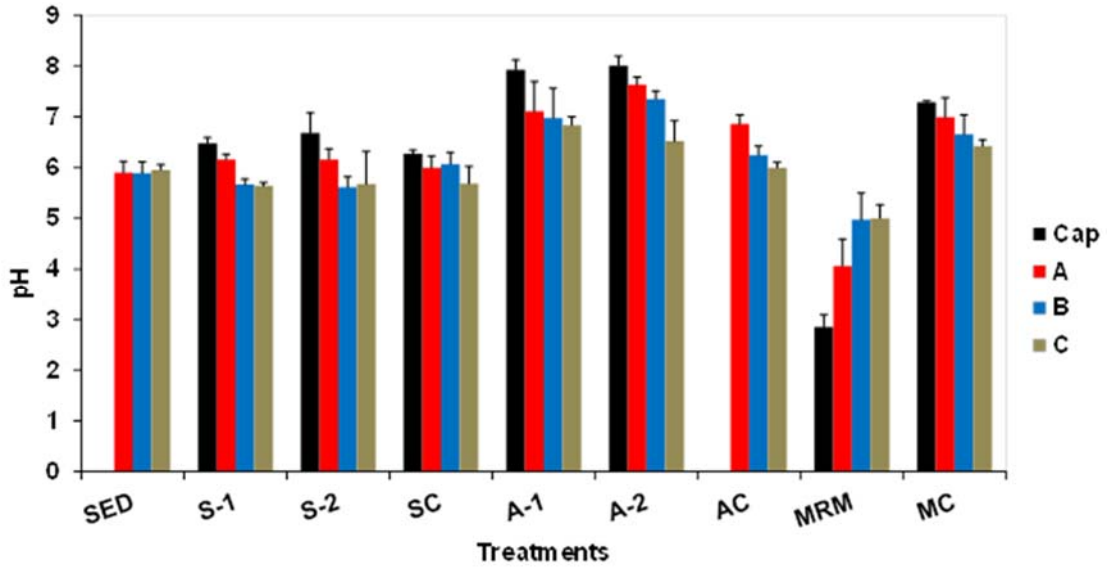



**Figure 21. Average pH values (n = 3) in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm) at 2520 hours; uncapped sediment (SED), sediment with passive sand caps (S-1: 2.5 cm, S-2: 5 cm), and sediment with several types of active caps (SC: 2.5 cm silty clay, A-1: 2.5 cm apatite, A-2: 5.0 cm apatite, AC: activated carbon treatment, MRM: 2.5 cm organoclay, and MC: 2.5 cm mixture of active amendments).**

#### 4.1.1.6 *Conclusions*

We hypothesized that some sequestering agents in active caps will bind metals from ongoing sources thereby reducing their bioavailability and protecting underlying remediated sediments from recontamination. In contrast, metals from ongoing sources will contaminate passive caps and uncapped sediment. Our results support this hypothesis:

1. The concentrations of most metals in the surface waters of mesocosms with apatite caps, mixed amendment caps, and activated carbon treatments were significantly lower than in mesocosms with passive caps (sand) and uncapped sediment.
2. Survival was significantly higher for *Lumbriculus variegatus* in mesoscosms with active caps than in mesocosms with passive caps or uncapped sediment, and whole-body concentrations of most metals were lower in *Lumbriculus variegatus* in mesoscosms with active caps.
3. Organoclay MRM was not effective at removing metals from surface waters with the exception of As and Se. However, toxicity and biouptake were lower in this treatment than in the uncapped sediment or sand cap treatments very likely due to increased water hardness associated with MRM.
4. Sediment DGT probes showed that ongoing contamination increased the bioavailable pool of metals in the top layer of uncapped sediment but not in sediment capped or treated with active amendments.

The remediation of contaminated sediments is a very expensive process that can be negated by the continued influx of contaminants from uncontrolled sources. However, our results indicate

that some types of active amendments have the potential to protect remediated sediments by reducing the bioavailable pool of metals emanating from ongoing sources of contamination.

### 4.1.2 SUBTAST 1.2 LOW LEVEL METALS AND ELEMENT INTERACTIONS

#### *4.1.2.1 Pore water properties and metal concentrations*

Pore water properties are summarized in Tables 12 - 14. The addition of cap materials influenced pore water chemistry, especially EC and ORP (Tables 12 - 14). As was expected, the highest EC values in pore water were observed in treatments with multiple amendment caps (MC) because the caps contained organoclay (Tables 12 - 14). The EC in pore water beneath the MC caps decreased from about 4000 μS $cm^{-1}$ (0 hours) to 1700 μS $cm^{-1}$ by the end of experiment (2880 h) (Tables 12 - 14).

The caps contributed to changes in the ORP of pore water in sediment under the caps as indicated by three sets of samples (Tables 12 - 14). Generally, ORP values beneath the caps were lower than in the control treatments or in situ treatment with activated carbon (Tables 12 - 14).

Pore water metal concentrations differed slightly among treatments with the lowest concentrations for most elements in the mesocosms with apatite (A) and MC caps (Tables 15 – 17; Appendix 1; Tables A1.61-A1.63). Metal concentrations in pore water collected at 1536 and 2880 h were not significantly different than concentrations in pore water collected at time zero for most treatments (Tables 15 - 17), especially for treatments with apatite and MC caps. However, for sand caps, metal concentrations in pore water were notably higher at 1536 and 2880 h than at time zero, especially for Cu, Cd, and Pb (Tables 15 – 17).

**Table 12. Average (AVG) and standard deviation (STDEV) of pore water quality parameters in Experiment I and II. Samples were collected on 2/1/2017 before addition of spike solutions. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).**

| | Temp °C | DO mg/L | Cond µS/cm | pH | ORP |
|---|---|---|---|---|---|
| | | | AVG | | |
| SED-MS | 19.9 | 2.9 | 78.2 | 5.3 | 41.7 |
| SC-MS | 20.0 | 2.5 | 77.8 | 5.3 | -13.5 |
| A-MS | 20.1 | 2.6 | 1808.3 | 4.9 | -12.3 |
| AC-MS | 20.0 | 2.7 | 282.8 | 5.9 | 40.7 |
| MC-MS | 20.2 | 2.5 | 4154.3 | 4.9 | -20.0 |
| SED-CuS | 20.0 | 2.5 | 79.4 | 5.2 | 36.7 |
| MC-CuS | 20.2 | 2.1 | 3947.0 | 4.9 | -27.0 |
| | | | STDEV | | |
| SED-MS | 0.1 | 0.2 | 0.7 | 0.0 | 5.8 |
| SC-MS | 0.1 | 0.1 | 1.0 | 0.0 | 2.1 |
| A-MS | 0.1 | 0.1 | 164.5 | 0.0 | 2.5 |
| AC-MS | 0.1 | 0.1 | 11.4 | 0.0 | 2.1 |
| MC-MS | 0.1 | 0.0 | 266.7 | 0.0 | 5.0 |
| SED-CuS | 0.1 | 0.1 | 8.3 | 0.0 | 4.2 |
| MC-CuS | 0.0 | 0.0 | 547.3 | 0.0 | 1.4 |

**Table 13. Average (AVG) and standard deviation (STDEV) of pore water quality parameters in Experiment I and II. Samples were collected on 4/11/2017 at 1536 h. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).**

| | Temp °C | DO mg/L | Cond µS/cm | pH | ORP |
|---|---|---|---|---|---|
| | | | AVG | | |
| SED-MS | 21.5 | 3.0 | 93.4 | 5.3 | 50.3 |
| SC-MS | 21.5 | 3.1 | 80.3 | 5.6 | -19.0 |
| A-MS | 21.5 | 2.8 | 900.7 | 5.0 | -13.3 |
| AC-MS | 21.6 | 3.0 | 168.0 | 6.8 | 48.5 |
| MC-MS | 21.4 | 2.8 | 1760.0 | 5.0 | -22.0 |
| SED-CuS | 21.4 | 3.3 | 86.0 | 5.0 | 36.0 |
| MC-CuS | 21.5 | 2.7 | 1695.0 | 5.0 | -19.0 |
| | | | STDEV | | |
| SED-MS | 0.0 | 0.2 | 4.9 | 0.1 | 4.7 |
| SC-MS | 0.1 | 0.2 | 0.7 | 0.1 | 1.4 |
| A-MS | 0.1 | 0.2 | 46.9 | 0.6 | 8.3 |
| AC-MS | 0.1 | 0.2 | 2.8 | 0.0 | 4.9 |
| MC-MS | 0.1 | 0.1 | 504.4 | 0.1 | 3.6 |
| SED-CuS | 0.0 | 0.1 | 6.0 | 0.1 | 5.7 |
| MC-CuS | 0.1 | 0.1 | 2.8 | 0.1 | 1.4 |

**Table 14. Average (AVG) and standard deviation (STDEV) of pore water quality parameters in Experiment I and II. Samples were collected on 6/6/2017 at 2880 h. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).**

| | Temp °C | DO mg/L | Cond µS/cm | pH | ORP |
|---|---|---|---|---|---|
| | | | AVG | | |
| SED-MS | 21.0 | 3.2 | 85.0 | 5.7 | 31.0 |
| SC-MS | 21.0 | 3.6 | 93.0 | 5.8 | -25.5 |
| A-MS | 21.0 | 3.0 | 723.3 | 5.4 | -21.7 |
| AC-MS | 21.0 | 2.7 | 162.5 | 6.2 | 63.5 |
| MC-MS | 21.0 | 2.9 | 1778.3 | 5.7 | -24.7 |
| SED-CuS | 21.0 | 3.4 | 102.0 | 5.1 | 43.5 |
| MC-CuS | 20.9 | 2.8 | 1639.0 | 5.7 | -15.5 |
| | | | STDEV | | |
| SED-MS | 0.0 | 0.4 | 8.7 | 0.3 | 4.4 |
| SC-MS | 0.0 | 0.2 | 2.8 | 0.2 | 0.7 |
| A-MS | 0.0 | 0.6 | 35.1 | 0.7 | 7.6 |
| AC-MS | 0.0 | 0.1 | 3.5 | 0.2 | 2.1 |
| MC-MS | 0.0 | 0.0 | 95.1 | 0.1 | 4.9 |
| SED-CuS | 0.1 | 0.0 | 11.3 | 0.0 | 2.1 |
| MC-CuS | 0.0 | 0.1 | 70.7 | 0.2 | 0.7 |

**Table 15. Average (AVG) and standard deviation (STDEV) of metal concentrations in pore water samples collected on 2/1/2017 before addition of spike solutions. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).**

| | Cu $\mu g\ L^{-1}$ | Zn $\mu g\ L^{-1}$ | As $\mu g\ L^{-1}$ | Cd $\mu g\ L^{-1}$ | Pb $\mu g\ L^{-1}$ |
|---|---|---|---|---|---|
| AVG | | | | | |
| Experiment I (multiple element spike solution) | | | | | |
| SED-MS | 0.67 | 39.7 | 1.45 | 0.59 | 0.09 |
| SC-MS | 0.81 | 37.6 | 1.58 | 0.72 | 0.11 |
| A-MS | 0.67 | 36.6 | 1.69 | 0.57 | 0.11 |
| AC-MS | 0.57 | 30.2 | 1.54 | 0.47 | 0.05 |
| MC-MS | 0.83 | 37.4 | 1.19 | 0.48 | 0.19 |
| Experiment II (Cu spike solution) | | | | | |
| SED-CuS | 0.72 | 38.3 | 1.53 | 0.60 | 0.05 |
| MC-CuS | 0.90 | 34.1 | 1.68 | 0.84 | 0.11 |
| STDEV | | | | | |
| Experiment I (multiple element spike solution) | | | | | |
| SED-MS | 0.07 | 3.8 | 0.14 | 0.02 | 0.06 |
| SC-MS | 0.23 | 1.6 | 0.04 | 0.00 | 0.03 |
| A-MS | 0.09 | 3.1 | 0.15 | 0.17 | 0.04 |
| AC-MS | 0.14 | 5.9 | 0.07 | 0.13 | 0.01 |
| MC-MS | 0.12 | 7.0 | 0.23 | 0.12 | 0.04 |
| Experiment II (Cu spike solution) | | | | | |
| SED-CuS | 0.19 | 6.9 | 0.37 | 0.10 | 0.04 |
| MC-CuS | 0.11 | 8.9 | 0.21 | 0.05 | 0.03 |

**Table 16. Average (AVG) and standard deviation (STDEV) of metal concentrations in pore water samples collected on 4/11/2017 at 1536 h. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).**

| | Cu $\mu g\ L^{-1}$ | Zn $\mu g\ L^{-1}$ | As $\mu g\ L^{-1}$ | Cd $\mu g\ L^{-1}$ | Pb $\mu g\ L^{-1}$ |
|---|---|---|---|---|---|
| AVG | | | | | |
| Experiment I (multiple element spike solution) | | | | | |
| SED-MS | 1.30 | 50.8 | 3.6 | 1.33 | 0.59 |
| SC-MS | 1.45 | 73.8 | 2.8 | 2.78 | 0.79 |
| A-MS | 0.75 | 38.1 | 2.2 | 0.79 | 0.07 |
| AC-MS | 0.06 | 30.5 | 2.2 | 0.52 | 0.14 |
| MC-MS | 0.33 | 33.6 | 2.1 | 0.48 | 0.07 |
| Experiment II (Cu spike solution) | | | | | |
| SED-CuS | 1.08 | 47.8 | 1.9 | 0.79 | 0.11 |
| MC-CuS | 0.43 | 35.0 | 2.0 | 0.61 | 0.16 |
| STDEV | | | | | |
| Experiment I (multiple element spike solution) | | | | | |
| SED-MS | 0.16 | 5.8 | 0.56 | 0.14 | 0.30 |
| SC-MS | 0.35 | 8.7 | 1.08 | 0.10 | 0.24 |
| A-MS | 0.45 | 11.1 | 0.13 | 0.07 | 0.02 |
| AC-MS | 0.08 | 1.7 | 0.11 | 0.00 | 0.06 |
| MC-MS | 0.08 | 4.6 | 0.09 | 0.15 | 0.02 |
| Experiment II (Cu spike solution) | | | | | |
| SED-CuS | 0.09 | 4.9 | 0.03 | 0.15 | 0.00 |
| MC-CuS | 0.02 | 7.9 | 0.48 | 0.02 | 0.02 |

**Table 17. Average (AVG) and standard deviation (STDEV) of metal concentrations in pore water samples collected on 6/6/2017 at 2880 h. Experiment I: uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).**

| | Cu $\mu g\ L^{-1}$ | Zn $\mu g\ L^{-1}$ | As $\mu g\ L^{-1}$ | Cd $\mu g\ L^{-1}$ | Pb $\mu g\ L^{-1}$ |
|---|---|---|---|---|---|
| AVG | | | | | |
| Experiment I (multiple element spike solution) | | | | | |
| SED-MS | 0.65 | 36.2 | 3.2 | 1.32 | 0.23 |
| SC-MS | 1.53 | 55.8 | 2.9 | 1.52 | 0.63 |
| A-MS | 0.53 | 30.8 | 2.4 | 1.00 | 0.11 |
| AC-MS | 0.70 | 25.8 | 2.2 | 0.90 | 0.28 |
| MC-MS | 0.42 | 40.0 | 3.4 | 0.91 | 0.17 |
| Experiment II (Cu spike solution) | | | | | |
| S-CuS | 0.56 | 46.9 | 2.4 | 0.82 | 0.05 |
| MC-CuS | 0.28 | 40.2 | 3.4 | 0.41 | 0.04 |
| STDEV | | | | | |
| Experiment I (multiple element spike solution) | | | | | |
| SED-MS | 0.22 | 8.8 | 1.21 | 0.45 | 0.08 |
| SC-MS | 0.98 | 2.1 | 0.54 | 0.71 | 0.38 |
| A-MS | 0.14 | 5.0 | 0.07 | 0.41 | 0.13 |
| AC-MS | 0.36 | 2.5 | 0.56 | 0.31 | 0.06 |
| MC-MS | 0.12 | 15.9 | 0.36 | 0.37 | 0.05 |
| Experiment II (Cu spike solution) | | | | | |
| S-CuS | 0.34 | 18.4 | 0.15 | 0.02 | 0.01 |
| MC-CuS | 0.08 | 8.6 | 0.06 | 0.00 | 0.05 |

#### *4.1.2.2 Surface water properties*

The hardness of the spiked synthetic soft water used in both experiments was about 20 mg $L^{-1}$ before entering the mesocosms. Some amendments increased the water hardness significantly: apatite increased hardness to above 180 mg $L^{-1}$ and the amendments in the mixed amendment (MC) caps increased hardness to about 250 mg $L^{-1}$ in Experiment I (Figure 22). A similar trend was observed in Experiment II with the MC cap amendments increasing surface water hardness to about 270 mg $L^{-1}$. The hardness for each treatment did not change with time through the 2880 h experiment. Because the acute toxicity of Cu and other elements depends on water hardness (EPA, 2016), these results indicate that the beneficial effects of some amendments may be at least partly related to their ability to influence this important property (Knox et al., 2016). Surface water pH was affected by the pH of the spike solution and by the cap materials. However, patterns were similar between Experiments I and II. The highest pH values were in treatments with activated carbon (AC) followed by MC and apatite caps (Figure 23). Average pHs in the mesocosms with apatite caps, MC caps, and activated carbon treatment were higher than in the mesocosms with sand caps and untreated sediment.

Surface water turbidity in Experiment I was highest in the mesocosms with sediment and activated carbon mixed with sediment (Figure 23). Turbidity levels were also high in the mesocosms with sediment in Experiment II. Turbidity levels were high in these treatments because of the relatively small size of the sediment particles, which facilitated their suspension. Sediment was not in direct contact with the surface water in the treatment with caps, and the relatively large particle size of the cap materials prevented their suspension in the water column. Surface water dissolved oxygen concentrations were consistent during the 2880 h test period and generally similar among treatments (Figure 23). Electrical conductivity (EC) trends were also consistent over time and highest in mesocosms with MC caps followed by mesocosms with apatite caps (Figure 23).

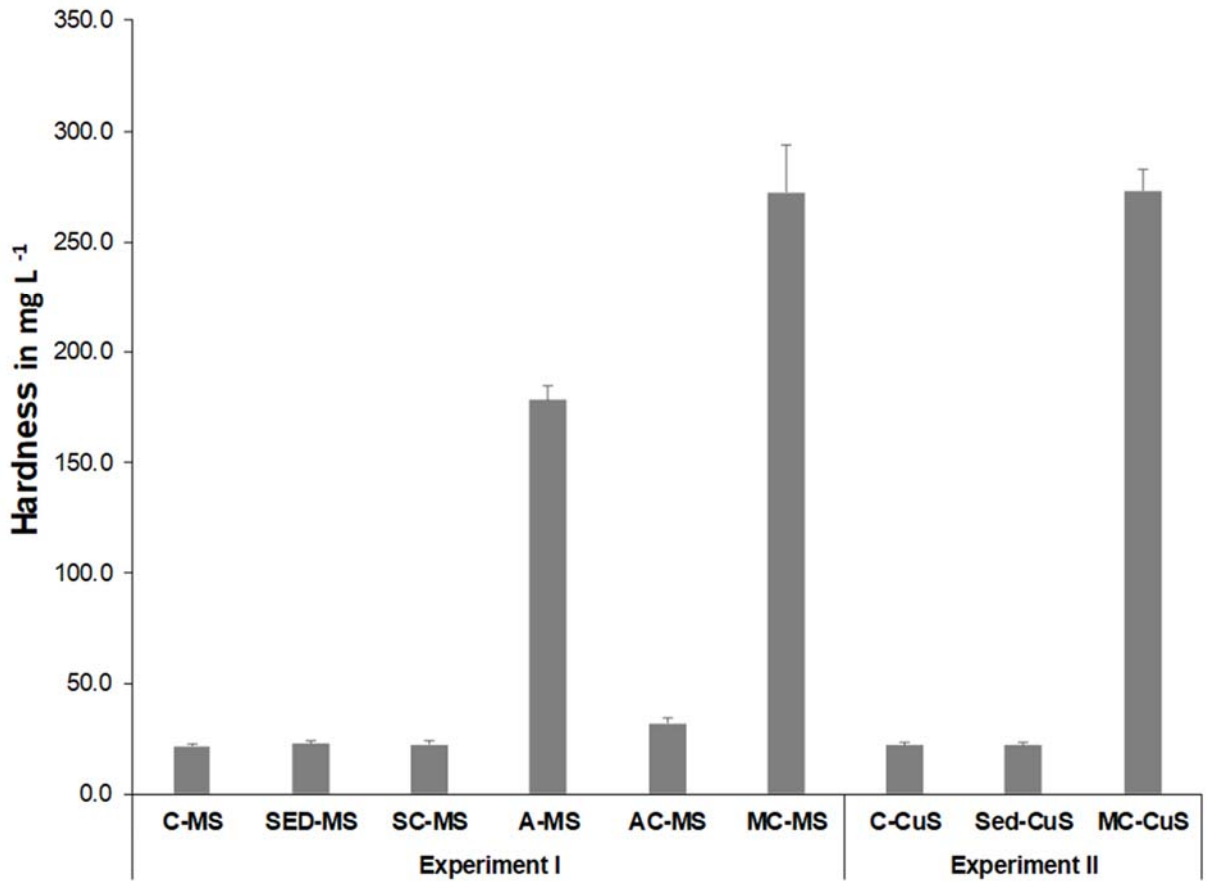



**Figure 22. Average hardness of surface water (mg L-1) (n = 21) for each treatment in both experiments. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS).**

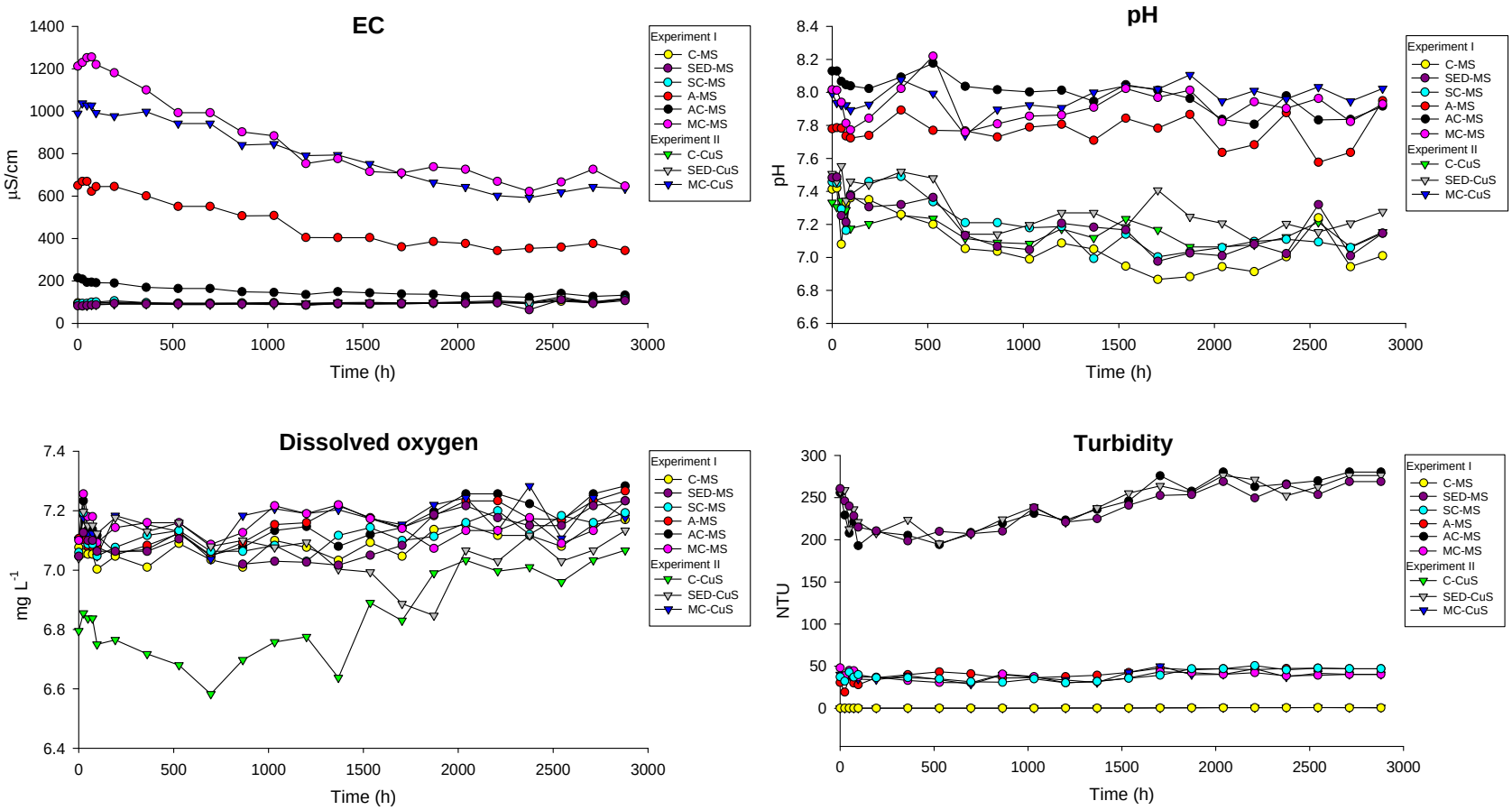



**Figure 23. Temporal changes in surface water electrical conductivity (EC), pH, dissolved oxygen (DO), and turbidity for each treatment. Each value is an average of three samples. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS).**

#### *4.1.2.3 Effect of amendments on elements and element interactions in surface water*

The target total concentrations of As, Cd, Cu, Pb, and Zn in the synthetic spike water for Experiment I were 150, 15, 30, 65, and 120 µg $L^{-1}$, respectively. The concentrations of As, Cd, Cu, and Zn in the control, C-MS, approximated the target levels near the middle of the experiment (864 -1200 h), thereby verifying the achievement of target concentrations in the spike solution (C-MS) (Tables 18 and 19). Similarly, Cu concentrations in the C-CuS mesocosms near the middle of Experiment II (~1200 h) were near the target concentration of about 30 µg $L^{-1}$ (Table 18). The largest deviation between target and actual concentrations was shown by Pb, which was present at slightly lower levels in the supply element spike solution and C-MS control than the target levels (Table 19). This was due to the low solubility of Pb at pH > 5, which was the case with the synthetic soft water in our experiment (pH > 7) (Figure 23) (Kabata-Pendias and Mukherjee, 2007). Also, Vignati (2004) classified Pb into terrigenous metals because Pb associates mainly with the particulate phase; often more than 90% of total.

The behavior of Cu was similar in Experiments I and II; i.e., total Cu concentrations were highest in control and sediment treatments and lowest in MC cap and apatite cap treatments (Tables 18 and 19 and Figure 24). However, Cu concentrations in surface water with MC treatments were slightly higher in Experiment II than Experiment I. In the controls of both experiments (C-MS and C-CuS), Cu dominated in dissolved form from time 0 to about 360 h (Figure 24). With additional time, the particulate form of Cu increased slightly but remained below 5 µg $L^{-1}$ throughout the experiments (2880 h). The opposite occurred in uncapped sediment where most of the Cu in surface water was in the particulate form in both experiments and very little (less than 5 µg $L^{-1}$) was in the dissolved form (Figure 24). On the other hand, MC caps in both experiments reduced both dissolved and particulate Cu, with the average total Cu concentrations in surface water being 3.7 and 5.2 µg $L^{-1}$ in Experiment I and II, respectively (Figure 24 and Table 18). The relationships among Cu in particulate, colloid, and dissolved phases depend on master environmental variables including oxides, organic matter content, and pH (Kabata-Pendias, 2011).

Slightly lower concentrations of Cu in Experiment I than Experiment II were visible after 528 h in treatments with mixed amendment caps (Table 18). This difference was likely related to increasing concentrations of Cd and Zn in Experiment I, which caused precipitation of Cu and lowering of the average total Cu concentration in the surface water (Tables 18 and 19; Figure 24). Other researchers have also reported that Cu-Zn and Cu-Cd interactions are common (Weltje, 1998, Komjarova and Blust, 2009; Kabata-Pendias, 2011; Van Ginneken et. al., 2015). In fact, substitution of essential metals like Cu and Zn is one of the underlying mechanisms of Cd and Pb toxicity (Weltje, 1998; Komjarova and Blust, 2009). Weltje (1998) showed displacement of Cu and Zn by Cd and to a lesser extent of Cu by Pb in earthworm tissue. Similarly, a decrease in Zn tissue concentrations after Cd exposure was observed in oribatid mites and sea stars (Van Straalen et al., 1989; Den Besten et al., 1991).

Total arsenic in surface waters increased over time in all treatments but increased least in the mesocosms with apatite and MC caps (Table 19). The total target concentration of As of about

150 µg $L^{-1}$ in the control treatment was achieved by about 864 h and remained at this level until the end of experiment (2880 h) (Table 19). The average arsenic concentration in uncapped sediment treatment was 32.8% lower than the target As concentration at 2880 h (Table 19). At 2880 h, the lowest total As concentrations were in mesocosms with apatite and mixed caps: 38.2 l and 41.3 µg $L^{-1}$, respectively (Table 19).

Zinc is very soluble, easily available to organisms over a wide range of pHs (Adriano, 2001), and has relatively low electronegativity (1.65) (McBride, 1994); therefore, Zn concentrations in the control treatments were comparable to those in the spike solution despite differences in pH (Table 19). Total Zn in the surface waters of the control mesocosms (C-MS) increased over the 2880 h experiment from about 31.8 to 123.0 µg $L^{-1}$ due to the continuous addition of spike solution (Table 19). In the sand cap treatment (one-inch sand cap), total Zn increased from 29.9 µg $L^{-1}$ to about 81.9 µg $L^{-1}$ (Table 19). However, in treatments with apatite and MC caps, the concentration of total Zn did not change and remained near concentrations typical of uncontaminated waters (Adriano, 2001) (Table 19). At 2880 h dissolved Zn concentrations were highest in control treatment (C-MS), sand cap, and uncapped sediment treatments (Figure 25).

Cadmium is soluble over a wide range of pHs (Kabata-Pendias, 2011). Like Zn, Cd concentrations in the control treatment were similar to Cd concentrations in the spike solution (Table 19). The relatively low metal electronegativity of Cd (1.69) tended to reduce the specific adsorption of this ion resulting in a relatively high proportion of Cd being dissolved (McBride, 1994). Therefore, dissolved Cd dominated in the control treatment (C-MS) during Experiment I (Figure 25). Particle bound Cd was a small fraction of total Cd in most treatments but was the highest fraction in uncapped sediment treatments (Figure 25). At 2880 h, total Cd concentrations in surface water were lowest in the mesocosms with apatite caps, which reduced the Cd concentration by 88.5% (Table 19). The next most effective treatments were the amendment mixture and the *in situ* application of activated carbon; Cd concentrations in surface water in both treatments were reduced by 76.3%. Total Cd concentration in the sand cap treatment remained high, near control treatment levels, throughout the experiment (i.e., 2880 h).
Total concentrations of Pb in the control treatments were lower than concentrations in the spike solution (Table 19) suggesting the possibility of solid phase partitioning through sorption and precipitation. This is consistent with other reports; e.g., Dragun (1998) reported that Pb is generally in particulate-bound forms such as $PbCO_3$ and PbO above Eh 0.0 and pH 4. Total Pb in the control mesocosms (C-MS) increased from 0.1 to 39.7 µg $L^{-1}$ (Table 19), and most of the Pb was in the particulate fraction (23.6 µg $L^{-1}$ at 2880 h) (Figure 4). The multiple element spike solution also had high concentrations of Pb in the particulate fraction (Figure 25). Lead is usually insoluble when the pH of the solution is above 5 (Dragun, 1998). The pH of the multiple element spike solution was generally below 7, but all other treatments had a pH above 7, consistent with the observation that most Pb was in the particulate fraction. Total Pb increased in all treatment types with time (Table 19), but like the other elements, the lowest increase was in treatments with apatite and MC caps (Table 19).

The amendment that resulted in the most effective reduction of element concentrations in surface waters was apatite. In this study, apatite reduced element concentrations in the surface waters of Experiment I in the following order: Pb<Cu<Cd<As<Zn (at 2880 h) (i.e., by 96, 90, 89, 76, and 63%, respectively (Table 19). In contrast, the passive sand cap reduced element concentrations in

the surface waters by less than 20-30% at time 2880 h; e.g., Cd and As (Table 19). These results support earlier findings that apatite effectively immobilizes metals in contaminated soils/sediments and reduces their toxicity and bioavailability (Ma et al., 1995; Knox et al., 2000 a and b, 2003; 2006; Singh et al., 1998). Apatite in commercial phosphate rocks is usually in the form of carbonate apatite with isomorphic substitution of carbonate for phosphate, F for hydroxyl anion, and minor substitution of $Ca^{2+}$ by $Na^{+}$ and $Mg^{2+}$ atoms. Apatite can immobilize Pb, Mn, Co, Cu, Cd, Zn, Mg, Ba, U, and Th in contaminated media (Ma et al., 1995; Knox et al., 2000 a and b, 2003, and 2006). Ma et al. (1995) reported that the interaction between apatite and metals in solution is controlled by apatite dissolution and results in the precipitation of various phosphate phases. Phosphate-metal precipitates are typically very stable over a wide range of environmental conditions (Wright et al., 1995).

In this study, activated carbon effectively removed Cd, Cu, and Zn: concentrations of these elements in surface water at time 2880 h were reduced by 76.3, 53.8, and 45%, respectively (Tables 18 and 19). Activated carbon, also called activated charcoal or activated coal, is carbon that has been processed to make it extremely porous and thus have a very large surface area for adsorption and chemical reactions. Numerous commercially available activated carbons have been tested for organic contaminant and metal sorption (Reed, 2001). Metal removal varies widely among carbon sources and metal types; however, removal is pH dependent for all carbon-metal combinations. For cationic metals, removal increases with increasing pH, and for anionic metals the opposite behavior occurs. Activated carbons can also be impregnated with various materials to impart unique sorption properties. For example, activated carbon impregnated with sulfur is a mature technology used for mercury removal from flue gases and water (Kwon and Vidic, 2000; Kwon et al., 2010). Bone char, which was used in this study, is activated carbon that is produced from animal bones. It differs from plant derived activated carbon by containing both carbon surface area and hydroxyapatite lattice surface area, which makes bone char very effective for metal removal.

**Table 18. Average (Avg) and standard deviation (Stdev) of total Cu concentrations (n = 3) in surface water in Experiments I and II from time 0 to 2880 h. Each value is an average of three samples. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS).**

| Time (h) | 0 | 192 | 360 | 528 | 864 | 1200 | 1872 | 2880 |
|---|---|---|---|---|---|---|---|---|
| Experiment I (multiple element spike solution) | | | | | | | | |
| **C-MS** | 0.4 ± 0.4 | 7.0 ± 1.4 | 11.1 ± 0.9 | 19.0 ± 1.4 | 24.6 ± 0.7 | 27.9 ± 0.9 | 24.7 ± 1.7 | 27.3 ±6.3 |
| **SED-MS** | 0.6 ± 0.1 | 5.8 ± 2.6 | 6.2 ± 0.0 | 13.6 ± 0.6 | 21.0 ± 3.5 | 23.4 ± 1.9 | 21.1 ± 0.7 | 20.1 ± 1.9 |
| **SC-MS** | 0.6 ± 0.2 | 4.7 ± 0.7 | 3.9 ± 0.5 | 14.9 ± 1.8 | 15.5 ± 1.0 | 21.9 ± 3.3 | 21.1 ± 1.9 | 18.7 ± 0.5 |
| **A-MS** | 0.8 ± 0.1 | 1.5 ± 0.4 | 1.5 ± 0.1 | 2.4 ± 0.4 | 3.3 ± 0.7 | 4.1 ± 0.7 | 3.4 ± 0.4 | 2.7 ± 0.4 |
| **AC-MS** | 0.5 ±0.5 | 4.8 ± 1.3 | 6.0 ± 0.3 | 11.6 ± 4.4 | 18.1 ± 1.4 | 17.1 ± 2.8 | 15.0 ± 0.8 | 12.6 ± 1.7 |
| **MS-MS** | 0.6 ± 0.1 | 2.0 ± 0.8 | 2.7 ± 0.1 | 3.3 ± 1.2 | 3.6 ± 0.8 | 3.7 ± 0.5 | 3.7 ± 0.5 | 3.7 ± 0.5 |
| Experiment II (Cu spike solution) | | | | | | | | |
| **C-CuS** | 0.0 ± 0.0 | 5.9 ± 0.6 | 10.4 ± 1.9 | 17.2 ± 2.5 | 23.4 ± 0.3 | 27.4 ± 1.1 | 29.0 ± 1.1 | 29.5 ± 0.7 |
| **SED-CuS** | 0.7 ± 0.0 | 3.6 ± 0.5 | 5.4 ± 2.2 | 12.9 ± 2.3 | 21.2 ± 2.9 | 19.4 ± 0.7 | 19.2 ± 0.7 | 16.2 ± 0.2 |
| **MS-CuS** | 0.6 ± 0.2 | 2.3 ± 1.5 | 2.4 ± 0.7 | 5.2 ± 0.6 | 5.5 ± 0.6 | 5.5 ± 1.2 | 5.0 ± 1.2 | 5.2 ± 0.2 |

**Table 19. Average and standard deviation of total As, Cd, Pb, and Zn concentrations (n = 3) in surface water in mesocosms with multiple element spike solution (Experiment I): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS) from time 0 to 2880 h.**

| Time (h) | 0 | 192 | 360 | 528 | 864 | 1200 | 1872 | 2880 |
|---|---|---|---|---|---|---|---|---|
| | As | | | | | | | |
| **C-MS** | 1.6 ± 0.3 | 66.5 ± 2.6 | 112.6 ± 2.3 | 120.0 ± 2.3 | 161.3 ± 1.4 | 159.8 ± 5.9 | 181.4 ± 0.6 | 157.8 ±7.3 |
| **SED-MS** | 1.0 ± 0.4 | 29.7 ± 6.0 | 53.0 ± 14.4 | 75.0 ± 3.0 | 89.4 ± 7.1 | 84.8 ± 8.5 | 95.2 ± 11.5 | 106.0 ± 7.7 |
| **SC-MS** | 1.1 ± 0.2 | 50.0 ± 0.4 | 83.1 ± 7.7 | 91.1 ± 12.8 | 107.3 ± 3.0 | 126.8 ± 14 | 145.9 ± 8.0 | 128.6 ± 2.7 |
| **A-MS** | 2.2 ± 0.4 | 9.0 ± 3.0 | 11.8 ± 1.4 | 13.8 ± 1.3 | 18.7 ± 1.3 | 44.1 ± 1.5 | 43.3 ± 0.4 | 38.2 ± 1.3 |
| **AC-MS** | 0.7 ±0.2 | 32.1 ± 2.5 | 55.0 ± 0.5 | 69.4 ± 3.3 | 81.8 ± 1.7 | 85.8 ± 2.2 | 89.2 ± 6.6 | 91.6 ± 6.9 |
| **MC-MS** | 2.6 ± 0.4 | 16.1 ± 3.9 | 18.6 ± 2.5 | 25.3 ± 2.5 | 25.6 ± 1.4 | 49.4 ± 2.9 | 55.7 ± 1.6 | 41.3 ±4.0 |
| | Cd | | | | | | | |
| **C-MS** | 0.4 ± 0.1 | 7.2 ± 0.4 | 9.9 ± 0.8 | 13.7 ± 1.0 | 16.4 ± 0.3 | 15.1 ± 0.2 | 15.9 ± 1.0 | 13.1 ± 0.9 |
| **SED-MS** | 0.6 ± 0.1 | 3.4 ± 0.7 | 3.7 ± 1.0 | 6.6 ± 0.9 | 7.3 ± 1.2 | 4.8 ±0.6 | 7.0 ± 1.7 | 11.5 ± 1.5 |
| **SC-MS** | 0.6 ± 0.2 | 4.4 ± 0.4 | 5.8 ± 0.3 | 7.4 ± 0.8 | 7.4 ± 0.8 | 9.2 ± 0.6 | 9.5 ± 0.3 | 9.2 ± 0.9 |
| **A-MS** | 0.8 ± 0.1 | 1.4 ± 0.2 | 0.8 ± 0.1 | 1.6 ± 0.2 | 1.8 ± 0.3 | 2.6 ± 1.3 | 1.4 ± 0.2 | 1.5 ± 0.1 |
| **AC-MS** | 0.5 ± 0.1 | 2.4 ± 0.4 | 2.0 ± 0.7 | 3.4 ± 0.4 | 5.3 ± 0.4 | 3.3 ± 0.8 | 3.7 ± 0.6 | 3.1 ± 0.4 |
| **MC-MS** | 0.6 ± 0.1 | 1.7 ± 0.2 | 1.2 ± 0.5 | 1.6 ± 0.4 | 2.1 ± 0.2 | 3.4 ± 0.5 | 3.4 ± 0.3 | 3.1 ± 0.5 |
| | Pb | | | | | | | |
| **C-MS** | 0.1 ± 0.0 | 8.2 ± 0.5 | 13.2 ± 1.4 | 16.9 ± 1.0 | 26.9 ± 1.1 | 27.9 ± 1.0 | 34.2 ± 1.3 | 39.7 ± 1.2 |
| **SED-MS** | 0.3 ± 0.1 | 9.8 ± 0.3 | 8.2 ± 1.5 | 16.0 ± 0.9 | 19.7 ± 1.3 | 17.3 ± 1.1 | 18.7± 0.8 | 22.2 ± 1.3 |
| **SC-MS** | 0.2 ± 0.0 | 8.8 ± 0.5 | 5.6 ± 0.4 | 8.7 ± 0.8 | 13.4 ± 1.1 | 13.7 ± 1.0 | 14.8 ± 3.0 | 16.8 ± 1.5 |
| **A-MS** | 0.1 ± 0.1 | 1.5 ± 0.7 | 1.1 ± 0.4 | 1.8 ± 0.2 | 2.4 ± 0.3 | 2.8 ± 0.5 | 1.8 ± 0.6 | 1.6 ± 0.1 |
| **AC-MS** | 0.2 ± 0.0 | 6.2 ± 0.6 | 9.3 ± 0.6 | 11.1 ± 0.4 | 11.7 ± 0.3 | 15.1 ± 0.3 | 13.6 ± 2.1 | 14.3 ± 2.5 |
| **MC-MS** | 0.4 ± 0.1 | 2.8 ± 1.0 | 2.9 ± 1.5 | 3.5 ± 0.4 | 2.5 ± 0.6 | 3.8 ± 0.7 | 4.1 ± 0.3 | 4.9 ± 0.5 |
| | Zn | | | | | | | |
| **C-MS** | 31.8 ± 6.3 | 62.3 ± 1.5 | 96.8 ± 10.6 | 108.6 ± 6.6 | 122.7 ± 5.7 | 132.8 ± 8.1 | 122.1 ± 5.0 | 123.0 ± 2.7 |
| **SED-MS** | 34.0 ± 7.3 | 44.7 ± 0.4 | 60.2 ± 5.0 | 66.8 ± 3.9 | 62.7 ± 9.6 | 80.1 ± 8.7 | 76.4 ± 5.4 | 82.3 ± 8.1 |
| **SC-MS** | 29.9 ± 5.2 | 63.7 ± 3.4 | 76.6 ± 1.5 | 80.0 ± 8.7 | 88.9 ± 2.9 | 86.1 ± 10.4 | 83.6 ± 3.2 | 81.9 ± 1.8 |
| **A-MS** | 30.0 ± 1.0 | 35.0 ± 7.2 | 34.7 ± 3.8 | 29.0 ± 8.7 | 43.6 ± 0.5 | 34.8 ± 4.4 | 27.5 ± 4.6 | 45.5 ± 5.3 |
| **AC-MS** | 26.3 ± 8.0 | 34.3 ± 4.3 | 58.3 ± 2.7 | 59.3 ± 5.7 | 61.0 ± 7.1 | 73.6 ± 1.2 | 49.1 ± 7.1 | 55.8 ± 3.7 |
| **MC-MS** | 34.8 ± 1.9 | 36.7 ±4.4 | 42.6 ± 2.9 | 33.9 ± 2.7 | 47.5 ± 4.8 | 44.2 ± 4.3 | 44.1 ± 3.7 | 48.6 ± 6.4 |

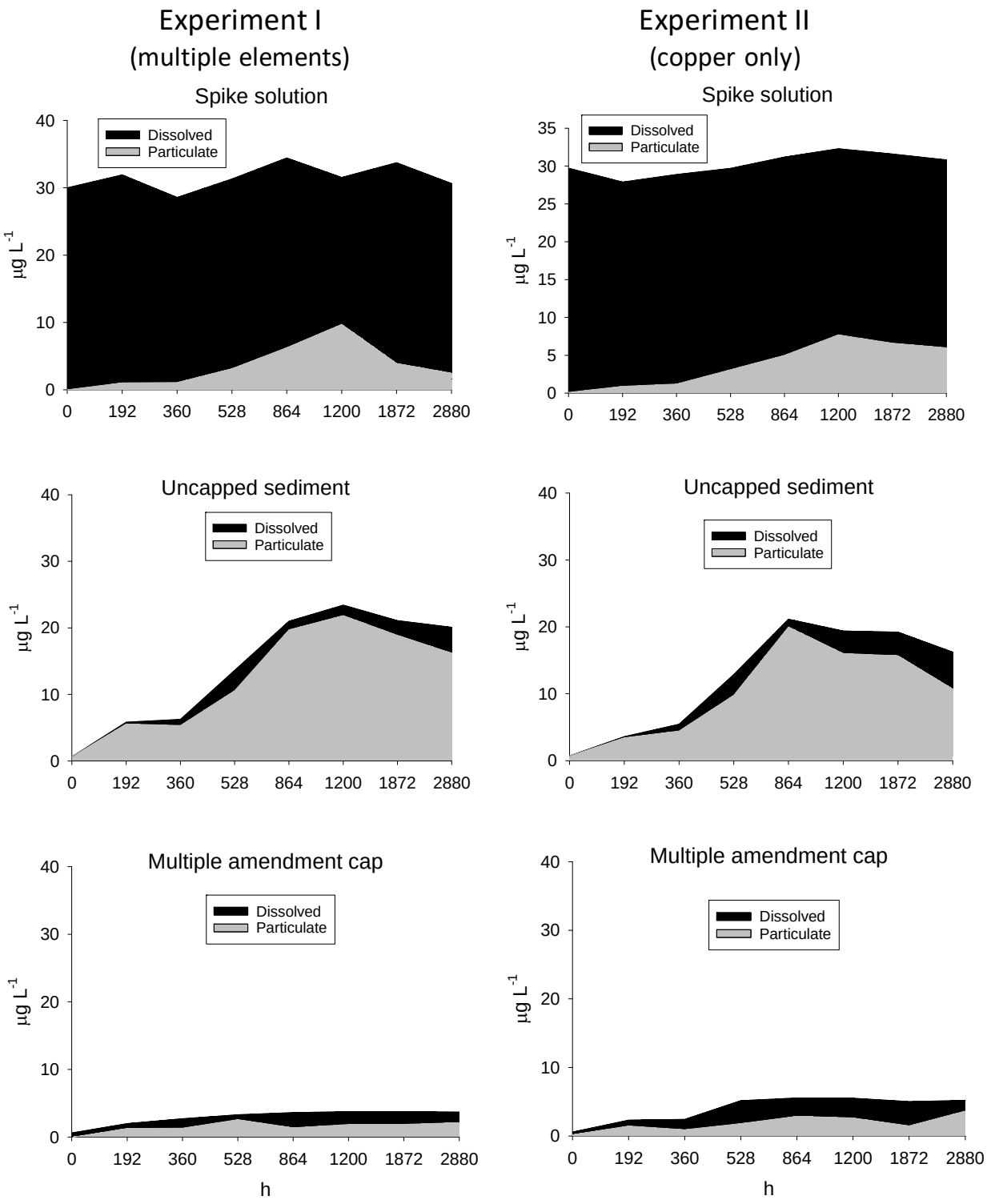



**Figure 24. Average Cu concentrations in surface water in Experiments I and II from time 0 to 2880 h. Each value is an average of three samples. Experiment I (multiple element spike solution): control with no sediment, uncapped sediment, sediment with multi-amendment caps. Experiment II (Cu spike solution): control with no sediment, uncapped sediment, and sediment with multiple amendment active caps.**

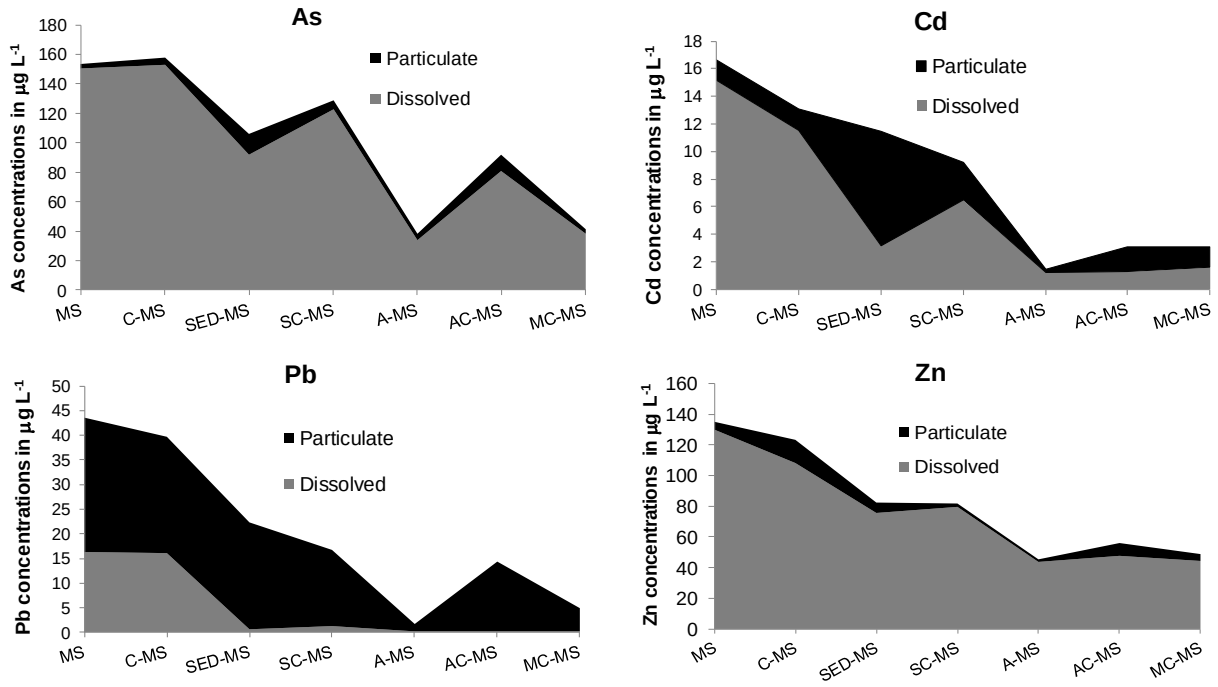



**Figure 25. Average dissolved and particulate surface water concentrations of As, Cd, Pb, and Zn in Experiment I mesocosms at 2880 h. Each value is an average of three samples; multiple element spike solution (MS), control mesocosms with multiple element spike solution and no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS).**

### *4.1.2.4 Toxicity and bioaccumulation assessment*

A toxicity test corresponding to ten days of exposure to elements in the mesocosms was conducted with California blackworms. In Experiment I, average percent mortality (based on changes in aggregate weight before and after placement in the mesocosms) for the ten-day test was 30, 51.2, 29.3, 11.6, and 12.9% for control, sediment only, sand, apatite, and MC caps, respectively (Figure 26). In Experiment II, the lowest mortality was observed in treatments with an MC cap; an average of 12.5% for 10 days of exposure. These results demonstrate that the active caps provided more protection from the continued influx of dissolved and particulate elements than the sand caps or uncapped sediment.

For uncapped sediment treatments, there were significant ($p<0.05$) differences in mortality between Experiment I and Experiment II: 51.2 and 34.7% mortality in SED-MS and SED-CuS, respectively (Figure 26). These results indicate that cumulative toxicity of the mixture of elements was greater than the toxicity of Cu alone (Figure 5). Treatments with lower mortality (i.e., apatite and MC caps) had lower concentrations of the tested elements, and the water had higher pH and hardness (Figures 22, 23, and 26). The toxicity of dissolved elements is related to

element concentration and speciation, which depends on the water composition. For instance, the concentration and type of dissolved organic carbon (DOC) have been shown to modify the bioaccumulation of Cu via chemical complexation (Lores et al., 1999; Luis et al., 2004; Zhong et al., 2012). Furthermore, some studies have shown that speciation alone is insufficient for predicting accumulation and toxicity because of competition with cations. For instance, the presence of competing cations such as $Ca^{2+}$, $Mg^{2+}$, $H^{+}$, $Na^{+}$ or $K^{+}$ reduces the bioavailability of Cu (De Schamphelaere and Janssen, 2002; Ferreira et al., 2009).

California blackworms that survived exposure in the mesocosms were analyzed for whole-body element concentrations (Figure 27). The concentrations of most elements in *Lumbriculus* (10-day evaluation) were significantly higher in the spike solution, sand cap, and uncapped sediment than in the apatite or MC caps, even though uncapped sediment removed significant amounts of the spiked elements (e.g., Cd and Pb) from the surface water (Table 19). This likely occurred because water hardness was significantly higher in treatments with apatite and mixed amendment caps (Figure 22). Analysis of variance of differences in *Lumbriculus variegatus* Cu concentrations (whole body, 10-day exposure) among treatments in Experiment I (multi-element) and Experiment II (Cu only) showed that the ability of the mixed amendment cap to influence the bioaccumulation of Cu was not affected by the presence of other elements (Figure 27).

Cadmium and Zn can suppress the uptake rates of other elements (e.g., Cu) under some conditions (Hopkin and Hames, 1994; Donker et al., 1996; Weltje, 1998; Norwood et al., 2003; Rainbow and Black, 2005; Komjarova and Blust, 2009; Abboud et al., 2013; Van Ginneken et al., 2015). This effect is observed even at low Cd and Cu concentrations and reaches a maximum at higher concentrations (Komjarova, 2009; Komjarova and Blust, 2008; Komjarova and Blust, 2009). Comparing results for Cu between Experiment I (Cu mixed with Cd, As, Pb, and Zn) and Experiment II (Cu only) provided insights concerning competitive interactions among multiple elements and their potential effects on treatment effectiveness. This study showed that a mixture of elements that included Cu was more toxic than Cu alone (at the same concentration as in the mixture) in uncapped sediment, likely because of additive toxicity contributed by the other elements (SED-MS versus SED-CuS in Figure 26). However, the effectiveness of the mixed amendment caps in both experiments was similar showing that Cu uptake, as indicated by toxicity and bioaccumulation, was not affected by the presence of other elements in Experiment I (MC-MS versus MC-CuS in Figures 26 and 28). These results suggest that the effectiveness of the amendments used in active caps and *in situ* treatments may be unaffected by element interactions that can influence bioaccumulation in aquatic organisms.

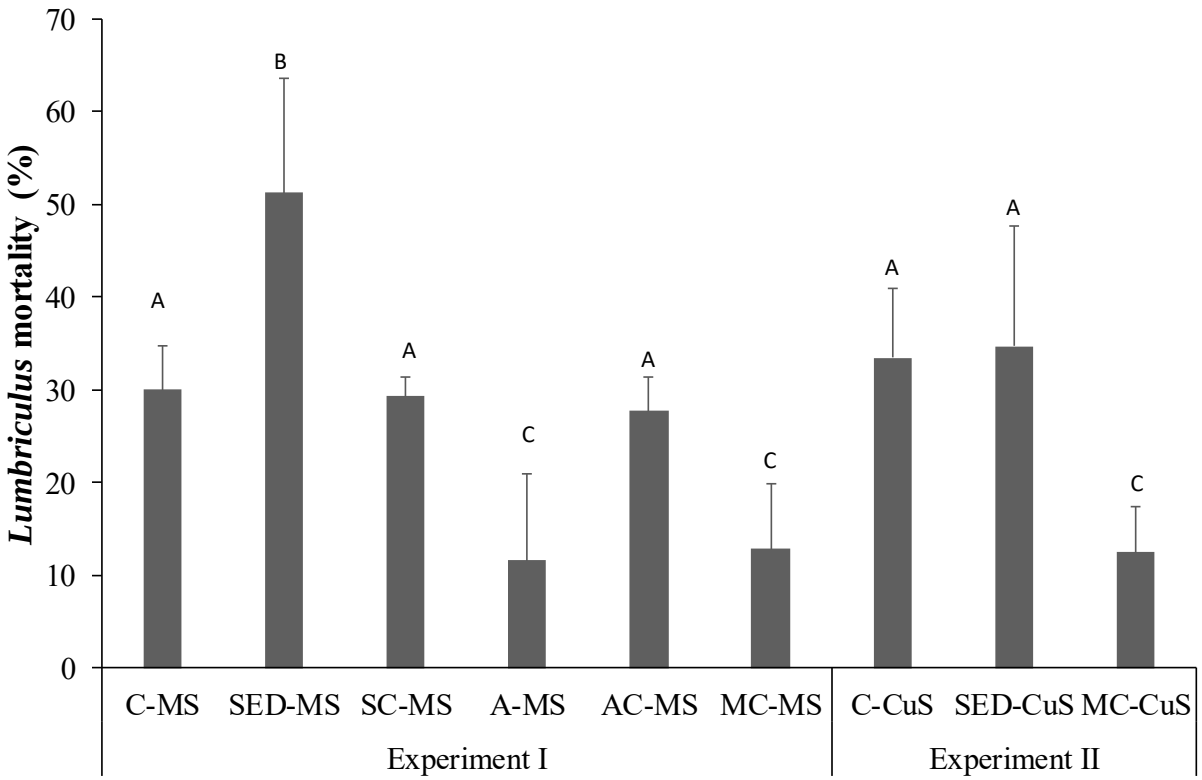



**Figure 26. Average mortality of *Lumbriculus variegatus* after ten-day toxicity tests conducted in mesocosms receiving water spiked with metals (MS) and copper only (CuS). Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). Groups represented by different letters are significantly different ($p<0.05$, ANOVA followed by Student-Newman-Keuls method for multiple comparison).**

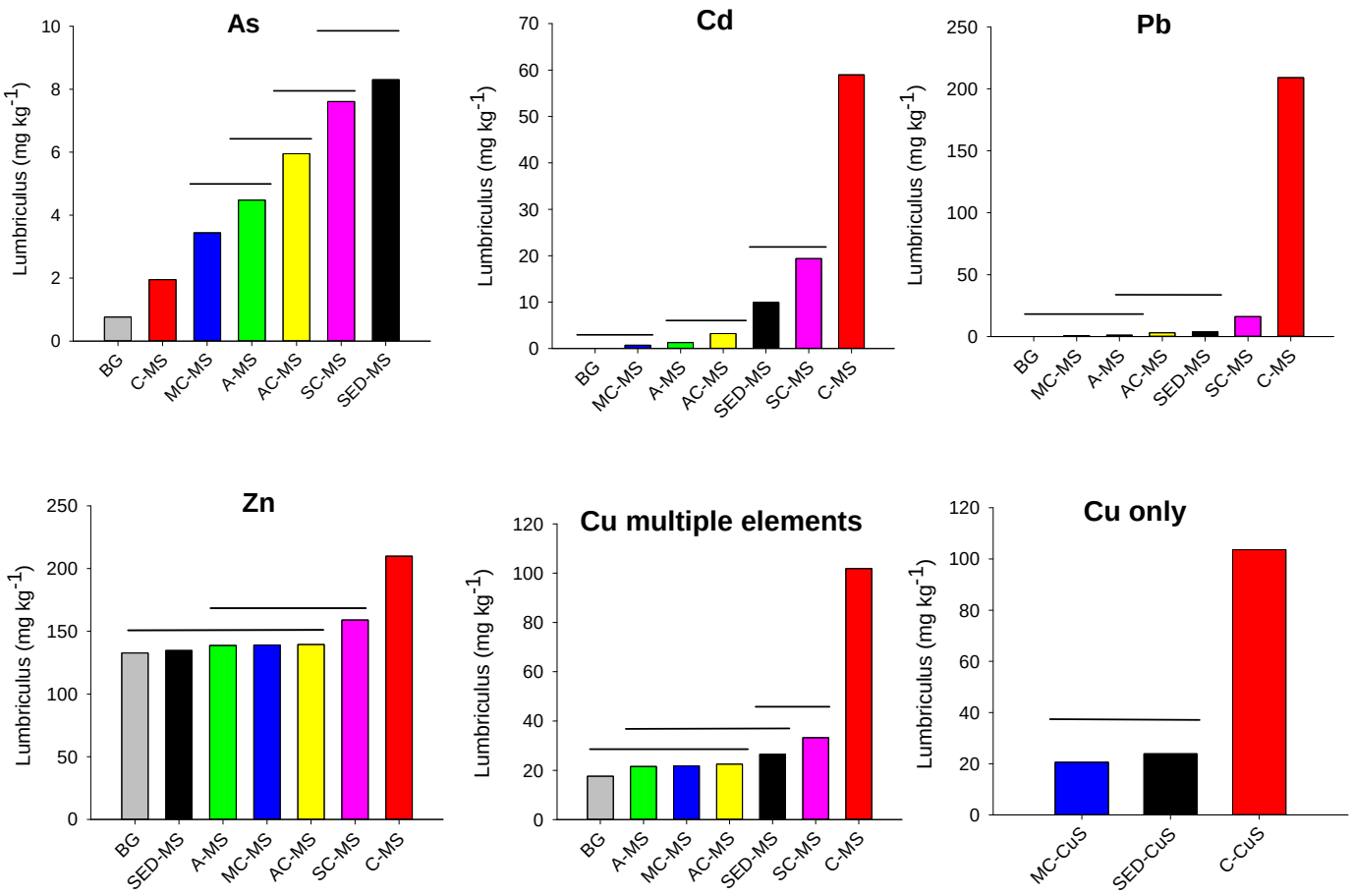



**Figure 27. Analysis of variance of differences in *Lumbriculus variegatus* element concentrations (whole body, 10-day exposure) among treatments. Geometric means connected by the same line are not significantly different at $\alpha<0.05$. Experiment I: background (BG), mesocosms with multiple element spike solution and no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II: mesocosms with Cu spike solution and no sediment (C-CuS), uncapped sediment (SED-CuS), sediment with mixed amendment active caps (MC-CuS), and background (BG).**

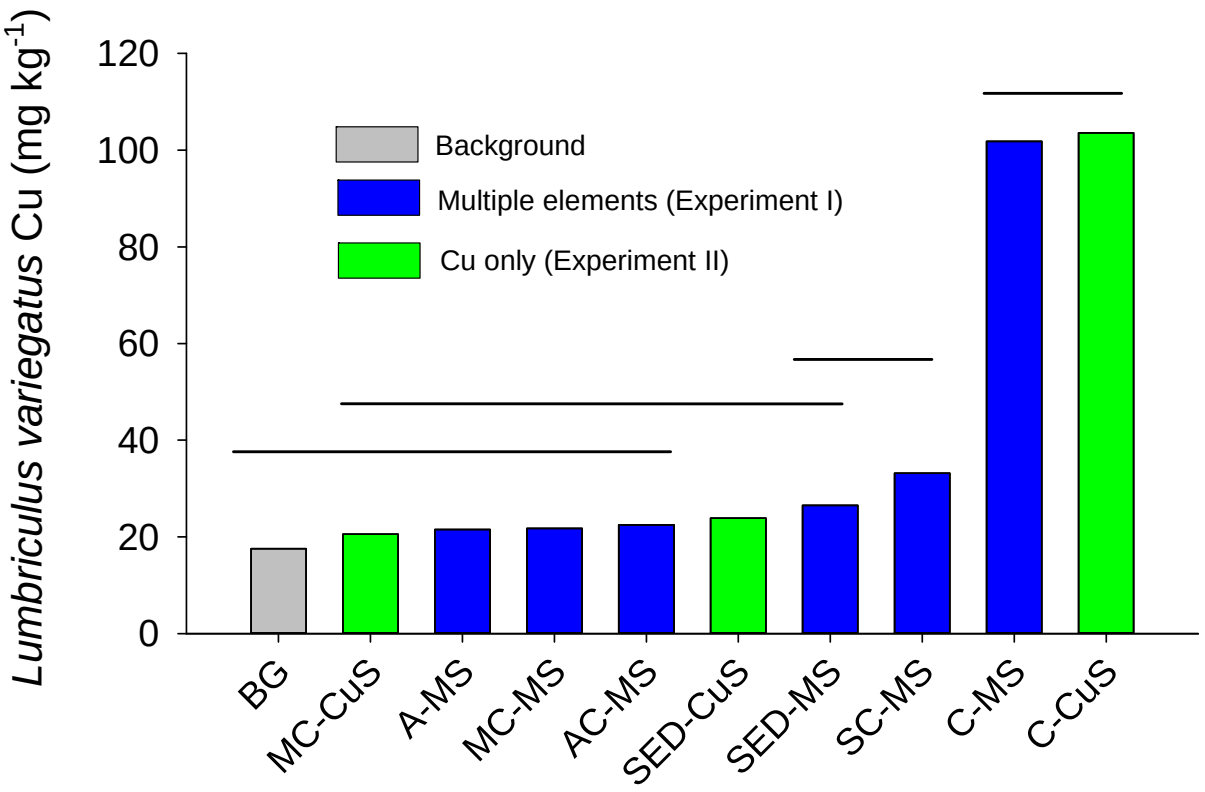



**Figure 28. Analysis of variance of differences in *Lumbriculus variegatus* Cu concentrations (whole body, 10-day exposure) among treatments in Experiment I and Experiment II. Geometric means connected by the same line are not significantly different at $\alpha<0.05$. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), sediment with mixed amendment active caps (MC-CuS), and background (BG).**

#### *4.1.2.5 Bioavailability assessment by diffusive gradients in thin films (DGT) probes*

Results from the DGT water probes showed that concentrations of potentially bioavailable Cu, Cd and Pb in the water column were significantly lower ($p<0.05$) in the apatite, activated carbon, and MC treatments than in the control and passive sand cap treatments (Figure 29). Also, there were no significant differences between Cu concentrations measured by water DGT probes in Experiments I and II for MC treatments indicating that the presence of other elements in Experiment I did not affect the potential bioavailability of Cu (as indicated by DGT measurements) and that the MC treatment was effective for Cu in presence of other elements such as Cd, Pb, and Zn (Figure 29).

Lower bioavailable pools of Cu and other elements measured by water DGT probes in apatite and MC treatments may be related to the higher pH and hardness of surface water in these treatments (Figures 18 and 19). Other researchers have reported that water hardness can reduce the concentrations of Cu ions and the amount of Cu measured by DGT (Philipps et al., 2018). The lower toxicity of Cu in hard water compared to soft water is due to the protective effects of $Ca^{2+}$ on and in living cells. Countries such as Canada have outlined Water Quality Standards for the protection of aquatic life that are stricter for soft water than hard water (Bradl, 2005; Wright and Welbourn, 2002).

DGT sediment probes showed that DGT element concentrations, especially Cd, Cu, and Pb in the apatite and MC cap layers, were very low compared with DGT element concentrations in the passive sand cap layer (Table 20). Lower sediment element levels in apatite and MC treatments persisted deeper within the sediment profile, especially compared with the uncapped sediment, which exhibited relatively higher Cu and Cd levels to a depth of 5.0 cm in the sediment column (Table 20). Although these differences in element concentration are likely amendment related, they could have been influenced by vertical differences in sediment pH among mesocosms (Figure 30). These results show that potentially bioavailable element species were lower in the sediments of treatments with apatite, activated carbon, and MC active caps than in uncapped sediments or sediments with passive caps. Differences were especially pronounced in the surface sediment/cap layers, which constitute the habitat for most benthic organisms. Linear regressions showing the relationship between element concentrations in *Lumbriculus* and potentially bioavailable element concentrations in the top 2.5 cm of sediment or cap materials (measured by DGT sediment probes) were strong ($R^2$ = 0.63-0.76) and significant ($p<0.05$) for Cd, Cu, and Pb (Figure 31). These results suggest a causative relationship and indicate the potential for active caps to control the bioaccumulation of elements by reducing concentrations of bioavailable elements in sediment porewater. In contrast to the previous elements, the relationship between DGT measurements of Zn and Zn concentrations in *Lumbriculus* were comparatively weak ($R^2$ = 0.22) and only marginally significant ($p<0.036$).

Some elements such as As, Cd, and Pb have no essential metabolic functions, are toxic at low concentrations, and tend to bioaccumulate (Rainbow, 1997, 2002). Other elements, such Cu and Zn, play an important role in cellular metabolism and their internal concentrations are regulated by organisms. Essential and non-essential elements may; however, share common uptake routes and interact with each other affecting mobility, uptake, bioaccumulation, and toxicity. These element interactions are highly variable since they depend on element concentrations, exposure scenarios, organism-specific differences, and examined organs (Norwood et al., 2003). For example, Pb at a concentration 0.25 µM increased Cu uptake in the water flea *Daphnia magna* showing that element interactions are significant and occur at environmentally realistic concentrations (Komjarova and Blust, 2008 and 2009).

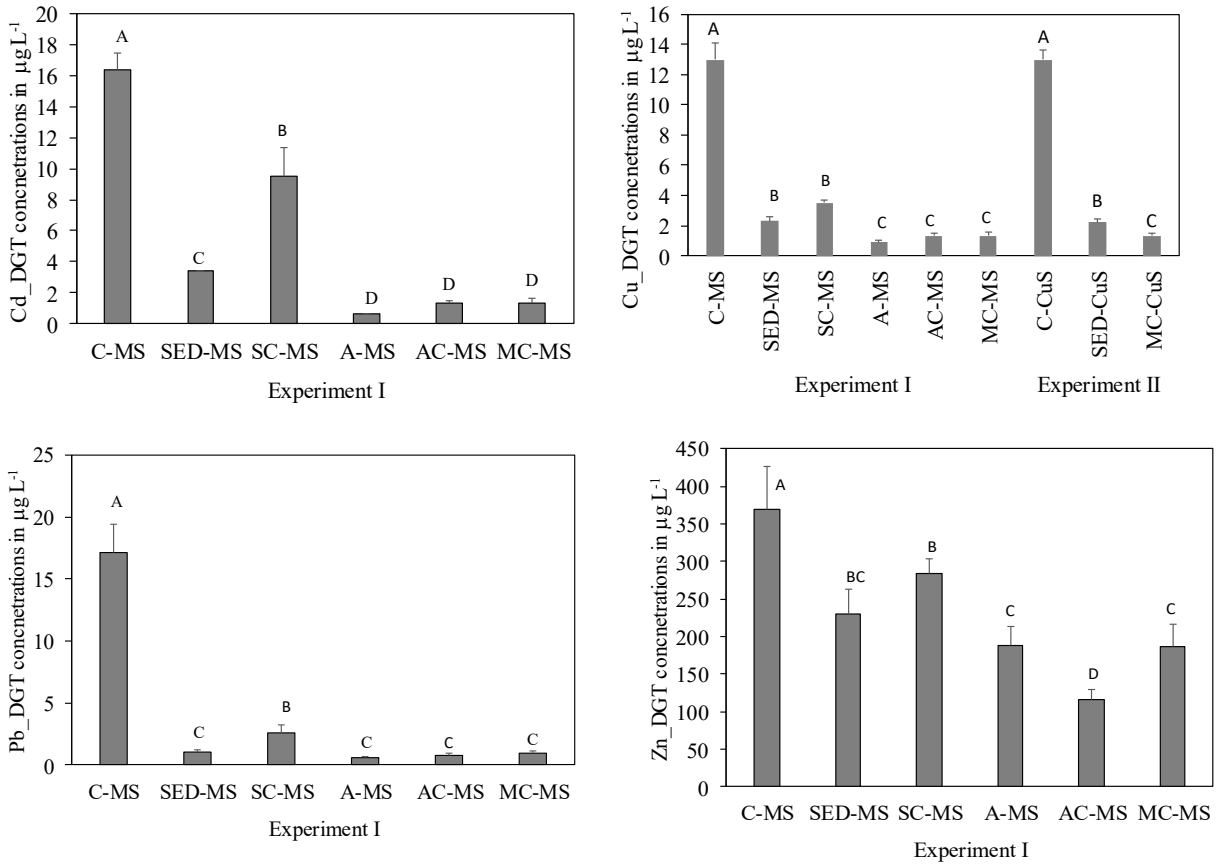



**Figure 29. Average Cd, Cu, Pb, and Zn concentrations (µg $L^{-1}$) measured by water DGT probes. Experiment I (multiple element spike solution): control with no sediment (C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): control with no sediment (C-CuS), uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS). Groups represented by different letters are significantly different (α<0.05, ANOVA followed by Student-Newman-Keuls method for multiple comparison).**

**Table 20. Metal concentrations (μg $kg^{-1}$) measured by sediment DGT probes (CDGT) in cap materials and individual layers of sediment (layer A: 0.0-2.5 cm, layer B: 2.5-5.0 cm, and layer C: 5.0-7.5 cm). Each value is an average (± standard deviation) of three samples. Experiment I (multiple element spike solution): uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): uncapped sediment (SED-CuS), and sediment with mixed amendment active caps (MC-CuS).**

| Layers | Cu | Zn | Cd | Pb |
|---|---|---|---|---|
| **SED-MS (Uncapped sediment – multiple element spike)** | | | | |
| **A** | 1.0 ± 0.1 | 163.5 ± 2.8 | 0.7 ± 0.0 | 0.3 ± 0.1 |
| **B** | 1.4 ± 0.4 | 21.4 ± 0.6 | 0.7 ± 0.1 | 0.1 ± 0.0 |
| **C** | 0.9 ± 0.2 | 19.5 ± 2.5 | 0.5 ± 0.1 | 0.1 ± 0.1 |
| **SED-CuS (Uncapped sediment – copper spike)** | | | | |
| **A** | 1.3 ± 0.2 | 23.2 ± 4.7 | 0.2 ± 0.0 | 0.1 ±0.0 |
| **B** | 0.7 ± 0.2 | 21.0 ± 3.5 | 0.2 ± 0.0 | 0.1 ± 0.0 |
| **C** | 0.6 ± 0.6 | 19.1 ± 2.2 | 0.2 ± 0.2 | 0.1 ± 0.1 |
| **AC-MS (Sediment with activated carbon – multiple element spike)** | | | | |
| **A** | 0.5 ± 0.1 | 82.4 ± 7.5 | 0.2 ± 0.0 | 0.1 ±0.0 |
| **B** | 0.3 ± 0.1 | 16.1 ± 2.8 | 0.2 ± 0.0 | 0.1 ± 0.0 |
| **C** | 0.5 ±0.1 | 17.8 ± 1.4 | 0.2 ± 0.0 | 0.1 ± 0.1 |
| **SC-MS (Sand cap and sediment – multiple element spike)** | | | | |
| **Cap** | 1.8 ± 0.2 | 157.5 ± 11.9 | 5.7 ± 0.5 | 1.2 ± 0.3 |
| **A** | 1.1 ± 0.3 | 127.9 ± 11.2 | 0.4 ± 0.1 | 0.3 ± 0.0 |
| **B** | 0.5 ± 0.2 | 19.2 ± 2.2 | 0.3 ± 0.1 | 0.1 ± 0.0 |
| **C** | 0.4 ± 0.1 | 19.9 ± 0.9 | 0.2 ± 0.1 | 0.1 ± 0.0 |
| **A-MS (Apatite cap and sediment – multiple element spike)** | | | | |
| **Cap** | 0.4 ± 0.1 | 90.7 ± 2.3 | 0.4 ± 0.1 | 0.1 ± 0.1 |
| **A** | 0.5 ± 0.1 | 33.4 ± 14.2 | 0.3 ± 0.0 | 0.2 ± 0.0 |
| **B** | 0.3 ± 0.0 | 19.1 ± 1.7 | 0.3 ± 0.0 | 0.1 ± 0.0 |
| **C** | 0.3 ± 0.1 | 19.9 ± 1.2 | 0.3 ± 0.1 | 0.1 ± 0.0 |
| **MC-MS (MC cap and sediment – multiple element spike)** | | | | |
| **Cap** | 0.3 ±0.1 | 47.2 ± 9.4 | 0.3 ± 0.2 | 0.1 ± 0.0 |
| **A** | 0.4 ± 0.2 | 23.0 ± 2.2 | 0.3 ± 0.1 | 0.1 ± 0.1 |
| **B** | 0.2 ± 0.0 | 18.2 ± 1.4 | 0.1 ± 0.1 | 0.1 ± 0.0 |
| **C** | 0.4 ± 0.0 | 21.7 ± 3.4 | 0.1 ± 0.1 | 0.1 ± 0.0 |
| **MC-CuS (MC cap and sediment – copper spike)** | | | | |
| **Cap** | 0.3 ± 0.0 | 20.8 ± 3.5 | 0.2 ± 0.0 | 0.1 ± 0.1 |
| **A** | 0.3 ± 0.3 | 24.5 ± 7.5 | 0.2 ± 0.1 | 0.1 ± 0.2 |
| **B** | 0.2 ± 0.0 | 23.3 ± 0.7 | 0.2 ± 0.0 | 0.1 ± 0.0 |
| **C** | 0.3 ± 0.0 | 18.1 ± 0.6 | 0.2 ± 0.0 | 0.1 ± 0.0 |

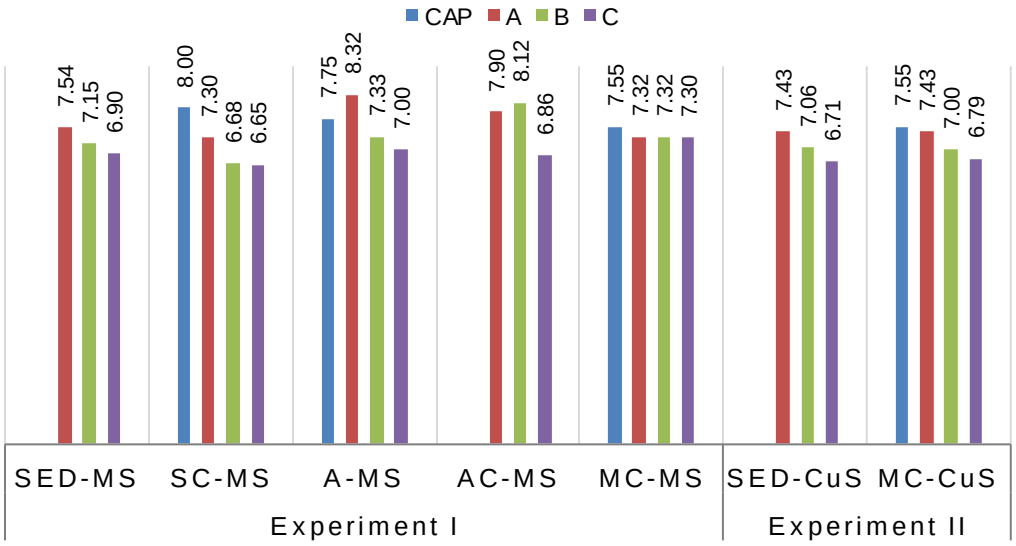



**Figure 30. Average pH values (n = 3) in cap materials and individual layers of sediment (layer A: 0.0-2.5 cm, layer B: 2.5-5.0 cm, and layer C: 5.0-7.5 cm) at 2880 h; Experiment I (multiple element spike solution): uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): uncapped sediment (SED-CuS) and sediment with mixed amendment caps (MC-CuS).**

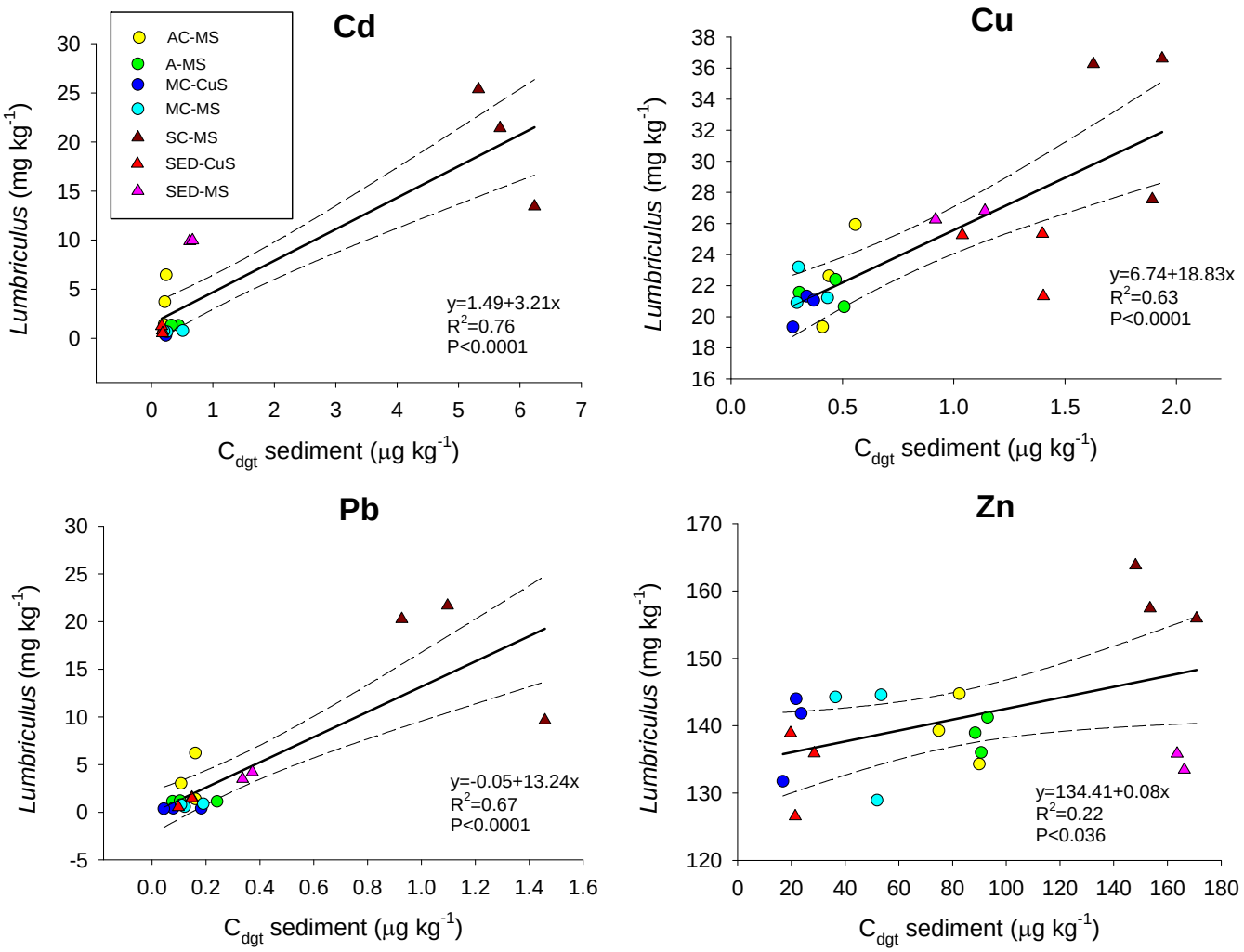



**Figure 31. Regression of metal concentrations in *Lumbriculus variegatus* (whole body) and metal concentrations in sediment measured by sediment DGT probes (Cdgt, depth 0.0-2.5 cm). Experiment I (multiple element spike solution): uncapped sediment (SED-MS), sediment with sand caps (SC-MS), sediment with apatite active caps (A-MS), sediment with mixed amendment active caps (MC-MS), and sediment treated *in situ* with activated carbon (AC-MS). Experiment II (Cu spike solution): uncapped sediment (SED-CuS) and sediment with mixed amendment active caps (MC-CuS).**

### *4.1.2.6 Conclusions*

We used mesocosms to investigate the effects of low levels of continuing Cu influx, alone and in the presence of other elements, over uncapped sediment and sediments remediated by different types of active and passive caps and *in situ* treatment with activated carbon. Our hypothesis was that the sequestering agents used in active caps and *in situ* treatments will bind elements introduced from uncontrolled sources of ongoing contamination, thereby reducing their bioavailability and protecting underlying, previously remediated sediments from recontamination. Competitive interactions between Cu and other elements were investigated to better understand conditions occurring at actual contaminated sediment sites where several

contaminants often co-occur. Tested elements in surface water remained at significantly lower concentrations in mesocosms with apatite and mixed amendment caps than in mesocosms with passive caps (sand), uncapped sediment, and spike solution throughout the 2880 h experiment. Element concentrations were significantly higher in *Lumbriculus variegatus* from untreated sediment than in *Lumbriculus variegatus* from the active caps, and regressions of element concentrations in *Lumbriculus* on element concentrations in the top 2.5 cm of sediment or cap measured by DGT were strong and significant ($p<0.05$) for most tested elements. Comparing results for Cu between Experiment I (Cu mixed with As, Cd, Pb, and Zn) and Experiment II (Cu only) showed that the ability of a mixed amendment active cap to control Cu was not affected by the presence of other elements. Our findings showed that some types of active caps can protect remediated sediments by reducing the bioavailable pool of elements from ongoing sources of contamination and that the ability of mixed amendment caps to control the bioaccumulation of Cu was not affected by the presence of other elements. This knowledge will contribute to more rigorous risk management that incorporates the resilience of remedies in the face of ongoing contamination into the criteria for remedy selection.

## 4.2 TASK2 UNDERSTANDING RELATIONSHIPS AMONG REMEDIATION METHODS, LOW LEVEL INFLUXES OF CONTAMINANTS, AND BIOLOGICAL RECEPTORS – COMPREHENSIVE STUDY

### 4.2.1. Introduction

Sediment with buried heavy metals may act as a source of contaminants with disturbances such as bioturbation and bioirrigation by benthic organisms (Remaili et al., 2008 and 2017; Joseffson et al., 2010). Several studies have demonstrated that bioturbation can influence the transfer of heavy metals between sediment and water. Tubificid worms renewed particles and adsorption sites for Cd at the interface of sediment and water and increased the Cd content in the sediment layer (Ciutat et al., 2005). However, the bivalve *Tellina deltoidalis* had little effect on the release of Zn and Pb from the sediment (Atkinson et al., 2007). Similarly, tubificids had little impact on Pb remobilization from the sediment, and bioturbation by *Monoporeia affinis* was insufficient to release Cu from Cu enriched sediment (Ospina-Alvarez et al., 2014). These findings suggest that the influence of bioturbation on heavy metals fluxes in sediment is complex and differs among bioturbating organisms (He et al., 2017).

The preceding research investigated the effects of bioturbation on metal fluxes in previously contaminated sediment. However, little is known concerning the effects of bioturbation on metal fluxes in contaminated sediment that has been deposited over previously remediated sediment; i.e., remediated sediment that has been recontaminated by the continued influx of contaminated sediment. Recontamination of remediated sediments by contaminated sediment influxes from permitted discharges, upstream contaminated sites, or stormwater discharge can slow or reverse recovery associated with sediment remediation and is the subject of increasing interest.

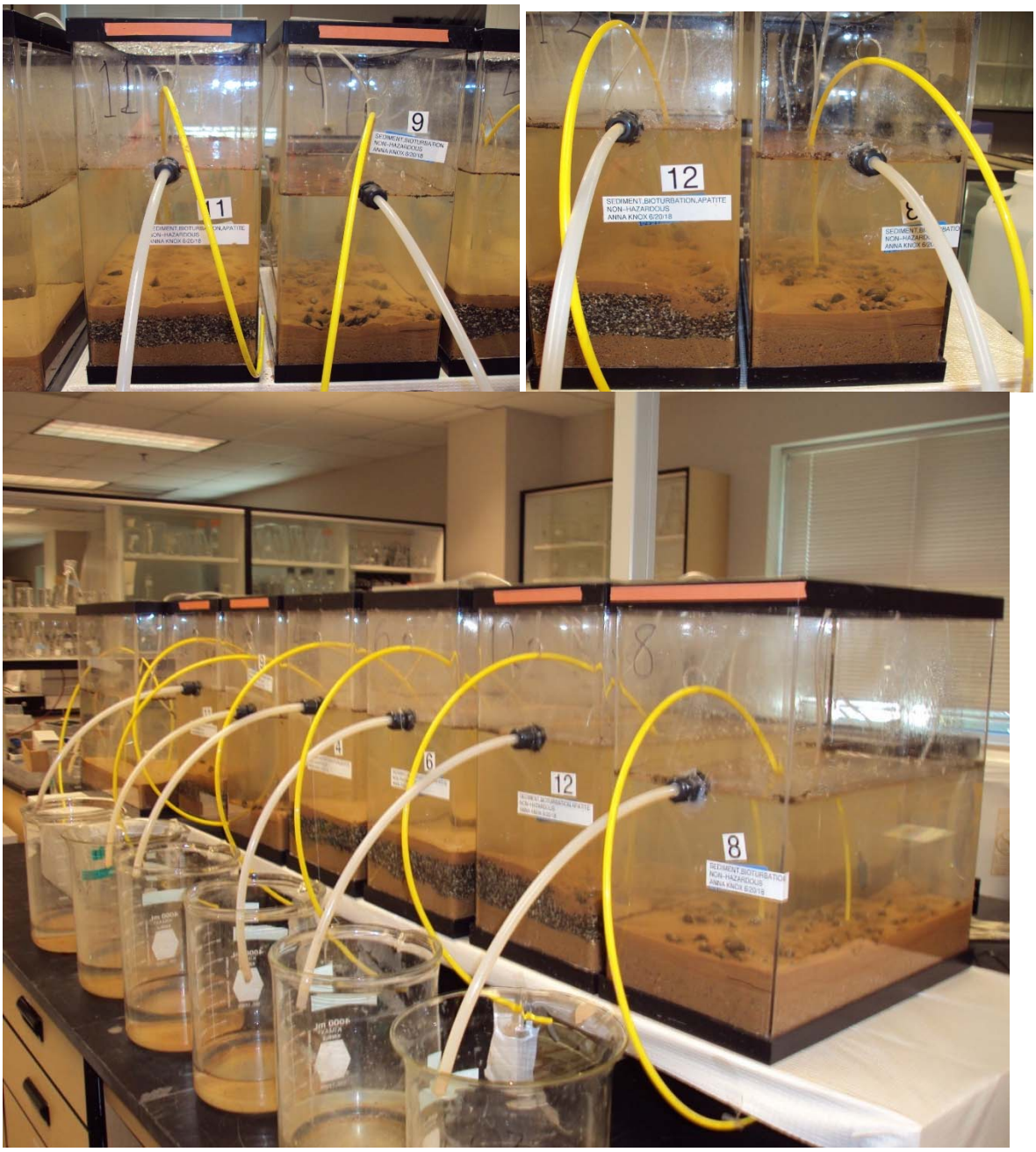
We employed experimental mesocosms to investigate the effects of bioturbation on the recontamination of clean sediment (e.g., sediments remediated by the removal of contaminants; i.e., dredging) and sediment that has been capped with chemically active materials that sequester contaminants (i.e., active capping). Bioturbation can influence recontamination processes by mixing newly deposited contaminated sediment with underlying uncontaminated sediment in the case of dredging or sequestering agents in the case of active capping. It may contribute to the release of contaminants from the newly deposited contaminated sediment or to their sequestration by burial in underlying clean sediments or active capping materials. In the latter case, contaminants may react with the capping materials to reduce their toxicity and bioavailability.

The objective of this research was to assess the effects of bioturbation on an incoming particulate contaminant load deposited over underlying clean sediment or active capping material. The effects of bioturbation were evaluated based on 1) metal fluxes from contaminated sediment to the overlying water, 2) the distribution of contaminants in the sediment, and 3) contaminant bioavailability and toxicity. We hypothesized that the bioturbation of contaminated sediment deposited over active caps would increase the contact of this sediments with underlying cap materials through mixing, thereby fostering chemical sequestration processes that reduce contaminant bioavailability and toxicity and the release of contaminants to the water column. We also hypothesized that these effects would be absent or weaker when bioturbation occurs in

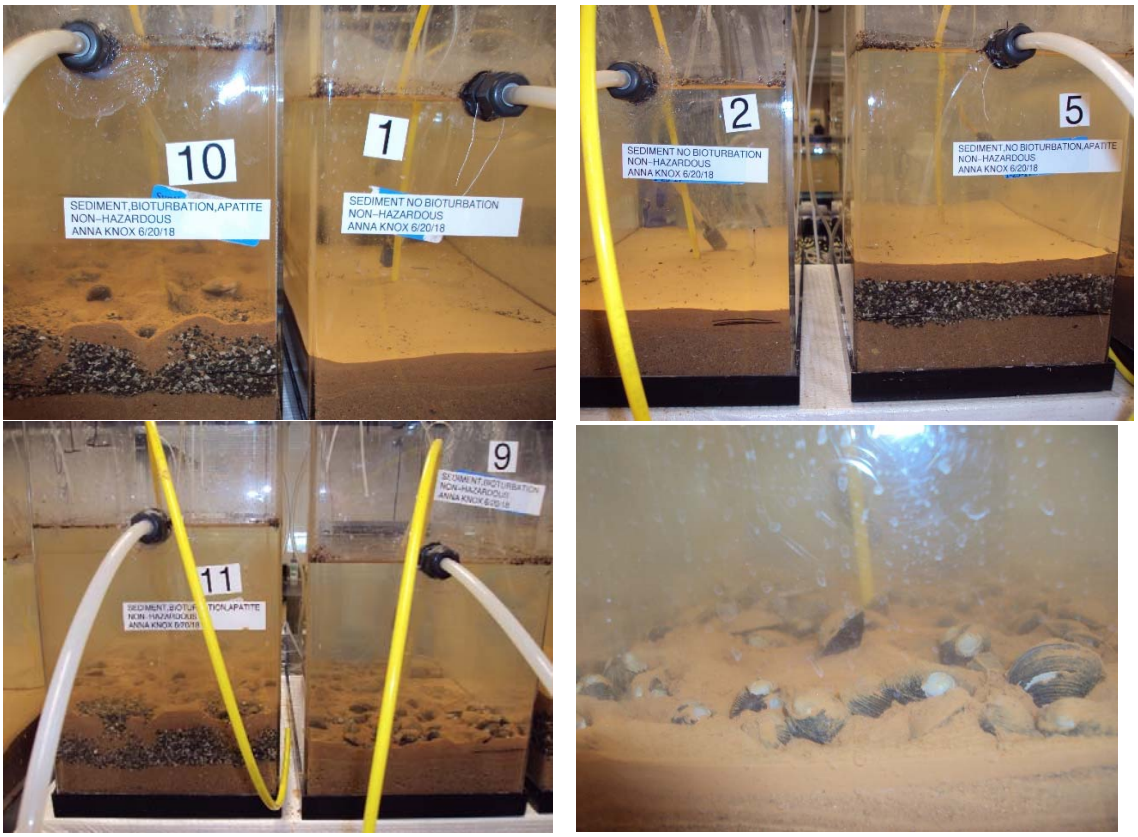
contaminated sediment deposited over uncontaminated sediment, as would be the case when areas dredged for contaminant removal are subjected to recontamination

### 4.2.2 Effects of bioturbation on contaminated sediment layer

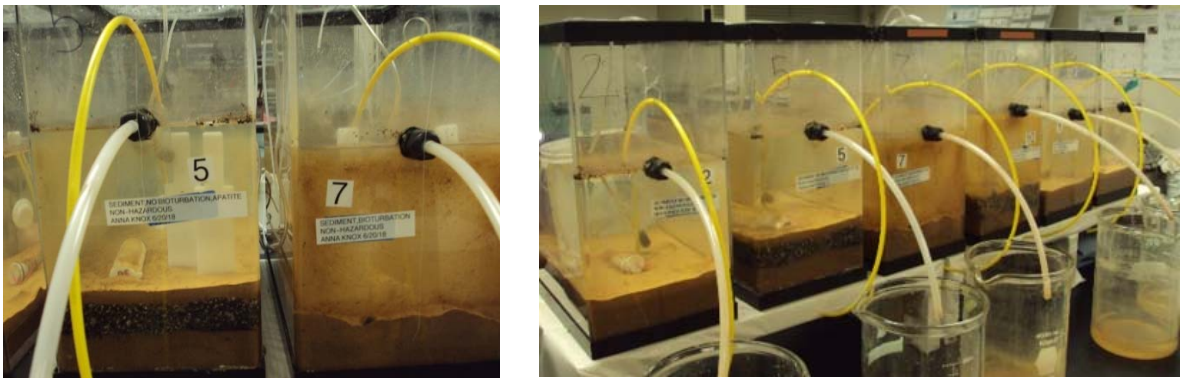
Bioturbation caused by the burrowing Asian clams strongly affected the integrity and vertical distribution of the layer of contaminated sediment that was added to the mesocosms. The added contaminated sediment initially formed a well consolidated and distinct layer overlying the cap or uncontaminated sediment in each mesocosm. Within 24 hours bioturbation was visible in all tanks with clams (Picture 14). Within 5 days bioturbation disrupted the layer of added sediment and mixed it with underlying materials (i.e., apatite or uncontaminated sediment) (Picture 15). By the end of the 28-day bioturbation experiment, mixing was extensive, as was particularly evident in the apatite treatments in which substantial quantities of apatite had been translocated above the contaminated sediment (Pictures 16 and 17). The estimated depth of bioturbation in the mesocosm was about 3 cm. Progression of the 28-day bioturbation experiment in tanks with uncapped sediment and sediment with apatite caps is shown in Pictures 14 - 17.



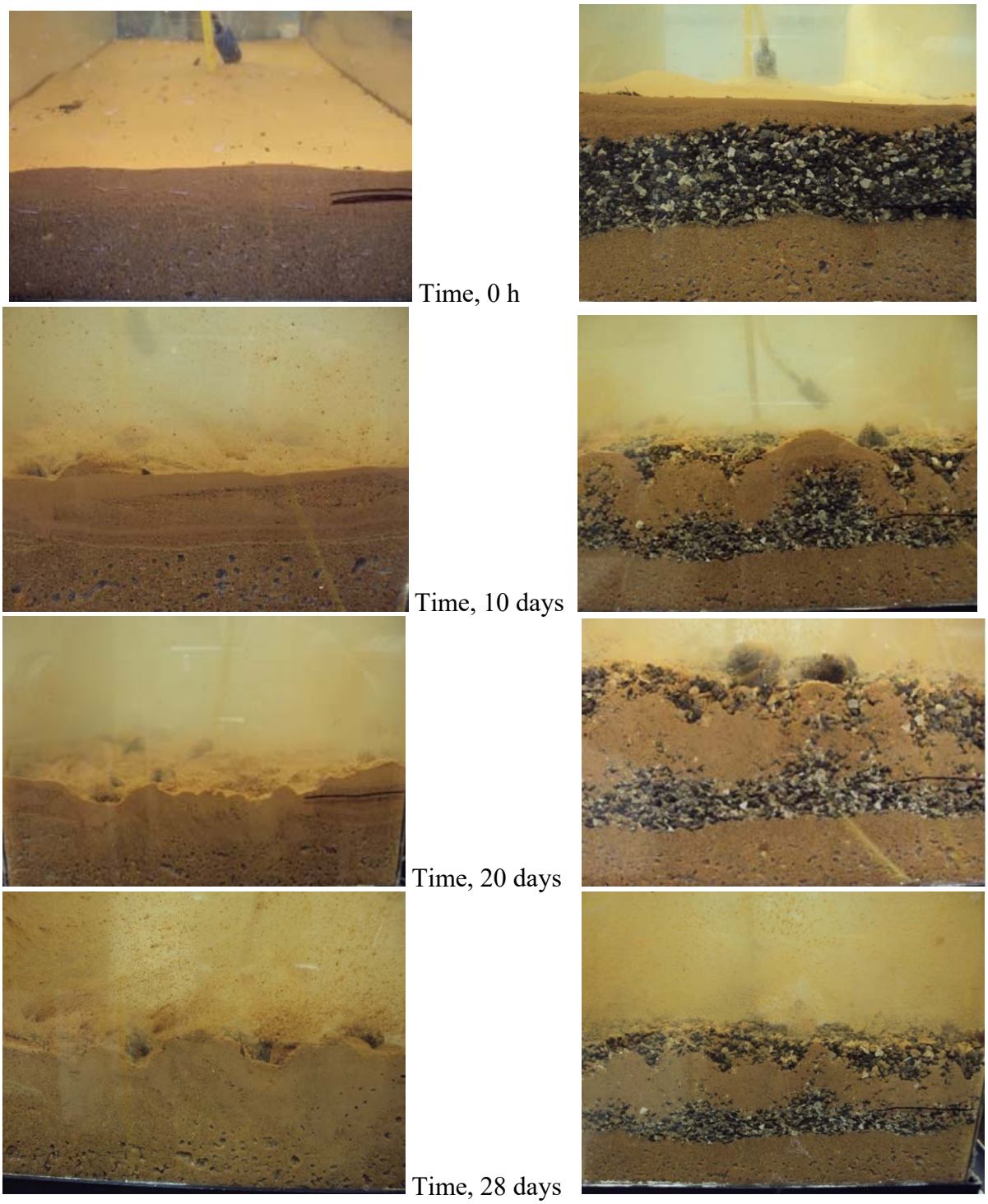

Picture 14. Twenty-four hours after the addition of Asian clams; mesocosms with bioturbation are marked by red tape.




Picture 15. Five days after addition of Asian clams (time, 120 hours). Comparison among treatments without bioturbation (tanks: 1, 2 and 5) and with bioturbation (tanks: 9, 10, and 11).




Picture 16. Twenty-five days after addition of Asian clams (time, 600 hours). Comparison among treatments without bioturbation (tanks: 2, 5 and 6) and with bioturbation (tanks: 7 and 10). Cages with California back worms and water and sediment DGT probes are visible in the mesocosms.




Picture 1. Progression of 28-day bioturbation experiment in tanks with sediment only (left column) and with apatite cap (right column).

### 4.2.3 Pore water properties and metal concentrations

Pore water properties are summarized in Tables 21 and Figures 32 and 33. The apatite caps strongly influenced pore water properties, especially pore water electrical conductivity (EC) and pH (Table 21). The highest pore water EC and pH values were observed in mesocosms with apatite caps with and without bioturbation. Electrical conductivity was slightly lower in the uncapped sediment without bioturbation (Table 21 and Figures 32 and 33).

The apatite caps contributed to changes in the ORP of pore water in sediment under the caps as shown in Table 21. Generally, ORP in the sediment beneath the caps was lower than in the sediment of the control treatments. This decrease was likely due to the addition of the layer of contaminated sediment and the apatite cap, which reduced oxygenation of the underlaying sediment. Bioturbation did not have obvious effects on ORP values (Table 21).

**Table 21. Properties of pore water collected at the end of experiment (time, 696 h); NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

| Treatments | Sample ID | pH | EC | Temp. | ORE |
|---|---|---|---|---|---|
| | | | μS/cm | °C | mV |
| SED-NB | 1 | 5.28 | 161.8 | 20.5 | -10 |
| SED-NB | 2 | 5.28 | 159 | 20.7 | -15 |
| SED-NB | 3 | 5.24 | 165.3 | 20.5 | -13 |
| A-NB | 4 | 7.78 | 1064 | 20.8 | -23 |
| A-NB | 5 | 7.73 | 955.4 | 20.5 | -26 |
| A-NB | 6 | 7.6 | 1151 | 20.6 | -30 |
| SED-B | 7 | 6.64 | 350 | 20.7 | -32 |
| SED-B | 8 | 5.52 | 128.5 | 20.5 | -32 |
| SED-B | 9 | 6.36 | 211.9 | 20.7 | -32 |
| A-B | 10 | 7.87 | 944.7 | 20.8 | -28 |
| A-B | 11 | 7.79 | 1016 | 20.5 | -30 |
| A-B | 12 | 7.79 | 788.4 | 20.5 | -29 |

Cu, Ni, Cd, Zn, and Pb concentrations were lower in mesocosms with active caps than in mesocosms with untreated sediments (Figure 34, raw data Table A1.85). Two-way ANOVA indicated that pore water concentrations of Ni, Zn, and Cd were significantly ($p<0.05$) lower in mesocosms with apatite caps than in sediment-only mesocosms, and that pore water concentrations of these metals were not affected by bioturbation (Table 22). In contrast, two-way ANOVA of Cu and Pb pore water concentrations indicated a significant interaction between treatment and bioturbation because bioturbation strongly increased porewater concentrations of these metals in the sediment-only mesocosms but not in the mesocosms with active caps. In the latter, porewater Cu and Pb concentrations remained significantly lower than in the sediment-only mesocosms regardless of the presence of bioturbating organisms (Figure 34). In summary, the ANOVAs indicated that apatite caps kept pore water metal concentrations at low levels even in the presence of bioturbation that caused marked increases in contamination in uncapped sediment.

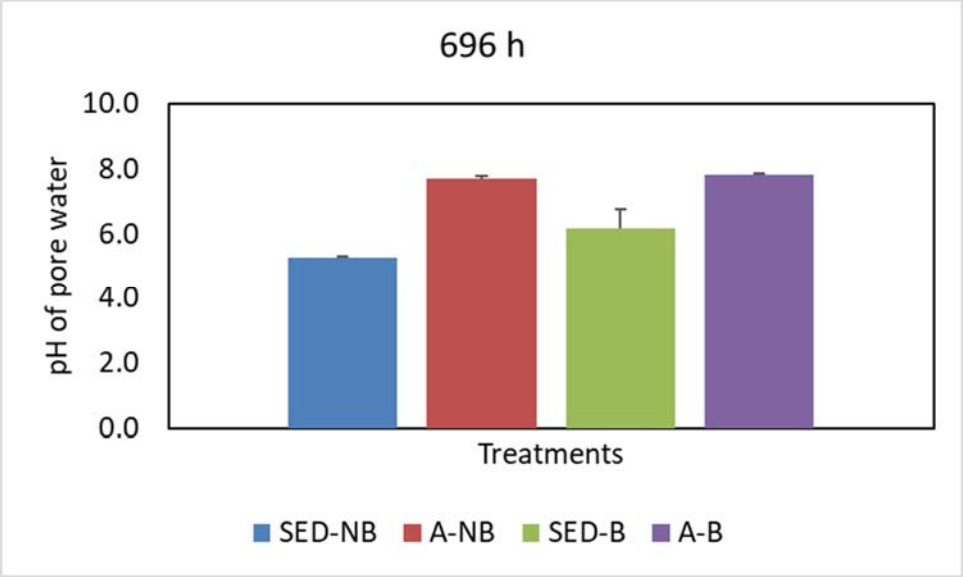



**Figure 32. Average pore water pH for each treatment (time, 696 h). NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

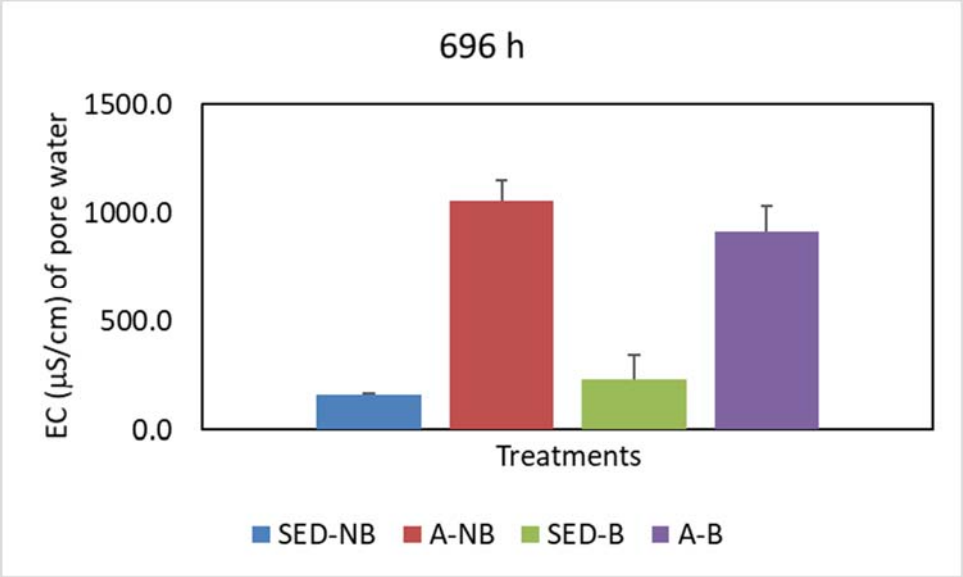



**Figure 33. Average pore water electrical conductivity (EC) for each treatment (time, 696 h). NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

**Table 22. Two-way ANOVAs of pore water metal concentrations in the experimental mesocosms. Main effects were treatment (apatite caps vs. sediment only) and bioturbation (presence vs. absence).**

| Metal | Treatment means (μg $L^{-1}$) | | | | Probabilities (Two-way ANOVA) | | |
|---|---|---|---|---|---|---|---|
| | Sediment | | Apatite cap | | | | |
| | Bioturbation | No bioturbation | Bioturbation | No bioturbation | Interaction | Treatment | Bioturbation |
| Cu | 2.59 | 7.10 | 1.21 | 1.30 | 0.025 | 0.002 | 0.021 |
| Ni | 19.13 | 22.31 | 5.42 | 4.16 | 0.642 | 0.009 | 0.839 |
| Zn | 65.27 | 71.81 | 41.39 | 41.48 | 0.599 | 0.002 | 0.590 |
| Pb | 1.75 | 4.63 | 0.86 | 0.68 | 0.005 | <0.001 | 0.010 |
| Cd | 4.28 | 4.00 | 0.84 | 0.82 | 0.896 | 0.011 | 0.885 |

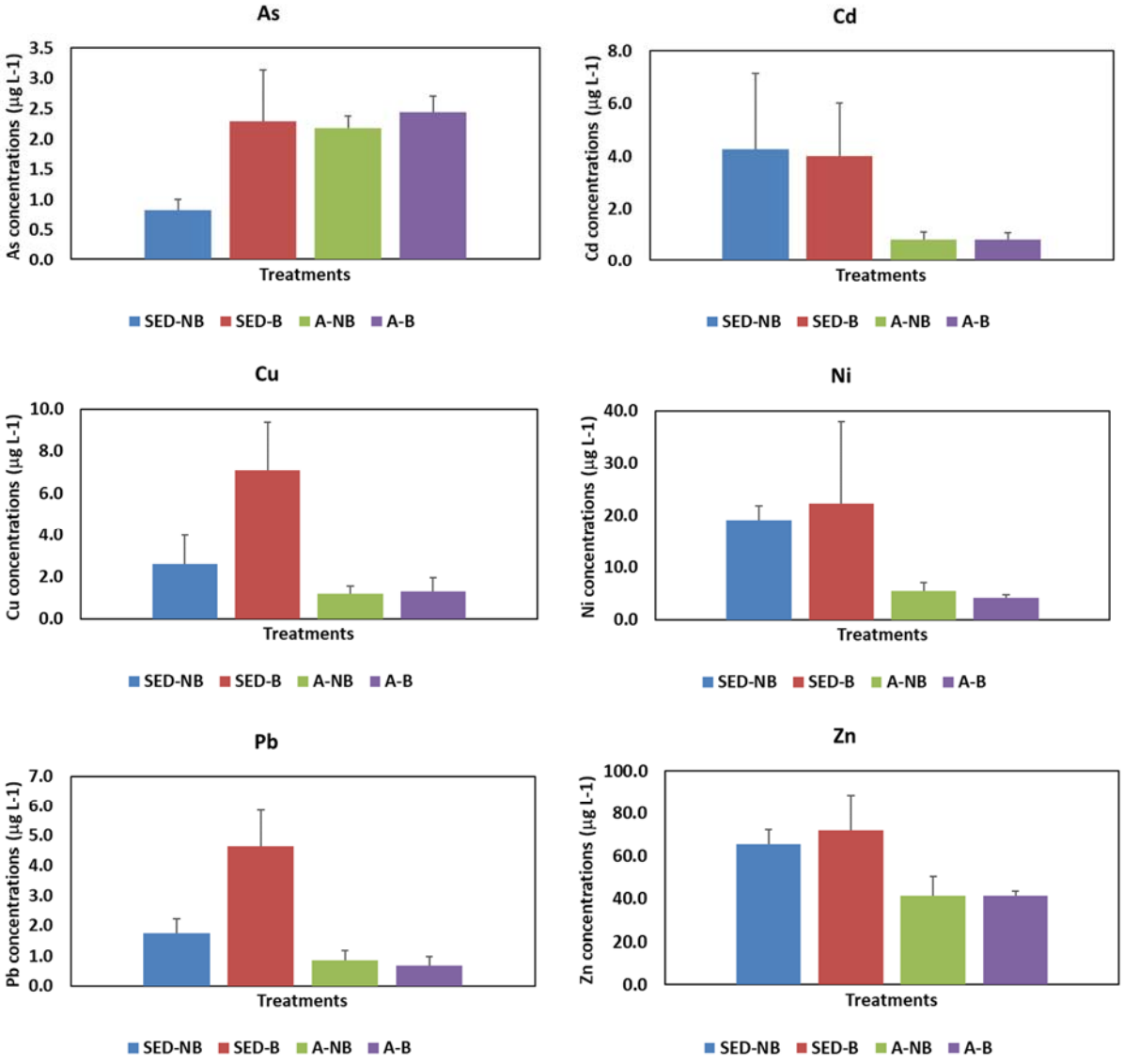



**Figure 34. Arsenic, Cd, Cu, Ni, Pb, and Zn concentrations in pore water collected at the end of experiment (time, 696 h).**

### 4.2.4 Surface water properties

Surface water properties were measured 8 times during the experiment at 0, 1, 24, 96, 264, 432, 600, and 696 hours. The following properties were measured: dissolved oxygen, temperature, electrical conductivity, pH, turbidity, and hardness. Surface water raw data (pH, electrical conductivity (RC), turbidity, and dissolved oxygen) are presented in Tables 23 – 26. Figures 35 - 42 show average values (8 sampling) of surface water pH, electrical conductivity (EC), turbidity, and dissolved oxygen.

Surface water pH was affected by the cap materials and to some degree by bioturbation (Table 23 and Figures 35 -36). The highest pH values were in treatments with apatite caps (Table 23 and Figures 35 - 36). However, the contaminated sediment layer that was deposited above the uncontaminated sediment and active caps briefly lowered surface water pH after deposition (Figures 35); the lowest values were observed 1 hour after deposition.

In contrast, electrical conductivity (EC) increased immediately after deposition of the contaminated sediment above the clean sediment or apatite caps (Figure 37). With time, electrical conductivity in all treatments gradually decreased, but decreased less in bioturbation treatments than in treatments without bioturbation. The highest electrical conductivity throughout the experiment was observed in mesocosms with apatite caps Table 24 and Figures 37 – 38).

Surface water turbidity increased immediately after deposition of the contaminated sediment (Figure 39). However, turbidity levels decreased rapidly in all treatments, and turbidity levels declined to baseline levels (i.e., similar to time 0 hour) in all mesocosm by 96 hours. After 96 hours, turbidity slowly increased in the mesocosms with bioturbation. At 696 hours, the highest turbidity levels were in mesocosms with apatite caps (Table 25 and Figures 39 - 40).

Surface water dissolved oxygen concentrations were similar among treatments and were consistent during the test period of 696 h (Table 26 and Figures 41 - 42).

The average temperature (20.3 $^{o}$C) was similar among treatments and stable throughout the experiment.

**Table 23. Raw data and average values of surface water pH for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

| Treatments | Sample ID | Time, h | | | | | | | | All | All |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 24 | 96 | 264 | 432 | 600 | 696 | AVG | STDEV |
| SED-NB | 1 | 6.43 | 5.38 | 5.45 | 6.14 | 7.14 | 7.4 | 7.39 | 7.26 | 6.6 | 0.8 |
| SED-NB | 2 | 6.24 | 5.2 | 5.44 | 6.08 | 7.09 | 7.38 | 7.4 | 7.41 | 6.5 | 0.9 |
| SED-NB | 3 | 6.22 | 5.12 | 5.45 | 6.05 | 7 | 7.3 | 7.35 | 7.37 | 6.5 | 0.9 |
| A-NB | 4 | 7.83 | 6.87 | 7.21 | 7.71 | 7.96 | 7.9 | 7.64 | 7.8 | 7.6 | 0.4 |
| A-NB | 5 | 7.83 | 6.8 | 7.14 | 7.73 | 7.95 | 7.84 | 7.71 | 7.83 | 7.6 | 0.4 |
| A-NB | 6 | 7.82 | 6.88 | 7.28 | 7.79 | 7.91 | 7.81 | 7.75 | 7.8 | 7.6 | 0.4 |
| SED-B | 7 | 6.3 | 5.3 | 5.51 | 6.57 | 7.34 | 7.62 | 7.89 | 7.74 | 6.8 | 1.0 |
| SED-B | 8 | 6.28 | 5.35 | 5.5 | 6.54 | 7.34 | 7.64 | 7.98 | 7.75 | 6.8 | 1.0 |
| SED-B | 9 | 6.37 | 5.27 | 5.45 | 6.59 | 7.4 | 7.88 | 7.91 | 7.77 | 6.8 | 1.1 |
| A-B | 10 | 7.95 | 6.8 | 7.26 | 7.69 | 7.94 | 8.14 | 8.27 | 8.22 | 7.8 | 0.5 |
| A-B | 11 | 7.95 | 6.9 | 7.31 | 7.72 | 7.98 | 8.14 | 8.26 | 8.24 | 7.8 | 0.5 |
| A-B | 12 | 7.95 | 6.96 | 7.3 | 7.68 | 7.91 | 8.16 | 8.26 | 8.23 | 7.8 | 0.5 |

**Table 24. Raw data and average values of surface water electrical conductivity (EC, μS cm$^{-1}$) for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A – apatite.**

| Treatments | Sample ID | Time, h | | | | | | | | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 24 | 96 | 264 | 432 | 600 | 696 | All | All |
| SED-NB | 1 | 75.29 | 306 | 300 | 272 | 213 | 179 | 151 | 145 | 205.2 | 82.6 |
| SED-NB | 2 | 76.54 | 270 | 300 | 260 | 210 | 171 | 154 | 148 | 198.7 | 75.1 |
| SED-NB | 3 | 68.72 | 250 | 299 | 274 | 221 | 179 | 158 | 148 | 199.7 | 75.9 |
| A-NB | 4 | 664 | 789 | 790 | 717 | 558 | 422 | 364 | 338 | 580.3 | 186.8 |
| A-NB | 5 | 609 | 722 | 783 | 698 | 512 | 400 | 333 | 312 | 546.1 | 183.9 |
| A-NB | 6 | 624.7 | 731 | 799 | 706 | 543 | 434 | 370 | 339 | 568.3 | 174.2 |
| SED-B | 7 | 69.56 | 306 | 308 | 270 | 277 | 253 | 231 | 225 | 242.4 | 76.3 |
| SED-B | 8 | 69.14 | 302 | 291 | 312 | 310 | 283 | 260 | 243 | 258.8 | 80.3 |
| SED-B | 9 | 76.25 | 304 | 291 | 289 | 287 | 276 | 257 | 241 | 252.7 | 74.1 |
| A-B | 10 | 646 | 794 | 823 | 731 | 618 | 565 | 510 | 471 | 644.8 | 129.2 |
| A-B | 11 | 643 | 781 | 805 | 720 | 672 | 589 | 531 | 504 | 655.6 | 110.6 |
| A-B | 12 | 624 | 747 | 817 | 740 | 634 | 574 | 513 | 472 | 640.1 | 120.6 |

**Table 25. Raw data and average values of surface water turbidity (in NTU) for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

| Treatments | Sample ID | Time, h | | | | | | | | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 24 | 96 | 264 | 432 | 600 | 696 | All | All |
| SED-NB | 1 | 2.3 | 370 | 190 | 4.56 | 4.3 | 2.3 | 2.7 | 2.7 | 72.4 | 136.9 |
| SED-NB | 2 | 2.4 | 350 | 200 | 5.72 | 3.6 | 3.2 | 2.7 | 2.7 | 71.3 | 132.0 |
| SED-NB | 3 | 3.1 | 515 | 189 | 4.12 | 4.3 | 3.5 | 2.3 | 2.3 | 90.5 | 183.4 |
| A-NB | 4 | 1.9 | 1061 | 245 | 4.72 | 2.7 | 4.5 | 3.2 | 3.2 | 165.8 | 371.5 |
| A-NB | 5 | 1.5 | 658 | 256 | 4.25 | 3.8 | 3.2 | 3.1 | 3.1 | 116.6 | 236.0 |
| A-NB | 6 | 1.4 | 726 | 234 | 3.18 | 4.1 | 2.9 | 2.9 | 2.9 | 122.2 | 257.0 |
| SED-B | 7 | 2.4 | 500 | 180 | 4.67 | 5.2 | 6.2 | 2.7 | 2.7 | 88.0 | 177.5 |
| SED-B | 8 | 2.6 | 535 | 206 | 5.21 | 5.1 | 6.9 | 7.3 | 7.3 | 96.9 | 190.4 |
| SED-B | 9 | 2.7 | 480 | 196 | 4.89 | 4.9 | 5.9 | 8.4 | 8.4 | 88.9 | 171.5 |
| A-B | 10 | 1.9 | 611 | 245 | 5.32 | 5.2 | 6.7 | 7.8 | 7.8 | 111.3 | 218.6 |
| A-B | 11 | 2 | 886 | 230 | 5.67 | 4.89 | 7.2 | 9.4 | 9.4 | 144.3 | 309.7 |
| A-B | 12 | 1.8 | 890 | 210 | 5.45 | 5.3 | 8.3 | 8.5 | 8.5 | 142.2 | 310.4 |

**Table 26. Raw data and average values of surface water dissolved oxygen (in mg $L^{-1}$) for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

| Treatments | Sample ID | Time, h | | | | | | | | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 24 | 96 | 264 | 432 | 600 | 696 | All | All |
| SED-NB | 1 | 7.6 | 6.78 | 7.67 | 7.85 | 7.88 | 7.77 | 7.89 | 7.89 | 7.7 | 0.4 |
| SED-NB | 2 | 7.54 | 6.45 | 7.89 | 7.67 | 7.67 | 7.68 | 7.67 | 7.67 | 7.5 | 0.4 |
| SED-NB | 3 | 7.63 | 5.67 | 6.78 | 7.86 | 7.68 | 7.89 | 7.56 | 7.56 | 7.3 | 0.8 |
| A-NB | 4 | 7.45 | 5.67 | 6.89 | 7.98 | 7.98 | 7.87 | 7.89 | 7.89 | 7.5 | 0.8 |
| A-NB | 5 | 7.65 | 5.76 | 7.32 | 7.56 | 7.89 | 7.68 | 7.56 | 7.56 | 7.4 | 0.7 |
| A-NB | 6 | 7.86 | 5.78 | 7.34 | 7.89 | 7.92 | 7.99 | 7.56 | 7.56 | 7.5 | 0.7 |
| SED-B | 7 | 7.68 | 6.34 | 7.34 | 7.89 | 8.01 | 7.6 | 7.89 | 7.89 | 7.6 | 0.5 |
| SED-B | 8 | 7.56 | 6.45 | 7.23 | 7.99 | 7.98 | 7.99 | 7.67 | 7.67 | 7.6 | 0.5 |
| SED-B | 9 | 7.97 | 6.54 | 7.34 | 7.67 | 7.78 | 8.01 | 7.89 | 7.89 | 7.6 | 0.5 |
| A-B | 10 | 7.89 | 5.87 | 7.5 | 7.89 | 8.01 | 8.02 | 7.98 | 7.98 | 7.6 | 0.7 |
| A-B | 11 | 7.98 | 6.01 | 7.34 | 7.88 | 7.99 | 8.03 | 7.89 | 7.89 | 7.6 | 0.7 |
| A-B | 12 | 7.9 | 5.98 | 7.4 | 7.77 | 7.89 | 7.99 | 7.67 | 7.67 | 7.5 | 0.7 |

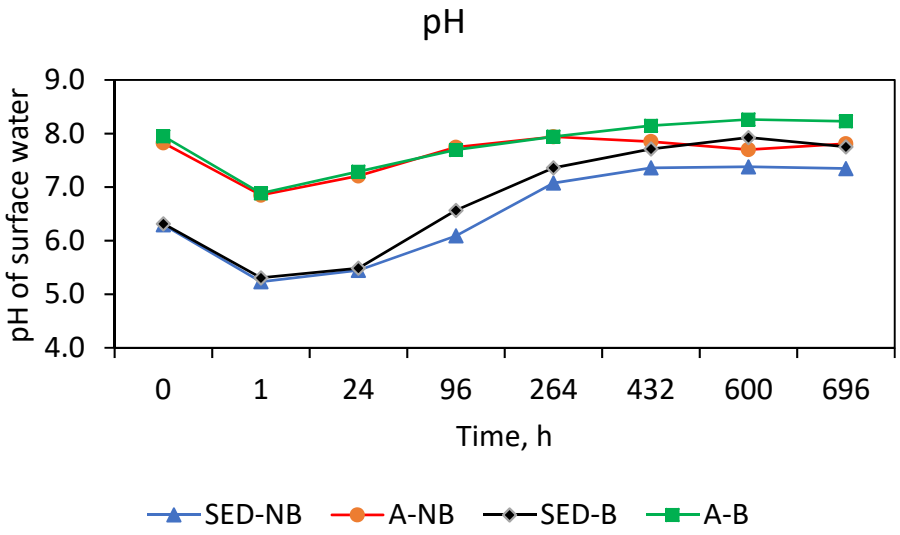



**Figure 35. Average values of surface water pH for all 8 samplings of surface water collected from time 0 to 696 hours. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

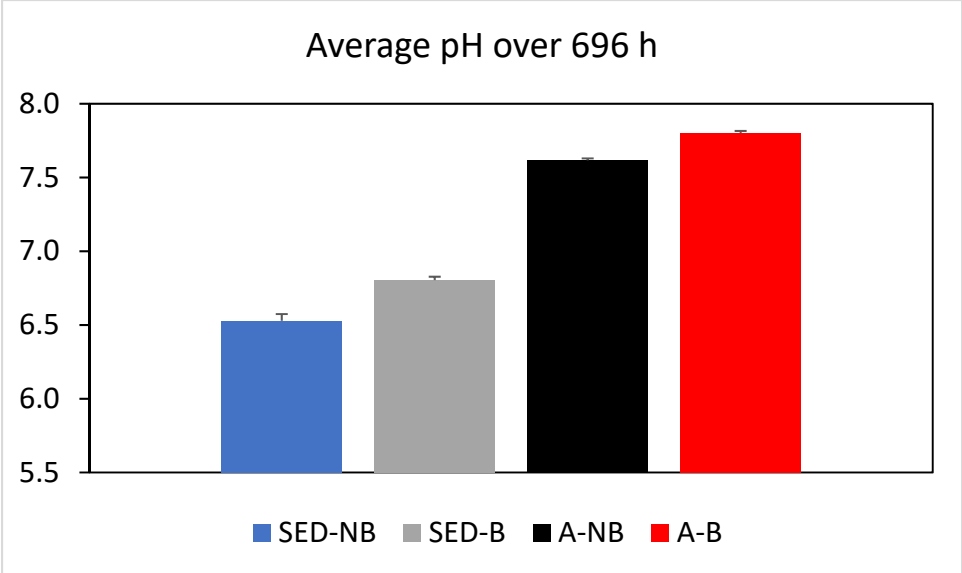



**Figure 36. Average values of surface water turbidity (in NTU) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

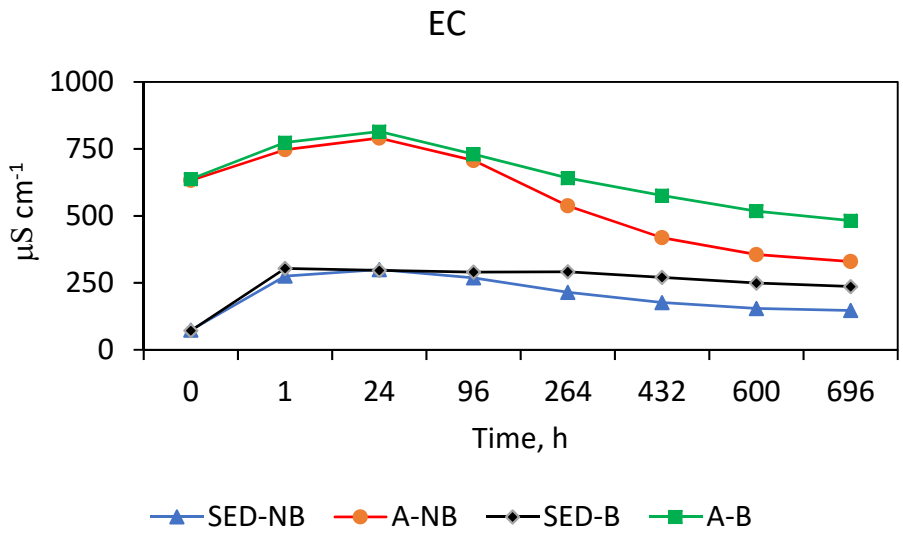



**Figure 37. Average values of surface water electrical conductivity (EC) for all 8 samplings of surface water collected from time 0 to 696 hours. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

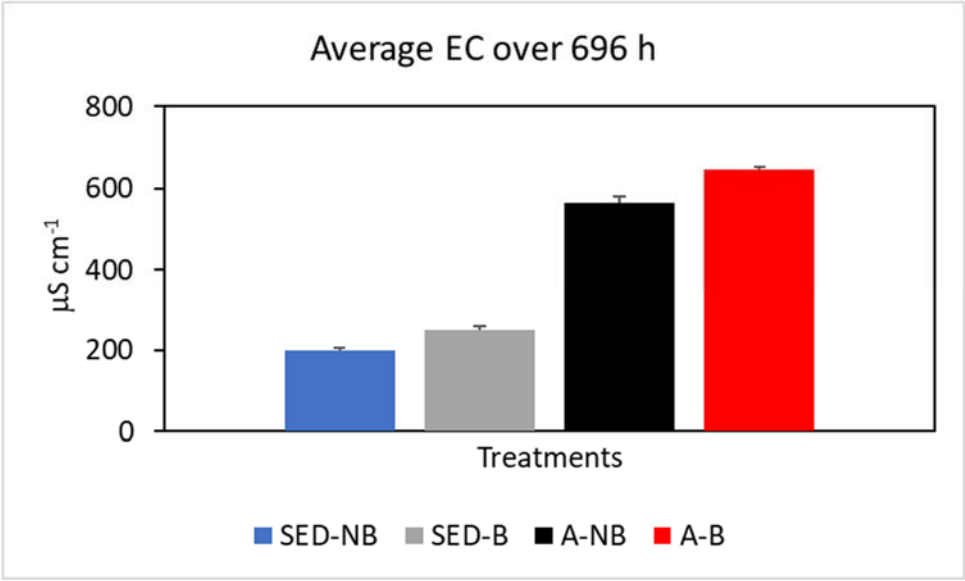



**Figure 38. Average values of surface water electrical conductivity (EC) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

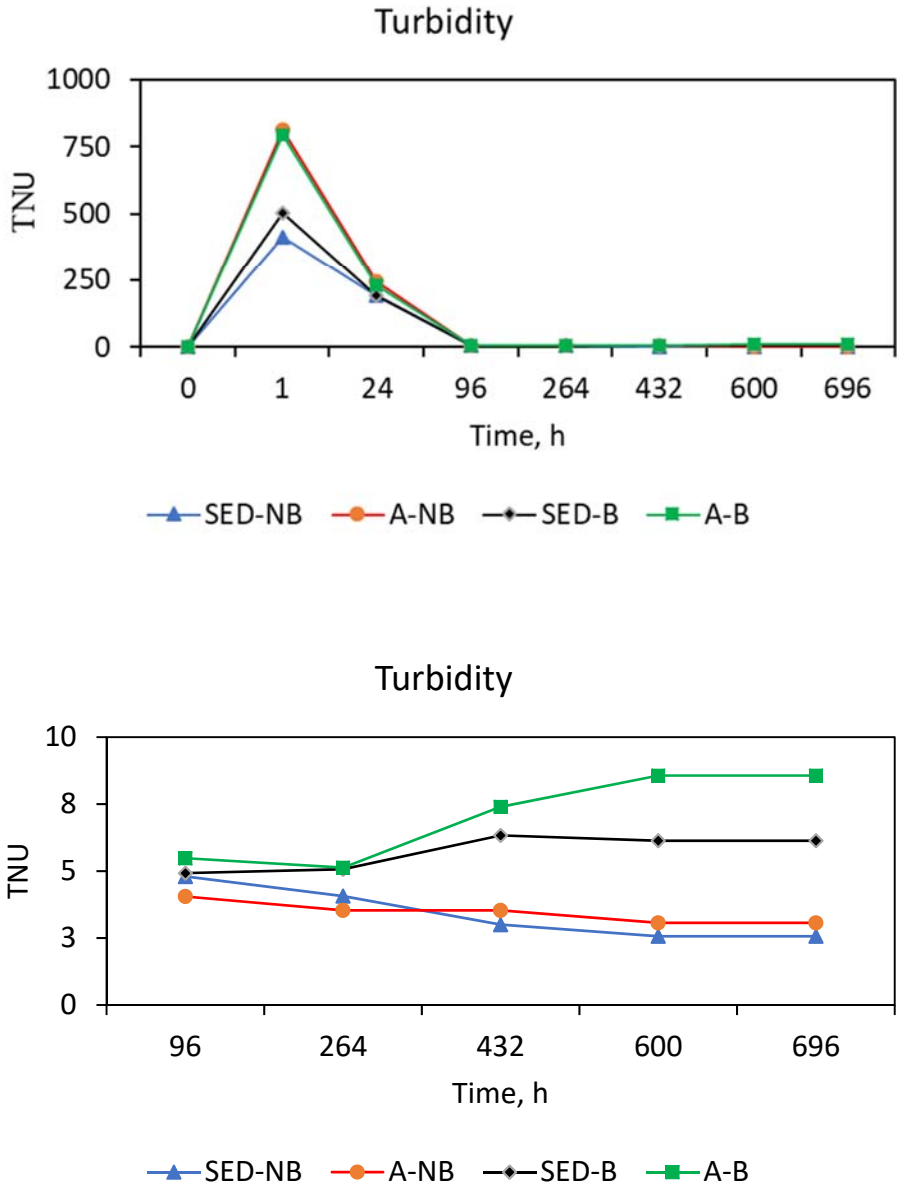



**Figure 39. Average values of surface water electrical conductivity (EC) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

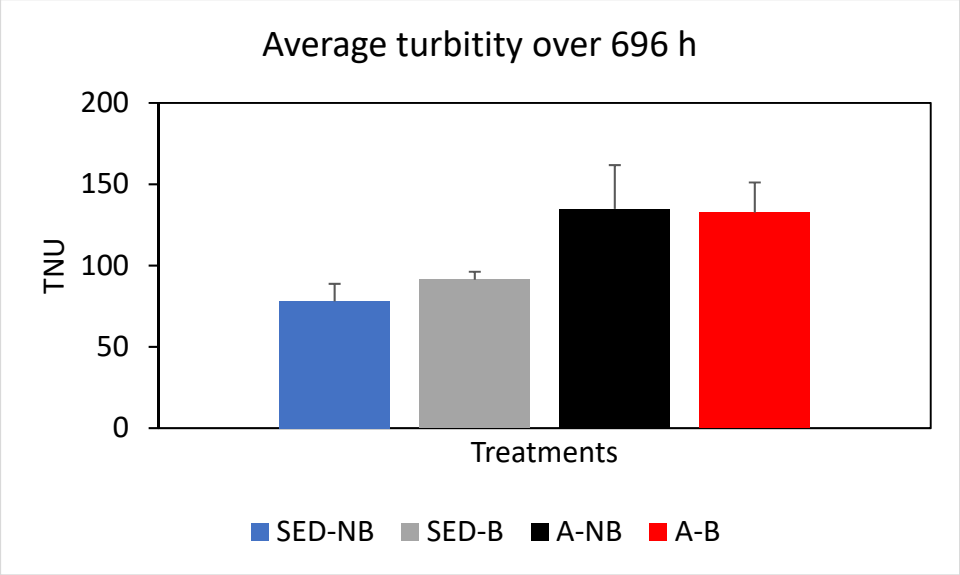



**Figure 40. Average values of surface water electrical conductivity (EC) for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

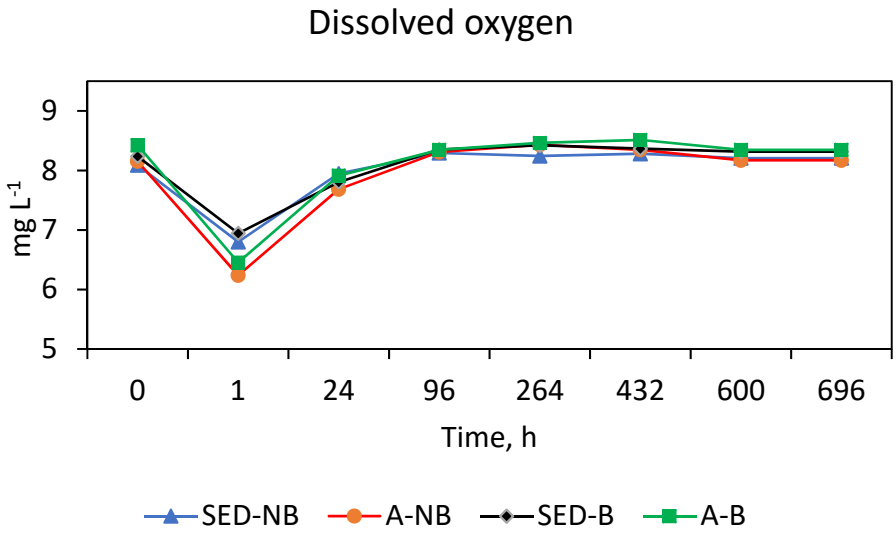



**Figure 41. Average values of surface water dissolved oxygen for all 8 samplings of surface water collected from time 0 to 696 h. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

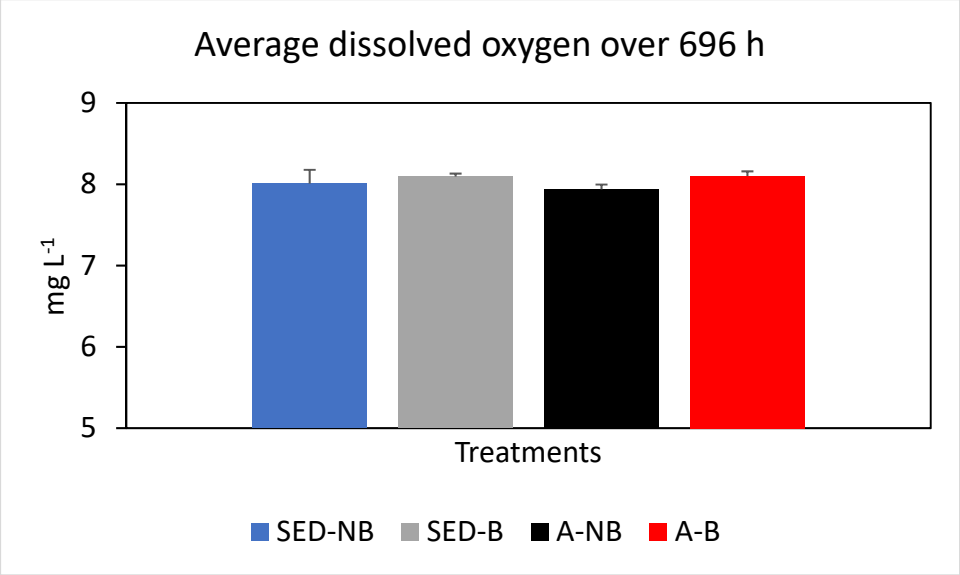



**Figure 42. Average values of surface water dissolved oxygen for all 8 samplings. NB – treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A - apatite.**

### 4.2.5 Effects of incoming contaminant load on element level in surface water

The greatest release of metals to surface waters occurred after the addition of contaminated sediment to the mesocosms (Appendix 1, Table A1.86 - raw data, and Figures 43-50). Total (i.e., sum of dissolved and particulate) As, Cd, Cu, Mn, Ni, Pb, and Zn concentrations were highest at 24 h and decreased to relatively low concentrations by 96 - 264 h for all metals (Figures 43-50). The strongest decreases were observed for Mn, Cu, and Pb. The presence of suspended sediment in the water column resulted in relatively high particulate metal fractions for some metals (especially Cu, As, and Pb) following the addition of the contaminated sediment. This fraction decreased rapidly for Mn, Cu, As, and Ni and, to a lesser extent, Zn and Ni, as suspended particles settled to the bottom. Pb differed in being almost entirely in particulate form throughout the study.

Two-way ANOVA of Cu, As, Ni, and Cd surface water concentrations indicated significant ($P \leq 0.05$) interactions between treatment and bioturbation. The interactions were similar for Cd and Ni: bioturbation had relatively little effect in mesocosms with active caps but greatly decreased concentrations of both metals in mesocosms with uncapped sediment (Figure 50). Cu exhibited a different interaction: bioturbation had little effect on metal concentrations in mesocosms with active caps but greatly increased Cu concentrations in mesocosms with uncapped sediment (Figure 50). Arsenic exhibited a weaker, although still significant, interaction in which bioturbation increased concentrations in both apatite cap and uncapped sediment mesocosms but increased it more in the latter. The two-way ANOVA for Zn lacked a significant interaction but indicated significant main effects for treatment and bioturbation at $P<0.05$. Zn concentrations were lower in mesocosms with active caps and lower in mesocosms with bioturbation (Figure 50).

The preceding results show that bioturbation and capping had interacting effects that differed among metals. Apatite caps maintained relatively low surface water concentrations of all metals except As regardless of bioturbation. In contrast, the ability of uncapped sediment to control surface water metal concentrations was strongly affected by bioturbation, which increased As, and Cu levels but decreased Cd, Ni, and Zn levels. Increases in As and Cu may have been caused by the release of metals due to disturbance of the sediment surface by bioturbating organisms. Decreases in Cd, Ni, and Zn levels may have been related to the capture of metals by sediment particles, which was facilitated by renewal of the sediment surface by bioturbation. This also occur to a lesser degree in the mesocosms with apatite caps (Figures 44, 47 and 48).

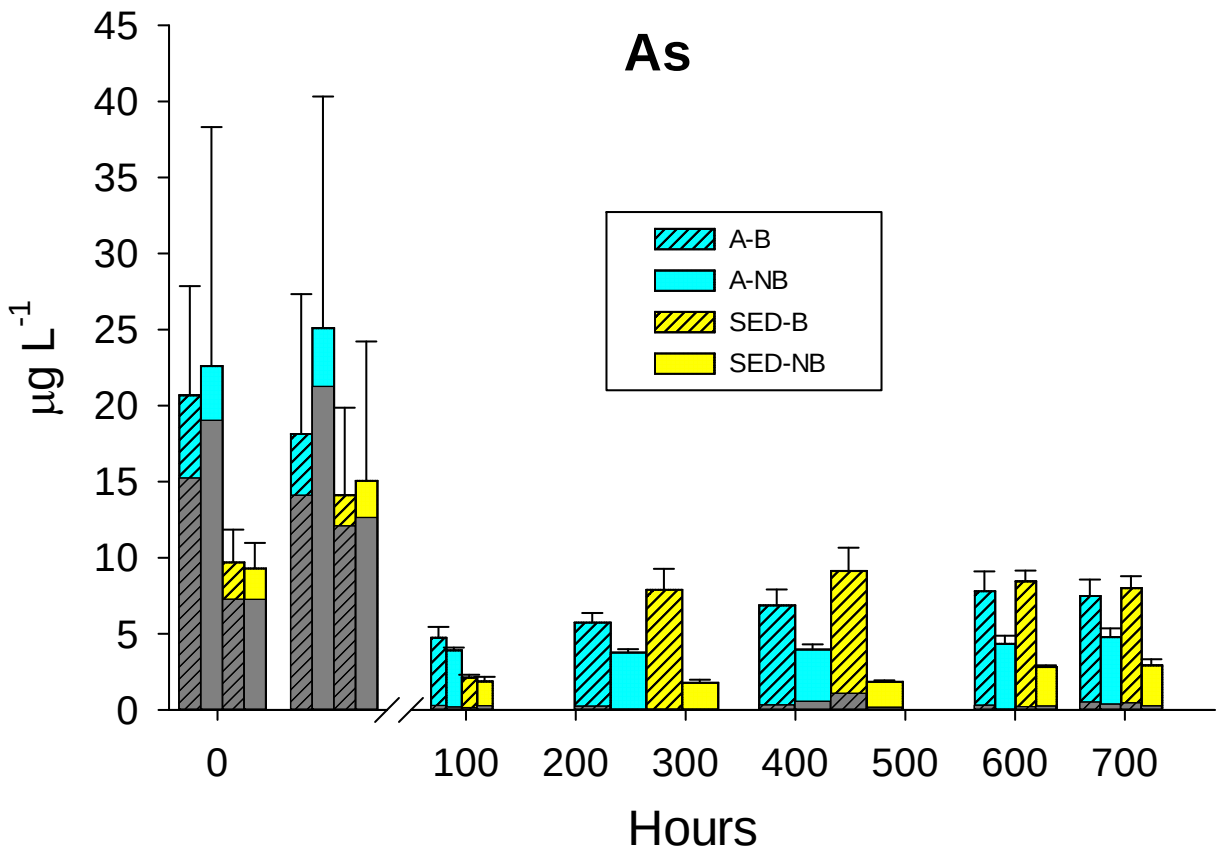



**Figure 43. Surface water concentrations of As in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate As, other colors dissolved As.**

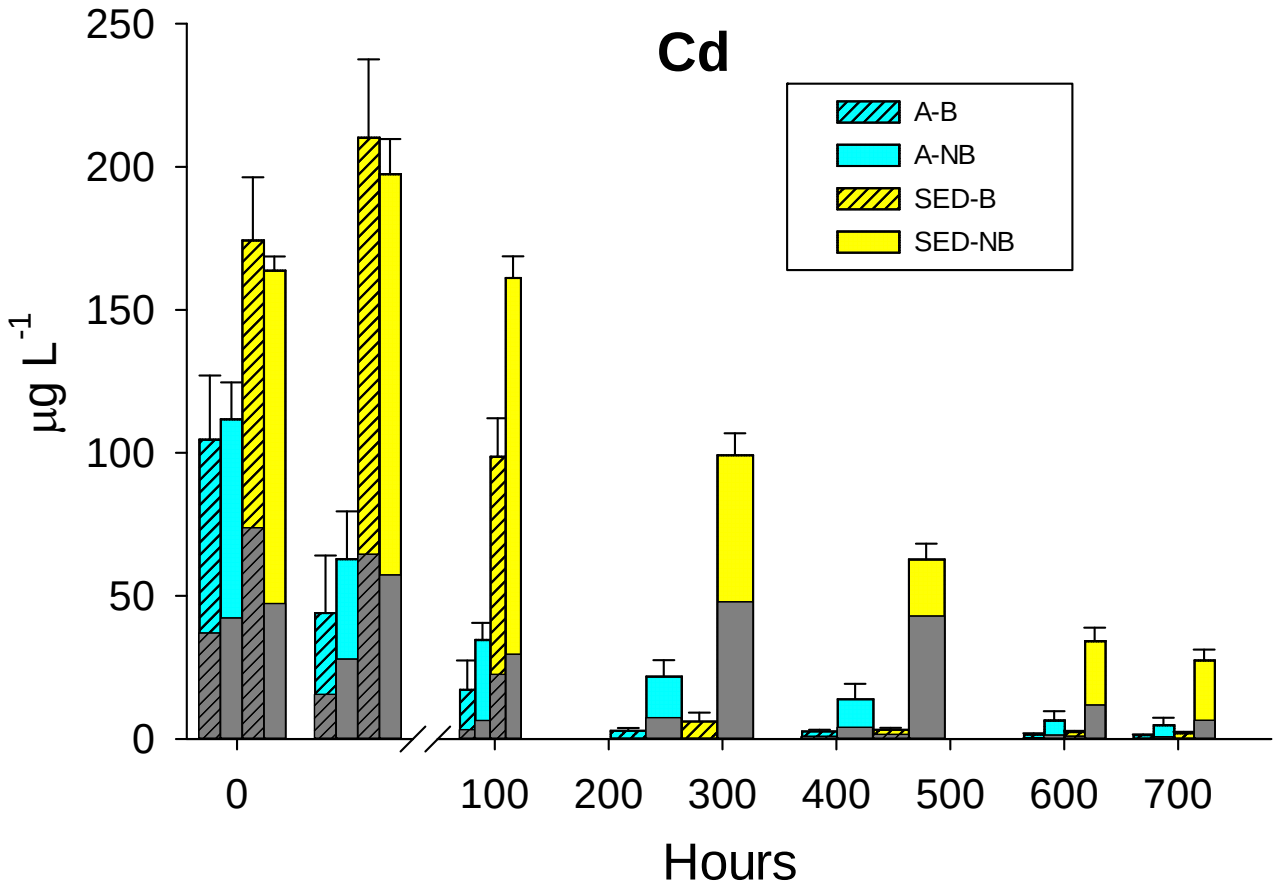



**Figure 44. Surface water concentrations of Cd in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Cd, other colors dissolved Cd.**

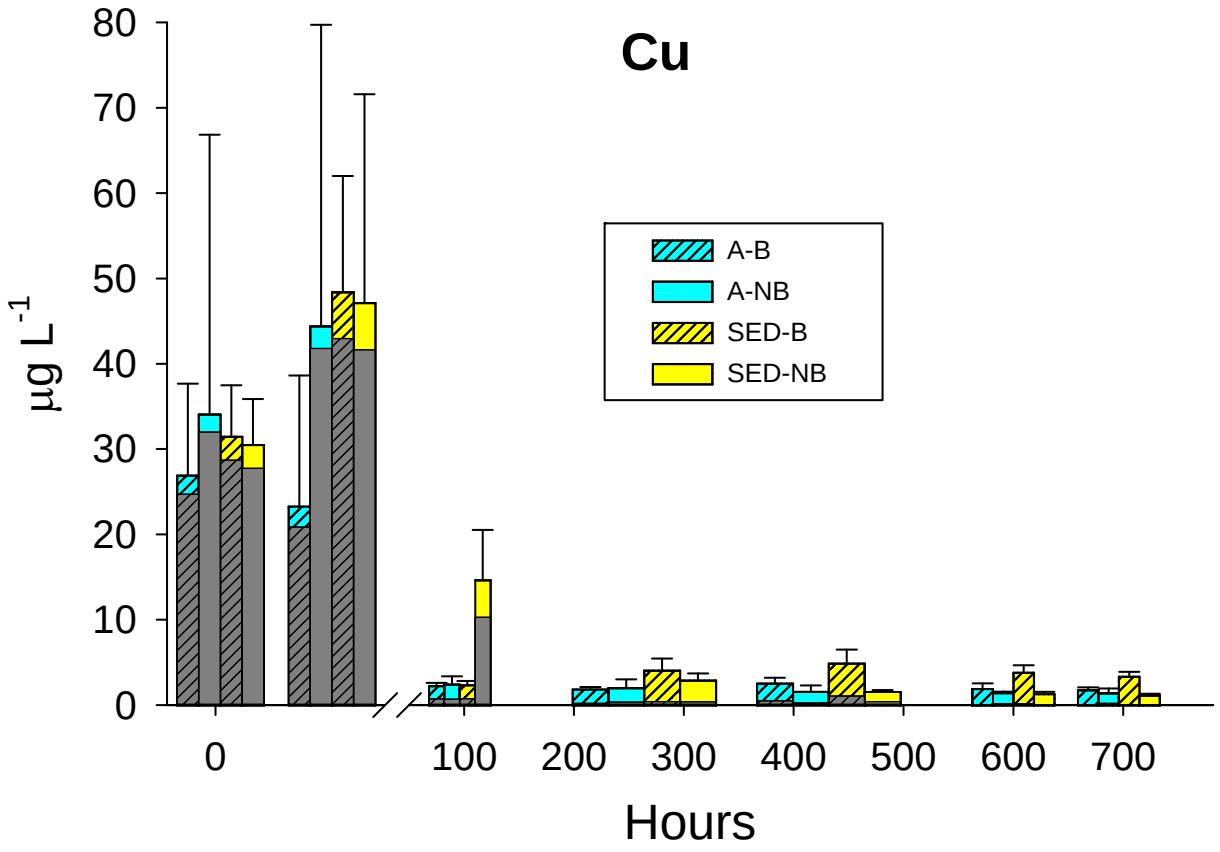



**Figure 45. Surface water concentrations of Cu in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Cu, other colors dissolved Cu.**

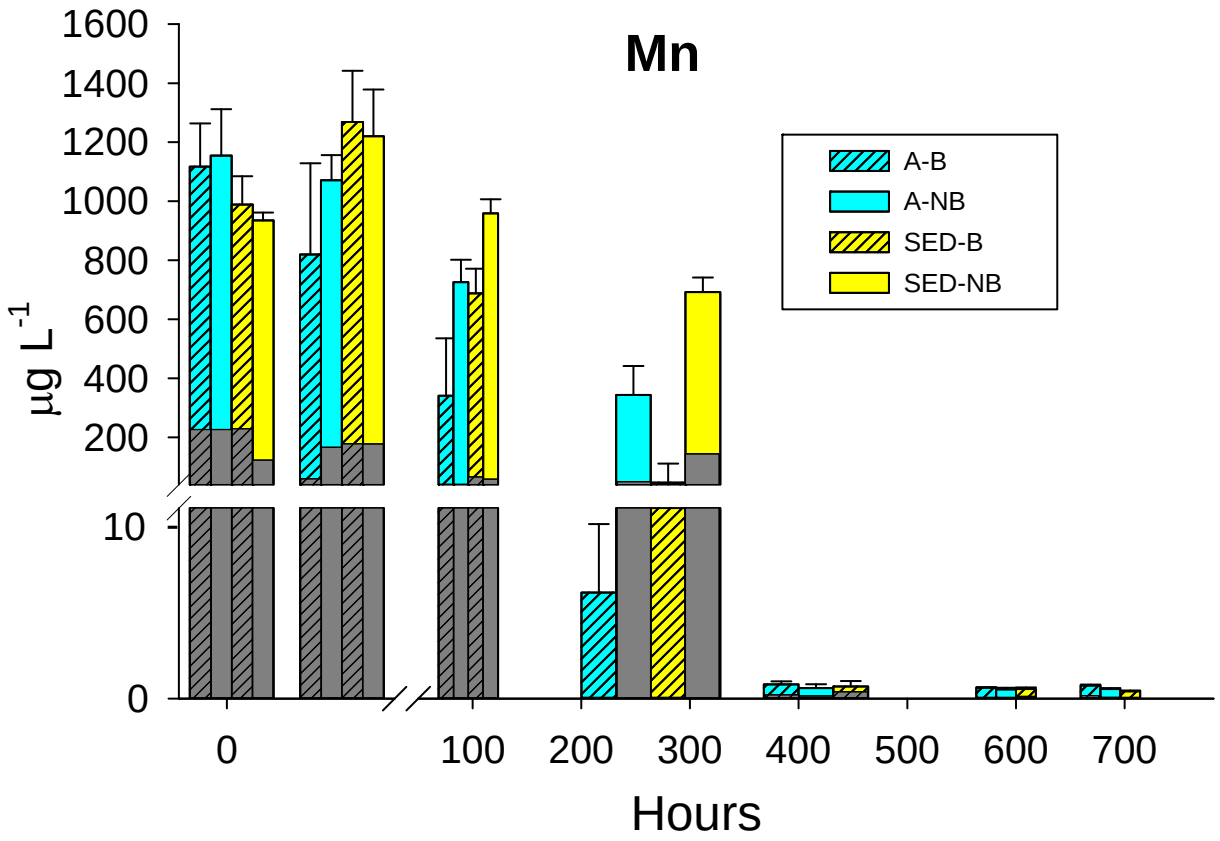



**Figure 46. Surface water concentrations of Mn in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (A-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Mn, other colors dissolved Mn.**

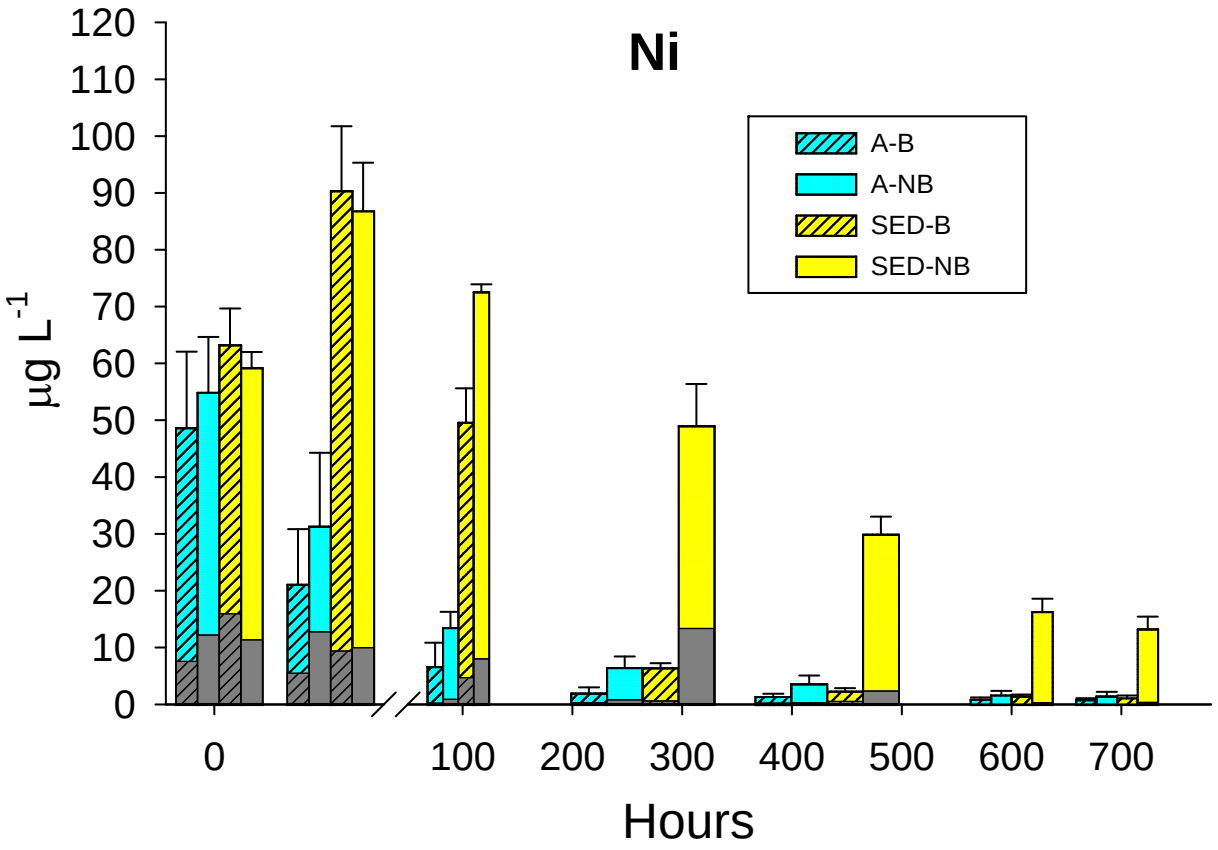



**Figure 47. Surface water concentrations of Ni in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (SED-B) and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Ni, other colors dissolved Ni.**

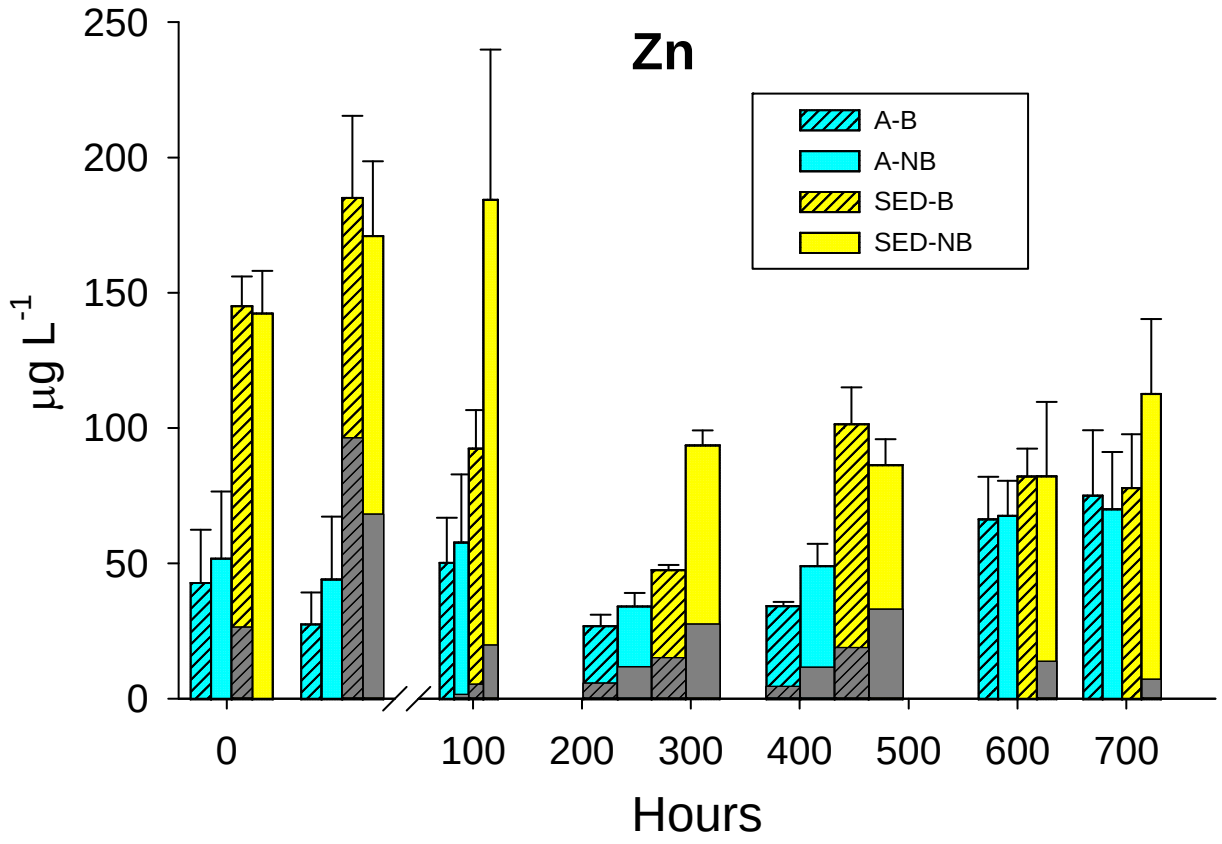



**Figure 48. Surface water concentrations of Zn in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (SED-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Zn, other colors dissolved Zn.**

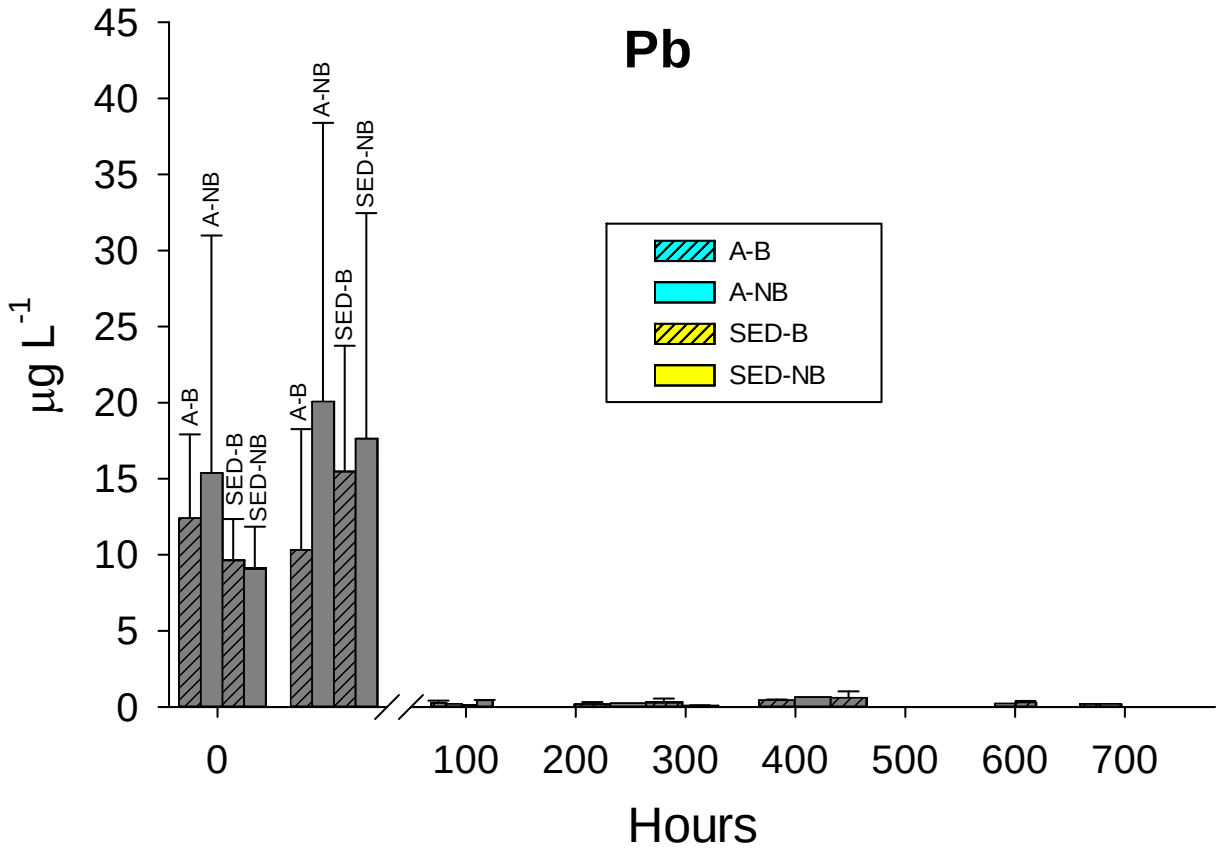



**Figure 49. Surface water concentrations of Pb in four types of experimental mesocosms (n=3 for each) exposed to influxes of metal-contaminated sediment: apatite cap with bioturbation (A-B), apatite cap without bioturbation (A-NB), uncapped sediment with bioturbation (SED-B), and uncapped sediment without bioturbation (SED-NB). Gray shading indicates particulate Pb.**

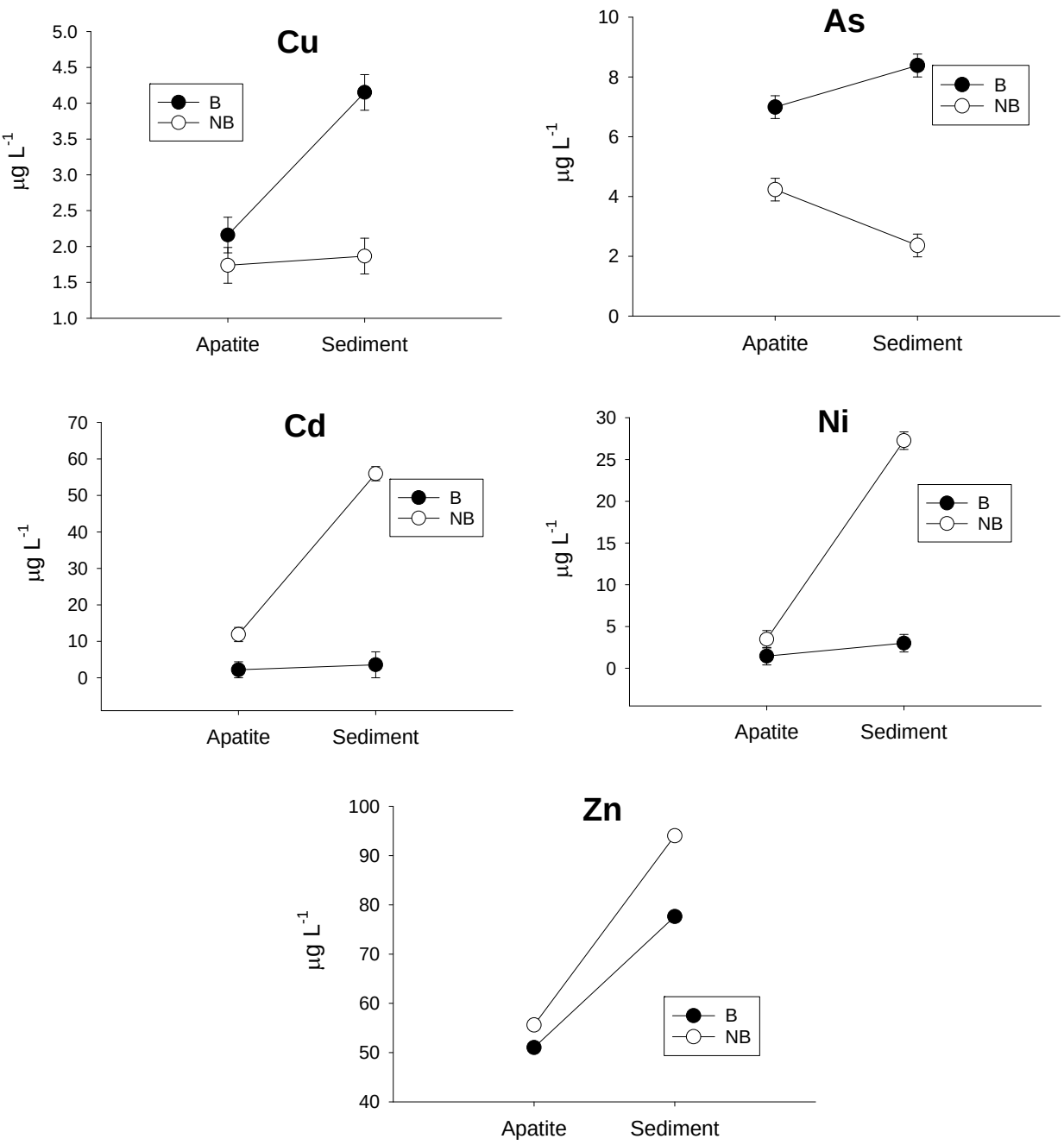



**Figure 50. Least square mean (LSM) metal concentrations (error bars = LSM standard error) for mesocosms with apatite caps or untreated sediment with or without bioturbation.**

### 4.2.6 Toxicity

Toxicity tests corresponding to 28 days of exposure to metals in the mesocosms were conducted with *Corbicula* in the mesocosms with bioturbation (Figure 51). By the end of the experiment (time, 696 hours), a total of 54 clams died in sediment-only mesocosms and 33 clams died in mesocosms with apatite caps. Average mortality was 45% in mesocosms with sediment only and 27.5 % in mesocosms with apatite cap (Figure 52); these differences were statistically significant (Student's t-test, $p = 0.011$). Better survival in the mesocosms with apatite caps was likely due to lower levels of bioavailable metals in sediments and surface water in these mesocosms.

Additional toxicity tests corresponding to ten days of exposure to sediment contaminated with metals (i.e., upper layer of contaminated sediment) were conducted with *Lumbriculus* in all treatments including treatments with and without bioturbation. The lowest mortality, 5 %, was in treatment with apatite cap in the presence of bioturbation (Figure 53). These results demonstrated that the active cap with bioturbation provided more protection from the influx of sediment contaminated with metals than did the sediment or capped sediment without bioturbation.

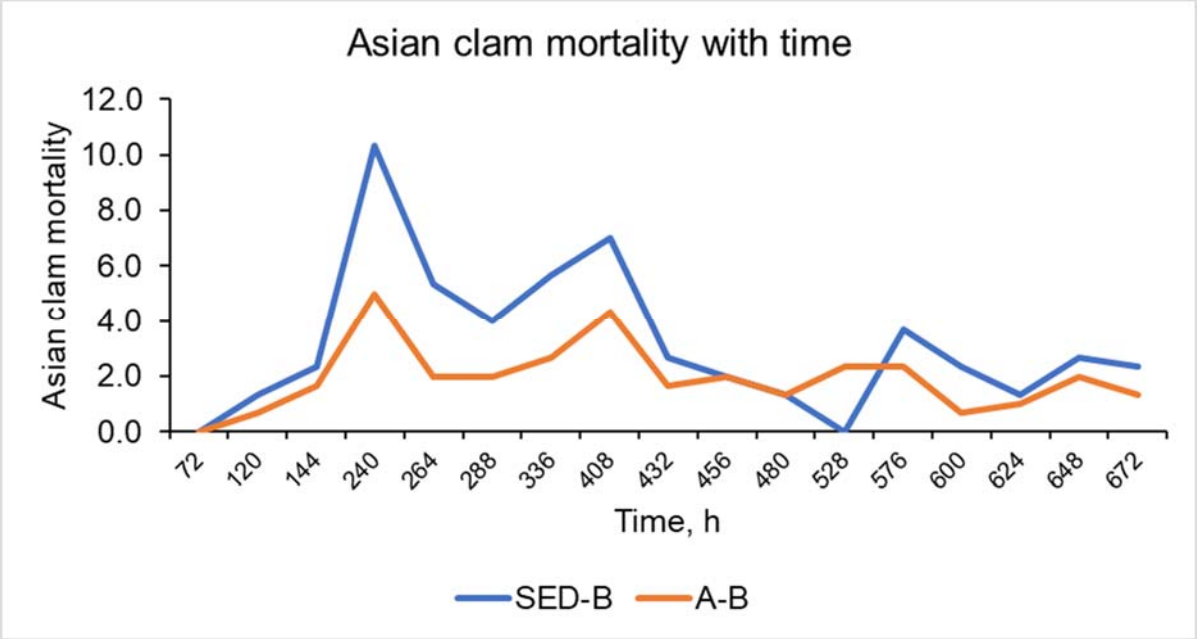



**Figure 51. Asian clam mortality in treatments with bioturbation over time; B – treatments with bioturbation, SED – sediment, A - apatite.**

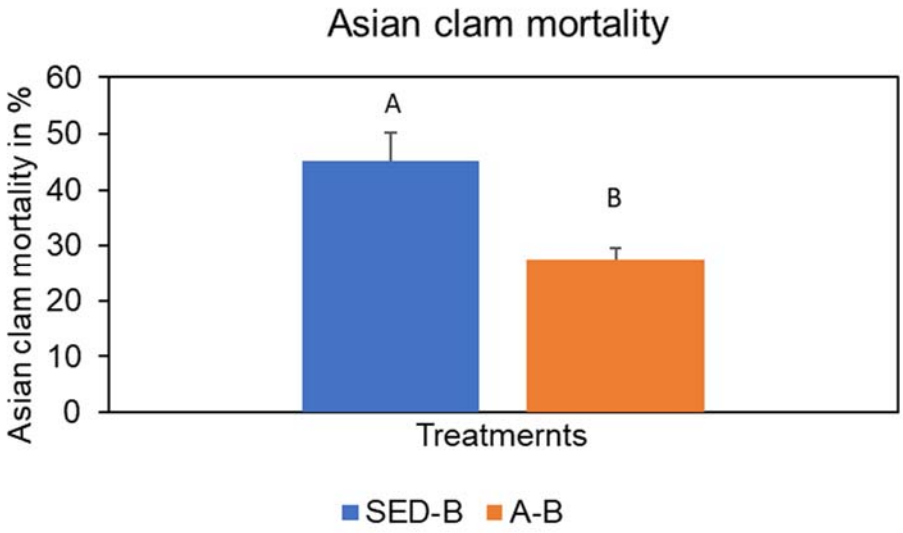



**Figure 52. Average Asian clam mortality in treatments with bioturbation; B – treatments with bioturbation, SED – sediment, A – apatite, A and B indicate significant differences at p=0.011 (Student's t-test).**

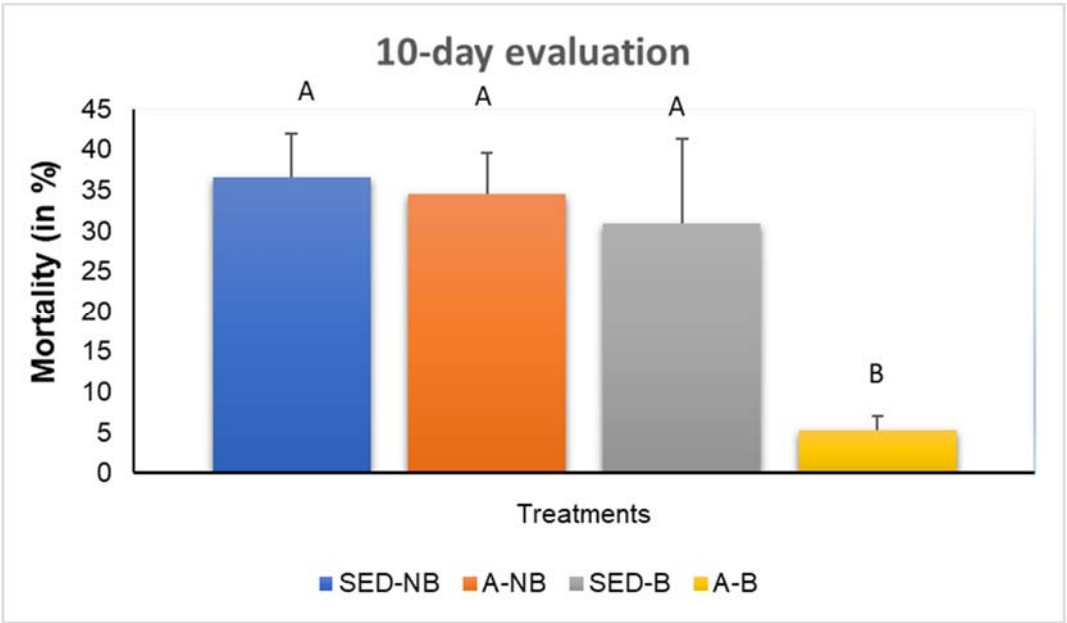



**Figure 53. Average *Lumbriculus variegatus* mortality; NB - treatments without bioturbation, B – treatments with bioturbation, SED – sediment, A – apatite, A and B indicate significant differences at p=0.011 (one-way ANOVA).**

### 4.2.7 Effect of bioturbation on bioaccumulation

Concentrations of physiologically nonessential elements including As, Cd, Ni, and Pb in *Lumbriculus* from the mesocosms were higher than *Lumbriculus* background concentrations regardless of treatment or bioturbation because of exposure to the contaminated top layer of sediment (Figure 54; raw data Appendix 1 Table A1.87). However, two-way ANOVA indicated that contaminant concentrations were significantly lower in *Lumbriculus* from mesocosms with bioturbation than mesocosms without bioturbation (Tables 27 – 32), regardless of treatment. This probably occurred because the top layer of contaminated sediment was mixed by the bioturbating organisms (Asian clams) with underlying clean sediment or active cap material. Such mixing can reduce metal contamination both by diluting contaminated sediment with clean sediment and by enhanced chemical treatment of contaminants. The latter occurs because the contact of sediment contaminants with underlying sequestering agents is increased by the mixing imparted by bioturbation.

Although bioturbation reduced the impact of contaminated sediments in all mesocosms, concentrations of Cd, Ni, and Pb in *Lumbriculus* were lower in mesocosms with active caps than in mesocosms with uncapped sediment, as indicated by significant treatment effects in the two-way ANOVAs. The ability of apatite active caps to significantly reduce concentrations of Ni and Cd compared with uncapped sediment was also indicated by the one-way ANOVAs of *Corbicula* tissues (Figure 55). The most pronounced effects were observed with Ni, for which apatite caps reduced bioaccumulation in *Corbicula* to background levels. Previous research has also shown that apatite can effectively reduce the uptake of Cd, Ni, and Pb in contaminated sediments (Knox et al., 2008, 2014, 2016; Ma et al, 1995).

As, Cu, and Zn concentrations in *Lumbriculus* and *Corbicula* were comparable across treatments indicating that the apatite caps conferred little additional remedial benefit over uncapped sediment (Figures 54 and 55). This may be partly related to high Fe levels in the uncapped sediments. Fe oxides can be used as a soil amendment for adsorbing Cd, Cu, and Zn (Knox 2016) suggesting that Fe in the mesocosm sediments may have acted as a sequestration agent for some metals. In addition, previous research has shown that apatite is not an effective sequestering agent for As in sediments (Knox et al., 2008 and 2016). Lastly, Cu and Zn are physiologically essential elements that are capable of internal regulation by many organisms. In neither *Lumbriculus* nor *Corbicula*, was Zn elevated above background levels. Cu in Lumbriculus was slightly elevated in both uncapped sediment and capped sediment but in Corbicula was comparable to background levels. These findings may reflect the effectiveness of both capped and uncapped sediment at sequestering Cu and Zn or the ability of the organisms under study to regulate internal concentrations of these metals.

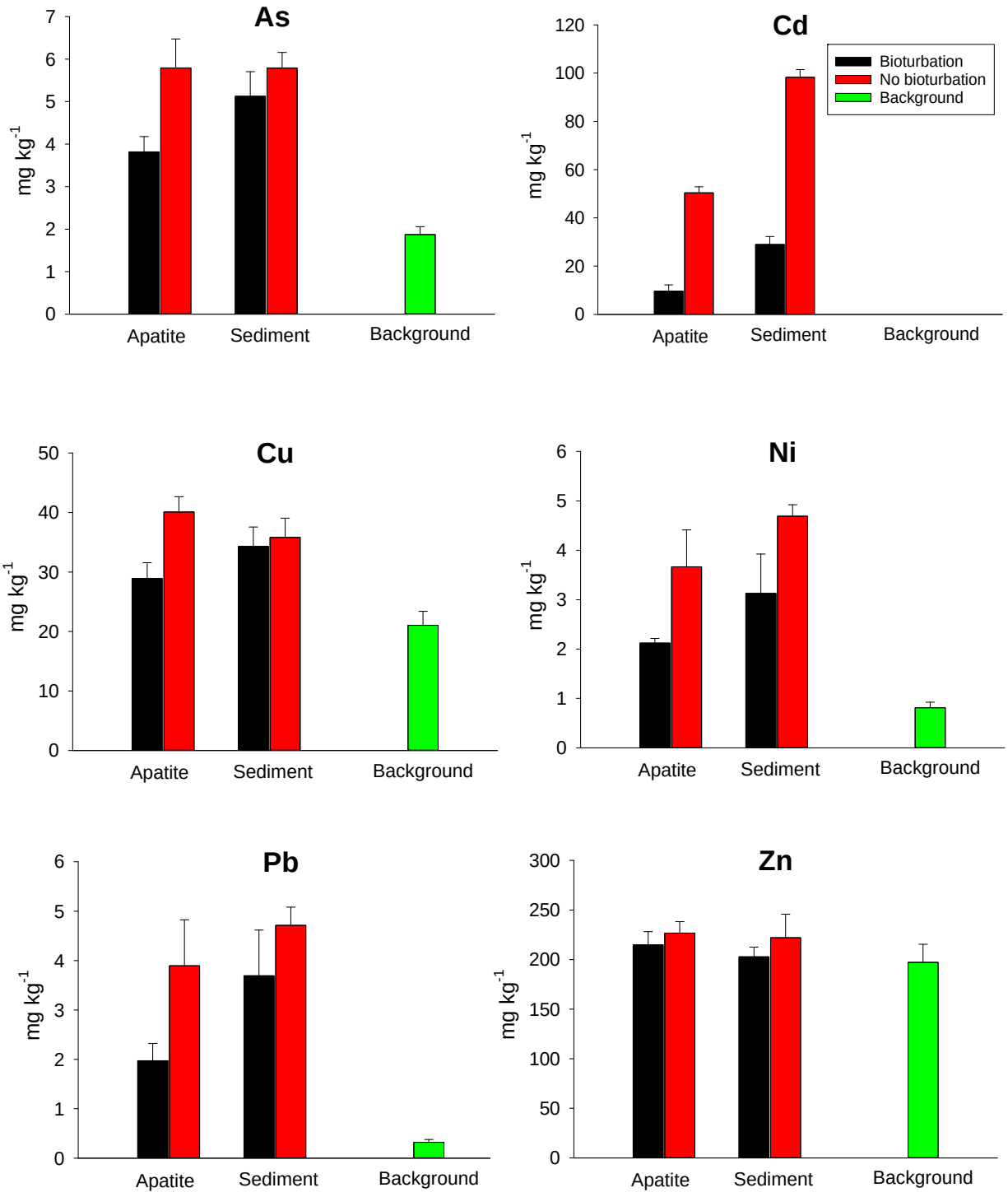



**Figure 54. Average element concentrations (whole body, 10-day exposure) in *Lumbriculus variegatus* among treatments: apatite- sediment with apatite active cap subjected to bioturbation (black), no bioturbation (red), sediment – sediment only, subjected to bioturbation (black), no bioturbation (red), background (green).**

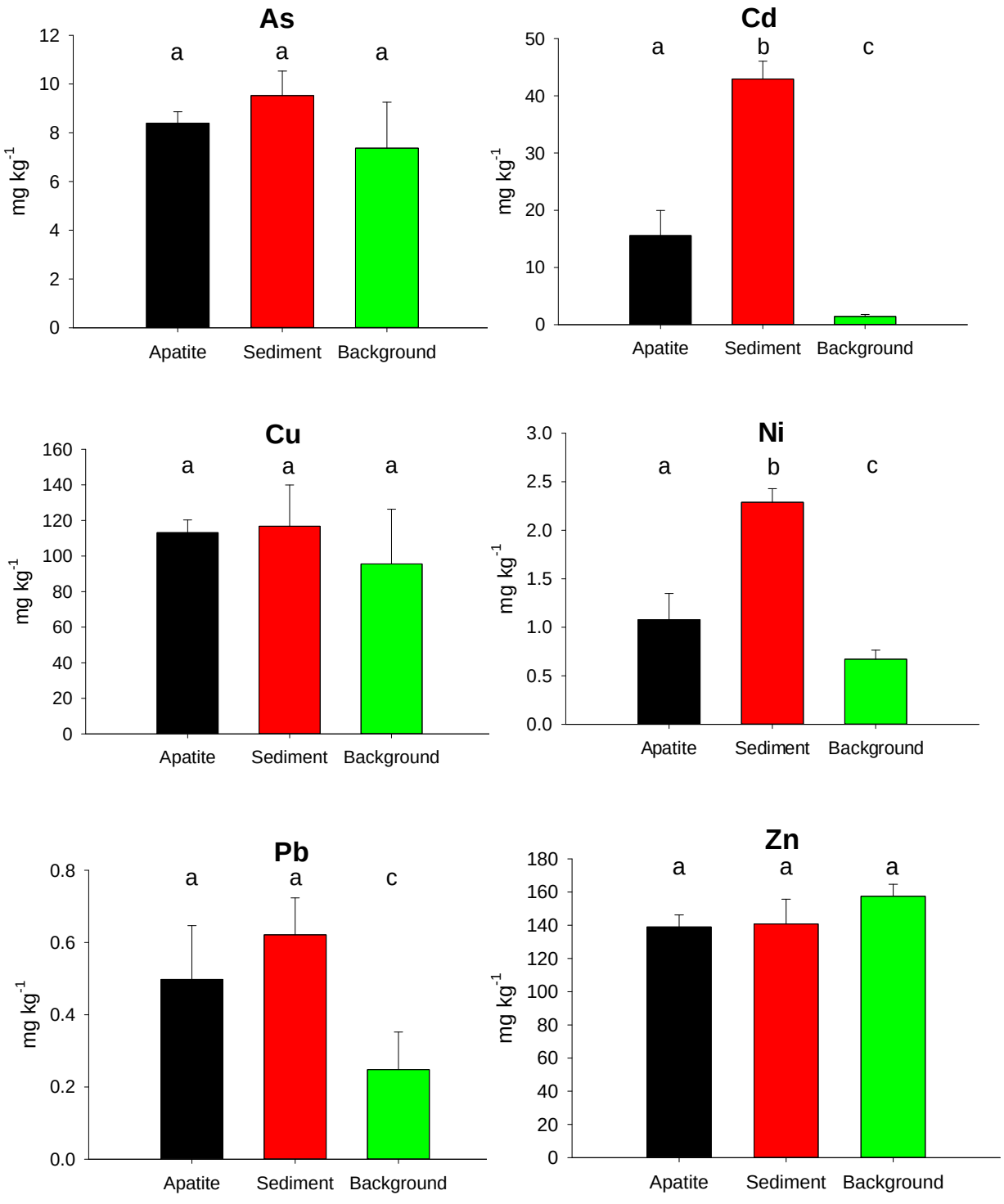



**Figure 55. Average element concentrations in Asia clams among treatments: apatite-sediment with apatite active cap subjected to bioturbation (black), sediment – sediment only, subjected to bioturbation (red), and background (green). Groups represented by different letters are significantly different ($p<0.05$, ANOVA).**

Bioturbation alters the properties of sediments and modifies contaminant bioavailability to benthic organisms. These naturally occurring disturbances are seldom considered during the assessment of sediment quality. Remaili et al., (2016) investigated how the presence and absence of a strongly bioturbating amphipod within three different sediments influenced metal bioavailability, survival, and bioaccumulation of metals by the bivalve *Tellina deltoidalis*. They showed that the concentrations of dissolved Cu decreased, and Mn increased with increased bioturbation. For Cu a strong correlation was observed between increased bivalve survival and dissolved concentrations in the overlying water. They also showed that increased bioturbation resulted in greater tissue concentrations for Cr and Zn in some sediments (Remaili et al., 2016). Other studies have reported less significant changes in Cu and/or Zn uptake by organisms in the presence of bioturbation (He et al., 2017)

The findings of Remaili et al. (2016) differed from our results, which showed that bioturbation reduced the uptake of most elements under study. However, their work dealt with preexisting contamination, while our work involved the recontamination of underlying clean sediment that could be mixed with overlying contaminated sediment resulting in contaminant dilution and enhanced treatment. There is a lack of information about how bioturbation will impact remediated contaminated sediments. Our research showed that bioturbation reduced the impact of an incoming load of contaminated sediment deposited over both capped and uncapped sediment and specifically resulted in less bioaccumulation of the divalent elements Cd and Ni in blackworms and clams (Figures 54 and 55), and Pb in blackworms (Figure 54).

**Table 27. Two-way analysis of variance (ANOVA) of As in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 1.135 | 1.135 | 4.758 | 0.066 |
| Bioturbation | 1 | 4.628 | 4.628 | 19.406 | 0.003 |
| Treatment x bioturbation | 1 | 1.146 | 1.146 | 4.807 | 0.064 |
| Residual | 7 | 1.669 | 0.238 | | |
| Total | 10 | 8.967 | 0.897 | | |

Multiple comparison results. Units for least square means (LSMs) are mg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Bioturbation main effect | 4.473 B* | 5.790 NB* | 1.317 | 4.405 | 0.003 |

*B = bioturbation, NB = no bioturbation

**Table 28. Two-way analysis of variance (ANOVA) of Cd in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 3015.882 | 3015.882 | 26.456 | 0.001 |
| Bioturbation | 1 | 8061.230 | 8061.230 | 70.716 | <0.001 |
| Treatment x bioturbation | 1 | 545.200 | 545.200 | 4.783 | 0.065 |
| Residual | 7 | 797.964 | 113.995 | | |
| Total | 10 | 13859.498 | 1385.950 | | |

Multiple comparison results. Units for least square means (LSMs) are mg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Bioturbation main effect | 19.322 B* | 74.304 NB* | 54.981 | 8.409 | <0.001 |
| Treatment main effect | 29.998 AC* | 63.628 SED | 33.63 | 5.144 | 0.001 |

*B = bioturbation, NB = no bioturbation, AC = apatite cap, SED = sediment

**Table 29. Two-way analysis of variance (ANOVA) of Cu in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 0.824 | 0.824 | 0.0612 | 0.812 |
| Bioturbation | 1 | 106.394 | 106.394 | 7.901 | 0.026 |
| Treatment x bioturbation | 1 | 61.985 | 61.985 | 4.603 | 0.069 |
| Residual | 7 | 94.266 | 13.467 | | |
| Total | 10 | 254.079 | 25.408 | | |

Multiple comparison results. Units for least square means (LSMs) are mg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Bioturbation main effect | 31.626 B* | 37.943 NB* | 6.316 | 2.811 | 0.026 |

*B = bioturbation, NB = no bioturbation

**Table 30. Two-way analysis of variance (ANOVA) of Ni in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 2.748 | 2.748 | 9.879 | 0.016 |
| Bioturbation | 1 | 6.437 | 6.437 | 23.146 | 0.002 |
| Treatment x bioturbation | 1 | <0.001 | <0.001 | 0.001 | 0.979 |
| Residual | 7 | 1.947 | 0.278 | | |
| Total | 10 | 12.203 | 1.22 | | |

Multiple comparison results. Units for least square means (LSMs) are mg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Bioturbation main effect | 2.625 B* | 4.179 NB* | 1.554 | 4.811 | 0.002 |
| Treatment main effect | 2.894 AC* | 3.909 SED | 1.015 | 3.143 | 0.016 |

*B = bioturbation, NB = no bioturbation, AC = apatite cap, SED = sediment

**Table 31. Two-way analysis of variance (ANOVA) of Pb in blackworm tissues. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions or for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 4.306 | 4.306 | 9.716 | 0.017 |
| Bioturbation | 1 | 5.782 | 5.782 | 13.047 | 0.009 |
| Treatment x bioturbation | 1 | 0.546 | 0.546 | 1.233 | 0.304 |
| Residual | 7 | 3.102 | 0.443 | | |
| Total | 10 | 14.95 | 1.495 | | |

Multiple comparison results. Units for least square means (LSMs) are mg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Bioturbation main effect | 2.831 B* | 4.304 NB* | 1.473 | 3.612 | 0.009 |
| Treatment main effect | 2.932 AC* | 4.203 SED | 1.271 | 3.117 | 0.017 |

*B = bioturbation, NB = no bioturbation, AC = apatite cap, SED = sediment

**Table 32. Two-way analysis of variance (ANOVA) of Zn in blackworm tissues.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 188.146 | 188.146 | 0.728 | 0.422 |
| Bioturbation | 1 | 652.333 | 652.333 | 2.524 | 0.156 |
| Treatment x bioturbation | 1 | 36.039 | 36.039 | 0.139 | 0.72 |
| Residual | 7 | 1809.363 | 258.48 | | |
| Total | 10 | 2682.348 | 268.235 | | |

### 4.2.8 Bioavailability assessment by diffusive gradients in thin films (DGT)

#### *4.2.8.1 Water DGT*

Raw data showing DGT metal concentrations are presented in Appendix 1, table A1.88. The effects of treatment and bioturbation on Cd, Cu, and Ni DGT concentrations in the mesocosm water columns were generally similar. In all cases, element DGT concentrations were markedly higher in the sediment treatments without bioturbation than in the apatite treatments with and without bioturbation (Figure 56). This pattern resulted in statistically significant interactions between treatment and bioturbation in the two-way ANOVAs for Cd and Ni (Tables 33 and 34). Multiple comparison tests for DGT concentrations of Cd and Ni showed that LSMs differed significantly between sediment mesocosms with and without bioturbation and between treatments in the absence of bioturbation. In contrast, differences between treatments were not significant in the presence of bioturbation. Similar results occurred for DGT concentrations of Cu, except they were not statistically significant because of the variability of the Cu data (Figure 56, Table 35). These results show that apatite reduced metal DGT concentrations in the mesocosm water, as also observed in previous studies conducted under this project (Knox et al, 2016 and 2019). They also show that bioturbation reduced DGT metal concentrations, and that this reduction was especially strong in the sediment mesocosms. It is likely that bioturbation reduced contaminant levels in the sediment mesocosms by physically burying overlying contaminated sediment with underlying clean sediment and possibly by enhancing chemical interactions between sediment constituents. The latter effect may have been less pronounced in the presence of apatite because of the strong affinity of this material for metals, which resulted in effective treatment without the need of augmentation by bioturbation.

Unlike Cd, Cu, and Ni, water column Pb DGT concentrations were similar among treatments and unaffected by bioturbation as indicated by graphical comparisons (Figure 56) and lack of significant results in the ANOVA (Table 36). Concentrations of Pb were very low and similar between the overlying contaminated and underlying uncontaminated sediment affording less potential for the development of treatment or bioturbation related differences than with the other metals.

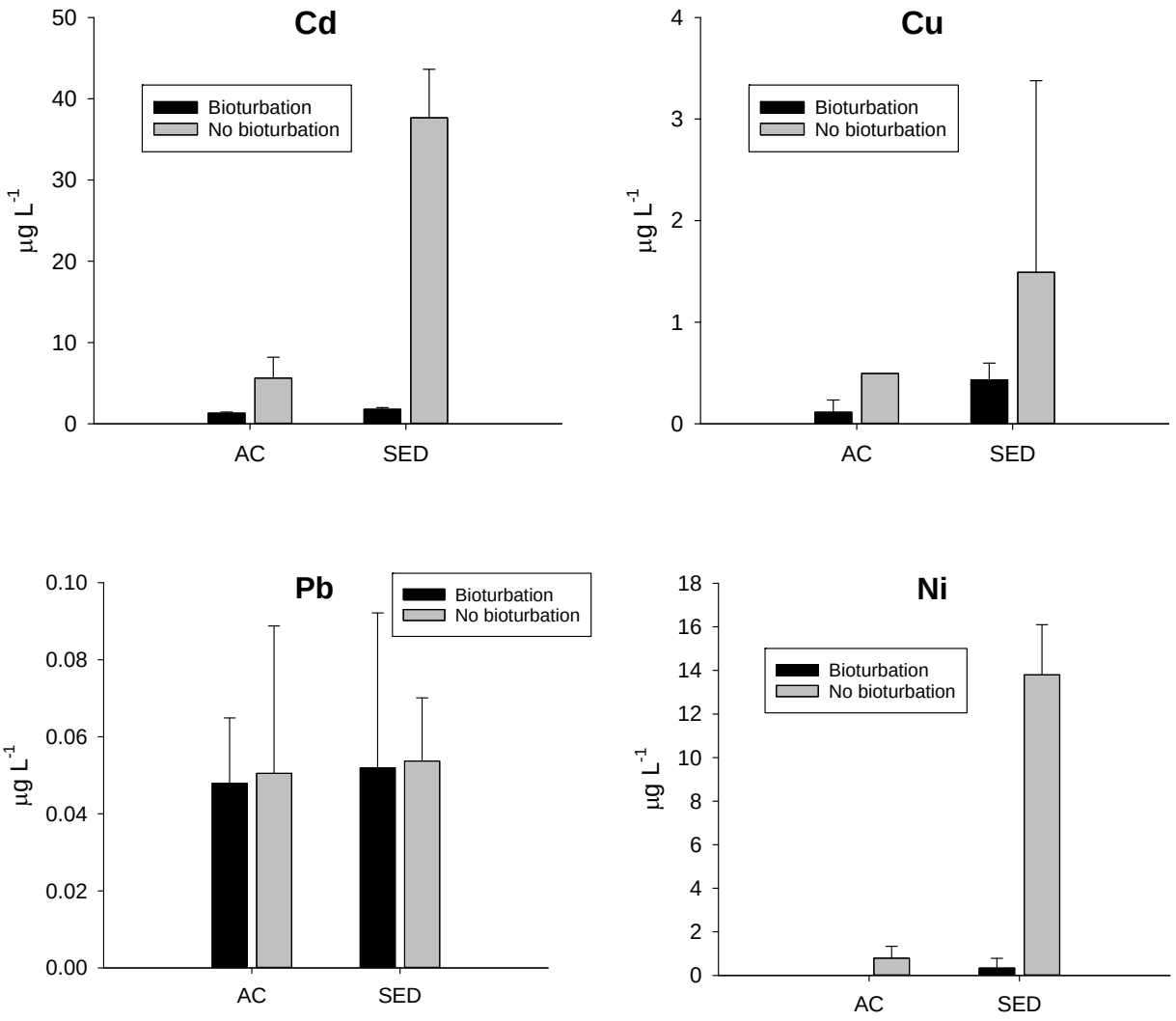



**Figure 56. Metal concentrations measured by DGT in the water of experimental mesocosms with untreated sediment (SED) and with sediment treated with apatite active caps (AC).**

**Table 33. Two-way analysis of variance (ANOVA) of DGT-Cd water data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions and for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 793.671 | 793.671 | 75.150 | <0.001 |
| Bioturbation | 1 | 1212.303 | 1212.303 | 114.789 | <0.001 |
| Treatment x bioturbation | 1 | 748.043 | 748.043 | 70.830 | <0.001 |
| Residual | 8 | 84.489 | 10.561 | | |
| Total | 11 | 2838.506 | 258.046 | | |

Multiple comparison results. Units for least square means (LSMs) are µg $L^{-1}$.

| Treatment x bioturbation interaction | | | | | |
|---|---|---|---|---|---|
| Comparison | LSM #1 | LSM #2 | Difference | t | P |
| Bioturbation within sediment mesocosms | 37.671 SED NB* | 1.778 SED B* | 35.893 | 13.527 | <0.001 |
| Bioturbation within apatite mesocosms | 5.615 AC NB* | 1.303 AC B* | 4.312 | 1.625 | 0.143 |
| Treatments with no bioturbation | 37.671 SED NB | 5.615 AC NB | 32.056 | 12.081 | <0.001 |
| Treatments with bioturbation | 1.778 SED B | 1.303 AC B | 0.474 | 0.179 | 0.863 |

*SED NB = sediment, no bioturbation; SED B = sediment, bioturbation; AC NB = apatite cap, no bioturbation; AC B = apatite cap, bioturbation.

**Table 34. Two-way analysis of variance (ANOVA) of DGT-Ni water data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions and for main effects if not part of a significant interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 131.35 | 131.35 | 91.904 | <0.001 |
| Bioturbation | 1 | 154.754 | 154.754 | 108.279 | <0.001 |
| Treatment x bioturbation | 1 | 122.544 | 122.544 | 85.742 | <0.001 |
| Residual | 8 | 11.434 | 1.429 | | |
| Total | 11 | 420.081 | 38.189 | | |

Multiple comparison results. Units for least square means (LSMs) are µg $L^{-1}$.

| Treatment x bioturbation interaction | | | | | |
|---|---|---|---|---|---|
| Comparison | LSM #1 | LSM #2 | Difference | t | P |
| Bioturbation within sediment mesocosms | 13.799 SED NB* | 0.226 SED B* | 13.573 | 13.906 | <0.001 |
| Bioturbation within apatite mesocosms | 0.791AC NB* | 0.000 AC B* | 0.791 | 0.81 | 0.441 |
| Treatments with no bioturbation | 13.799 SED NB | 0.791 AC NB | 13.008 | 13.326 | <0.001 |
| Treatments with bioturbation | 0.226 SED B | 0.000 AC B | 0.226 | 0.231 | 0.823 |

*SED NB = sediment, no bioturbation; SED B = sediment, bioturbation; AC NB = apatite cap, no bioturbation; AC B = apatite cap, bioturbation.

**Table 35. Two-way analysis of variance (ANOVA) of DGT-Cu water data.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 1.052 | 1.052 | 1.592 | 0.243 |
| Bioturbation | 1 | 0.319 | 0.319 | 0.483 | 0.507 |
| Treatment x bioturbation | 1 | 0.168 | 0.168 | 0.255 | 0.627 |
| Residual | 8 | 5.285 | 0.661 | | |
| Total | 11 | 6.824 | 0.62 | | |

**Table 36. Two-way analysis of variance (ANOVA) of DGT-Pb water data.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | Probability (P) of F |
|---|---|---|---|---|---|
| Treatment | 1 | 3.85E-05 | 3.85E-05 | 0.042 | 0.842 |
| Bioturbation | 1 | 1.40E-05 | 1.40E-05 | 0.015 | 0.904 |
| Treatment x bioturbation | 1 | 4.97E-07 | 4.97E-07 | 0.001 | 0.982 |
| Residual | 8 | 0.007 | 0.00091 | | |
| Total | 11 | 0.007 | 0.000666 | | |

#### *4.2.8.2 Sediment DGT*

The DGT sediment probes provided an opportunity to observe the effects of treatment and bioturbation on vertical differences in the distribution of contaminants within the mesocosm sediments (Figure 57; raw data – Appendix 1, Table A1.89 -A1.94). Three-way ANOVA of the sediment Cu DGT data indicated significantly lower Cu DGT concentrations in the apatite cap mesocosms that in the uncapped sediment mesocosms (LSMs of 0.36 and 1.17 μg $kg^{-1}$, respectively) that was consistent across sediment layers and unaffected by bioturbation (Table 37). In contrast, the Cd DGT sediment data was characterized by significant treatment effects, bioturbation effects, and two-way interactions between bioturbation and sediment layers (Table 38). Examination of the multiple comparison results for Cd indicated lower concentrations in apatite mesocosms than in sediment mesocosms regardless of bioturbation, and lower concentrations in mesocosms with bioturbation than in mesocosms without bioturbation regardless of treatment. They also showed that differences among sediment layers were significant in the absence of bioturbation but not in the presence of bioturbation. Paralleling the water data, these results showed that apatite caps reduced Cd DGT levels compared with uncapped sediment and that bioturbation reduced Cd DGT levels in both capped and uncapped sediment. Additionally, they showed that bioturbation affected the vertical distribution of sediment contaminants, resulting in more uniform vertical distribution than in sediments without bioturbation.

The three-way ANOVA of the Ni DGT data indicated that treatment effects, bioturbation effects, and all two-way and three-way interactions were significant (Table 39, Figure 57). Multiple comparison results showed that Ni DGT concentrations in all sediment layers of the apatite cap mesocosms were significantly lower than in the sediment mesocosms when bioturbation was absent. In contrast, Ni DGT concentrations in all sediment layers of the apatite cap mesocosms and sediment mesocosms were similar when bioturbation was present. Bioturbation significantly reduced Ni DGT concentrations in all sediment layers within the sediment mesocosms but reduced Ni concentrations only in contaminated layer (CL) within the apatite mesocosms. As with the other metals, these results indicate the strong effects of bioturbation on treatment effectiveness, especially within the sediment mesocosms. The greater effects in the sediment mesocosms may have been related to burying and diluting of contaminated sediment with uncontaminated sediment and to enhancement of chemical interactions that resulted in contaminant immobilization due to mixing of clean sediment with contaminated sediment. As previously mentioned, bioturbation may have had lesser effects in the apatite mesocosm because of the strong affinity of apatite for metals, which resulted in effective treatment without augmentation by bioturbation.

The DGT sediment data for Pb indicated significant differences related to treatment and bioturbation and a significant two-way interaction between these two main effects (Table 40, Figure 57). Generally paralleling the results observed with Ni, multiple comparison tests showed that bioturbation significantly reduced Pb DGT levels in the sediment mesocosms. Apatite caps significantly reduced Pb DGT levels when bioturbation was present but not when it was absent. These reduction in metal mobility and bioavailability were likely related to higher sediment pH in the apatite treatments (Figure 58, raw data – Appendix 1, Table A1.95). Other researchers

have reported that bioturbation increases sediment pH and lowers the bioavailability of some elements, especially divalent metals such as Cd, Pb, and Zn (Krantzberg, 1985).

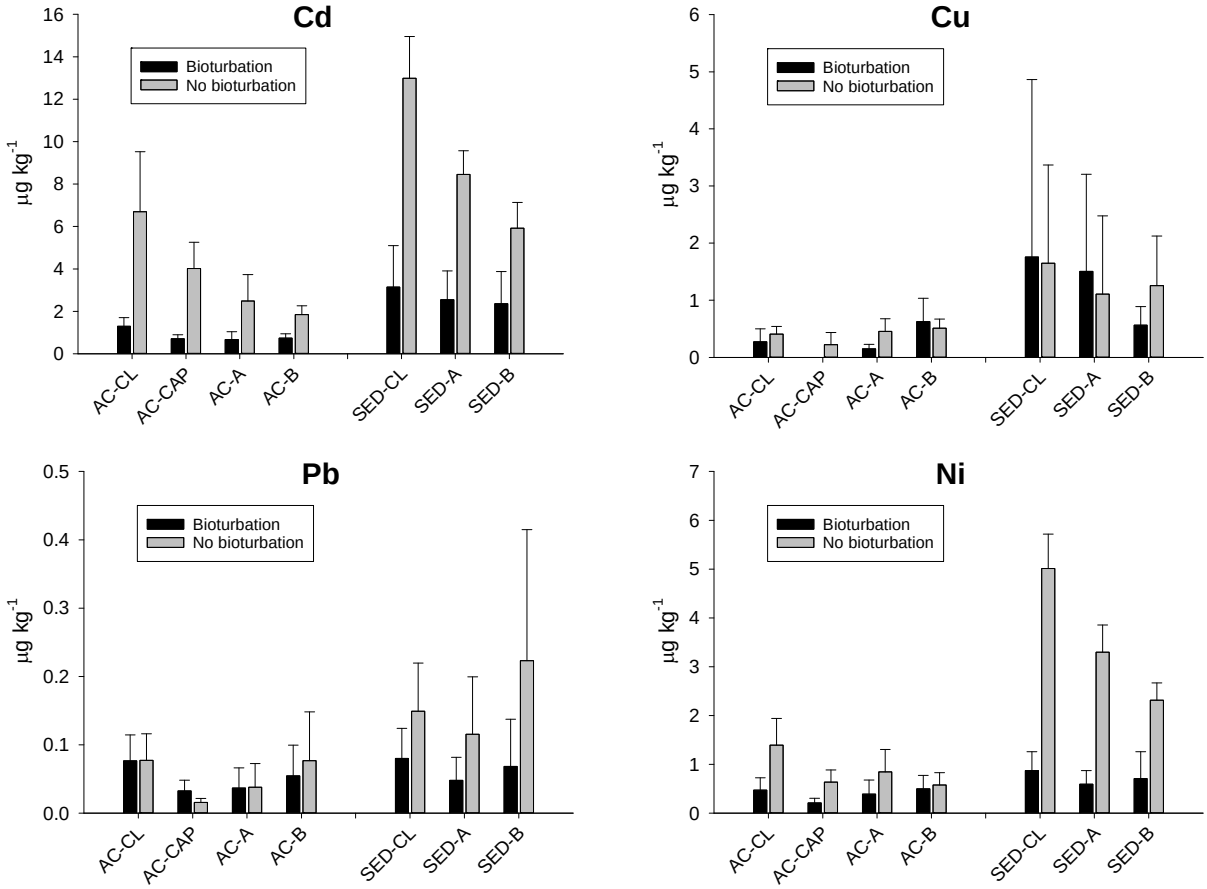



**Figure 57. Metal concentrations measured by DGT in the sediment of experimental mesocosms with untreated sediment (SED) and with sediment treated with apatite active caps (AC). Three sediment layers are represented: surficial contaminated layer (CL), cap layer (for mesocosms with cap, CAP), sediment layer beneath the cap or surficial contaminated layer (A), and deeper sediment layer (B).**

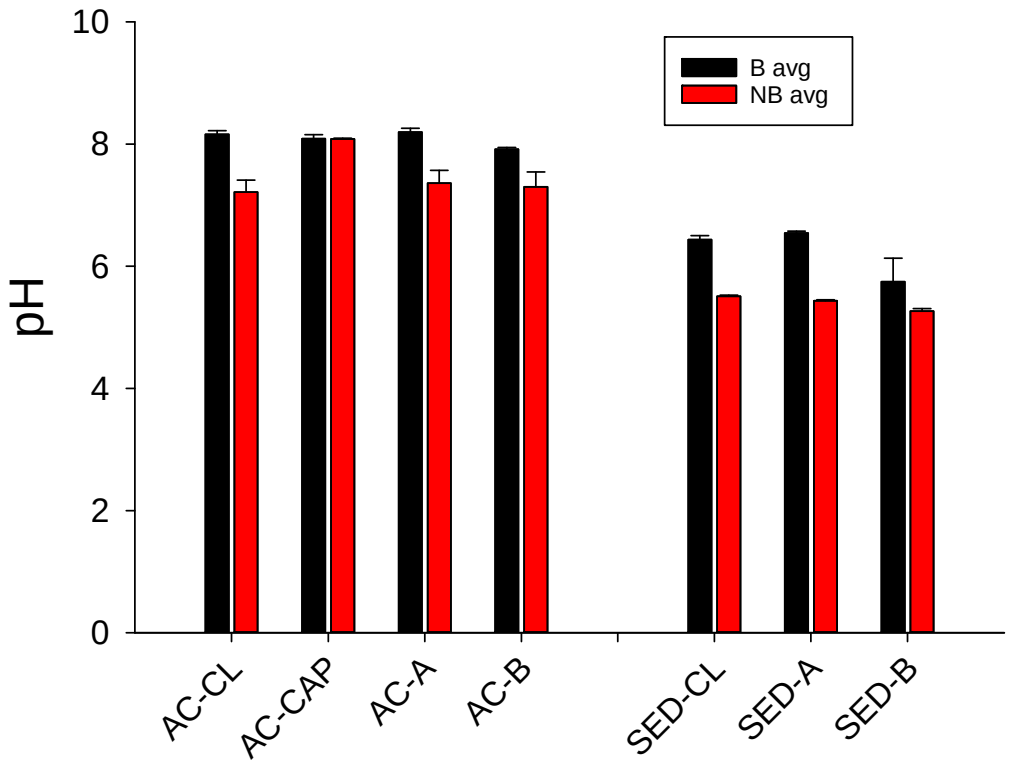



**Figure 58. Average pH values (n = 3) in cap materials and individual layers of sediment (CL: contaminated layer, layer A: 0.0-2.5 cm, layer B: 2.5-5.0 cm) in treatments with bioturbation (B) and without bioturbation (NB) at 696 h.**

**Table 37. Three-way analysis of variance (ANOVA) of DGT-Cu sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant main effects.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | P |
|---|---|---|---|---|---|
| Treatment (apatite cap vs. uncapped) | 1 | 11.11 | 11.11 | 7.55 | 0.008 |
| Bioturbation (presence vs. absence) | 1 | 0.93 | 0.93 | 0.64 | 0.429 |
| Layers (CL, A, B) | 2 | 1.04 | 0.52 | 0.35 | 0.704 |
| Treatment x bioturbation | 1 | 0.14 | 0.14 | 0.09 | 0.762 |
| Treatment x layers | 2 | 2.04 | 1.02 | 0.69 | 0.504 |
| Bioturbation x layers | 2 | 0.09 | 0.04 | 0.03 | 0.971 |
| Treatment x bioturbation x layers | 2 | 0.57 | 0.29 | 0.19 | 0.824 |
| Residual | 56 | 82.45 | 1.47 | | |
| Total | 67 | 98.35 | 1.47 | | |

Multiple comparison results for treatment. Units for least square means (LSMs) are µg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Effect of treatment | 1.17 SED* | 0.36 A | 0.82 | 2.75 | 0.008 |

*SED = uncapped sediment, A = apatite cap

**Table 38. Three-way analysis of variance (ANOVA) of DGT-Cd sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | P |
|---|---|---|---|---|---|
| Treatment (apatite cap vs. uncapped) | 1 | 234.95 | 234.95 | 114.53 | <0.001 |
| Bioturbation (presence vs. absence) | 1 | 381.43 | 381.43 | 185.94 | <0.001 |
| Layers (CL, A, B) | 2 | 142.84 | 71.42 | 34.82 | <0.001 |
| Treatment x bioturbation | 1 | 60.34 | 60.34 | 29.41 | <0.001 |
| Treatment x layers | 2 | 5.34 | 2.67 | 1.30 | 0.280 |
| Bioturbation x layers | 2 | 88.99 | 44.49 | 21.69 | <0.001 |
| Treatment x bioturbation x layers | 2 | 3.38 | 1.69 | 0.82 | 0.444 |
| Residual | 60 | 123.08 | 2.05 | | |
| Total | 71 | 1040.35 | 14.65 | | |

Multiple comparison results for treatment x bioturbation interaction. Units for least square means (LSMs) are µg $kg^{-1}$.

| Comparisons | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Effect of bioturbation | | | | | |
| Within uncapped sediment mesocosms | 9.12 NB* | 2.69 B | 6.43 | 13.48 | <0.001 |
| Within apatite cap mesocosms | 3.68 NB | 0.90 B | 2.77 | 5.81 | <0.001 |
| Effect of treatment | | | | | |
| Without bioturbation | 9.12 SED | 3.68 A | 5.44 | 11.40 | <0.001 |
| With bioturbation | 2.69 SED | 0.90 A | 1.78 | 3.73 | <0.001 |

Multiple comparison results for bioturbation x layers interaction. Units for least square means (LSMs) are µg $kg^{-1}$.

| Differences among layers without bioturbation | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| CL vs BL | 9.84 Cl | 3.88 BL | 5.96 | 10.19 | <0.001 |
| CL vs AL | 9.84 CL | 5.47 AL | 4.37 | 7.47 | <0.001 |
| AL vs BL | 5.47 AL | 3.88 BL | 1.59 | 2.72 | 0.009 |
| Differences among layers with bioturbation | | | | | |
| CL vs BL | 2.22 CL | 1.61 BL | 0.67 | 1.14 | 0.592 |
| CL vs AL | 2.22 CL | 1.55 AL | 0.61 | 1.04 | 0.513 |
| AL vs BL | 1.61 AL | 1.55 BL | 0.06 | 0.10 | 0.920 |
| Effect of bioturbation on layers | | | | | |
| On CL | 9.84 NB | 2.22 B | 7.62 | 13.03 | <0.001 |
| On AL | 5.47 NB | 1.61 B | 3.86 | 6.60 | <0.001 |
| On BL | 3.88 NB | 1.55 B | 2.33 | 3.98 | <0.001 |

*SED = uncapped sediment; A = apatite cap, B = bioturbation, NB = no bioturbation, CL = contaminated layer, BL = B layer, AL = A layer.

**Table 39. Three-way analysis of variance (ANOVA) of DGT-Ni sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for the 3-way interaction.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | P |
|---|---|---|---|---|---|
| Treatment (apatite cap vs. uncapped) | 1 | 36.38 | 36.38 | 189.45 | <0.001 |
| Bioturbation (presence vs. absence) | 1 | 50.07 | 50.07 | 260.77 | <0.001 |
| Layers (CL, A, B) | 2 | 10.80 | 5.40 | 28.11 | <0.001 |
| Treatment x bioturbation | 1 | 25.18 | 25.18 | 131.13 | <0.001 |
| Treatment x layers | 2 | 3.41 | 1.71 | 8.88 | <0.001 |
| Bioturbation x layers | 2 | 8.57 | 4.29 | 22.32 | <0.001 |
| Treatment x bioturbation x layers | 2 | 2.14 | 1.07 | 5.58 | 0.006 |
| Residual | 60 | 11.52 | 0.19 | | |
| Total | 71 | 148.06 | 2.09 | | |

Multiple comparison results for treatment x bioturbation x layer interaction. Units for least square means (LSMs) are µg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Effect of treatment without bioturbation | | | | | |
| Within contaminated layer | 5.01 SED* | 1.39 A | 3.62 | 14.31 | <0.001 |
| Within A layer | 3.30 SED | 0.85 A | 2.46 | 9.70 | <0.001 |
| Within B layer | 2.31 SED | 0.58 A | 1.74 | 6.87 | <0.001 |
| Effect of treatment with bioturbation | | | | | |
| Within contaminated layer | 0.87 SED | 0.47 A | 0.40 | 1.59 | 0.117 |
| Within A layer | 0.50 SED | 0.39 A | 0.11 | 0.42 | 0.678 |
| Within B layer | 0.71 SED | 0.50 A | 0.27 | 1.08 | 0.412 |
| Effect of bioturbation within uncapped sediment mesocosms | | | | | |
| Within contaminated layer | 5.01 NB | 0.87 B | 4.14 | 16.37 | <0.001 |
| Within A layer | 3.30 NB | 0.50 B | 2.80 | 11.08 | <0.001 |
| Within B layer | 2.31 NB | 0.71 B | 1.61 | 6.35 | <0.001 |
| Effects of bioturbation within apatite cap mesocosms | | | | | |
| Within contaminated layer | 1.39 NB | 0.47 B | 0.92 | 3.65 | <0.001 |
| Within A layer | 0.85 NB | 0.39 B | 0.46 | 1.80 | 0.077 |
| Within B layer | 0.58 NB | 0.50 B | 0.08 | 0.31 | 0.759 |

*SED = uncapped sediment, A = apatite cap, B = bioturbation, NB = no bioturbation.

**Table 40. Three-way analysis of variance (ANOVA) of DGT-Pb sediment data. Also shown are the results of multiple comparisons tests among means conducted with the Holm-Sidak all pairwise comparison procedure (overall significance level = 0.05). Multiple comparison results are shown for significant interactions.**

| Source of Variation | Degrees of freedom | Sum of squares | Mean squares | F ratio | P |
|---|---|---|---|---|---|
| Treatment (apatite cap vs. uncapped) | 1 | 0.05 | 0.05 | 9.61 | 0.003 |
| Bioturbation (presence vs. absence) | 1 | 0.07 | 0.07 | 13.49 | <0.001 |
| Layers (CL, A, B) | 2 | 0.03 | 0.02 | 2.81 | 0.069 |
| Treatment x bioturbation | 1 | 0.03 | 0.03 | 6.23 | 0.015 |
| Treatment x layers | 2 | 0.01 | <0.01 | 0.54 | 0.587 |
| Bioturbation x layers | 2 | 0.01 | <0.01 | 0.53 | 0.594 |
| Treatment x bioturbation x layers | 2 | <0.01 | <0.01 | 0.39 | 0.679 |
| Residual | 58 | 0.31 | 0.01 | | |
| Total | 69 | 0.50 | 0.01 | | |

Multiple comparison results for treatment x bioturbation interaction. Units for least square means (LSMs) are µg $kg^{-1}$.

| Comparison | LSM #1 | LSM #2 | Difference | t | P |
|---|---|---|---|---|---|
| Effects of bioturbation | | | | | |
| Within uncapped sediment mesocosms | 0.16 NB* | 0.05 B | 0.11 | 4.29 | <0.001 |
| Within apatite cap mesocosms | 0.06 NB | 0.04 B | 0.02 | 0.85 | 0.401 |
| Effects of treatment | | | | | |
| With no bioturbation | 0.16 SED | 0.06 A | 0.10 | 3.96 | <0.001 |
| With bioturbation | 0.05 SED | 0.04 A | 0.01 | 0.43 | 0.671 |

*SED = uncapped sediment, A = apatite cap, B = bioturbation, NB = no bioturbation.

### 4.2.9 Conclusions

There have been numerous studies on the effects of bioturbation on metal release from un-remediated contaminated sediments and, to a lesser extent, from contaminated sediments remediated by passive capping. However, the effects of bioturbation on the release of metals from remediated sediments that have been re-contaminated has been little studied. We found that the ability of apatite active caps to reduce the bioavailability of most metals in incoming contaminated sediment was unaffected or even enhanced by bioturbation, probably because bioturbation mixed apatite with the incoming sediment, thereby enhancing chemical sequestration of the metals. We also found that bioturbation reduced the bioavailable pool of some metals in contaminated sediment that was deposited over uncapped clean sediment, although it contributed to the release of others. It is likely that the reductions observed for some metals were the result of burial and dilution of the contaminated sediment combined with chemical processes such as sequestration by minerals and other compounds in the clean sediment. These more complex results simulated what may occur when newly dredged, uncapped sediment is challenged by a combination of recontamination and bioturbation. The effects, in this case, will likely be metal specific and influenced by the chemical composition of the sediment. Additional factors unexplored in this study that might be important in determining the effects of bioturbation combined with recontamination include the type of bioturbating organism and depth of bioturbation and cap thickness. However, as observed in previous studies involving recontamination without bioturbation (Knox et al. 2016, 2019), apatite active caps can reduce the impacts of ongoing metal contamination from uncontrolled sources.

## 4.3 TASK 3. PREDICTION OF LONG-TERM RELATIONSHIPS AMONG THE LOW LEVEL OF INFLUX OF CONTAMINANTS, BIOLOGICAL RECEPTORS, AND REMEDIATED SEDIMENTS

### 4.3.1 Model review

The objective of the modeling conducted for this project was to configure and apply a numerical model that can be used to predict the long-term relationships between a low-level influx of contaminants to a surface water system and the response of cap-remediated sediments and biological receptors. The modeling effort initially focused on the review and diagnostic testing of two existing modeling frameworks that have been developed and/or applied on prior SERDP-funded projects and have relevance to this study. These model frameworks are:

- TICKET (Tableau Input Coupled Kinetic Equilibrium Transport) (Farley et al. 2008), which is a model that was previously used to support project ER-1746; and
- SFM (Sediment Flux Model), which is a model that was developed and applied by LimnoTech to support project ER-1371 (Adriaens et al., 2009).

The primary objectives of the modeling effort were to:

1) Develop a comparative evaluation of LimnoTech's SFM and the TICKET model developed by Dr. Kevin Farley and his collaborators based on the application of these models to simulate the cap conditions represented in the mesocosm experiments; and
2) Based on that comparative evaluation, recommend a specific modeling approach for use in supporting field experimental work and forecasting long-term sediment conditions under different sediment treatment scenarios.

Initial diagnostic testing was conducted with both models within the context of the mesocosm experiments that were carried for Task 1, Subtask 1.1. The following sections describe the data available to support the mesocosm modeling effort, discussion of the SFM and TICKET modeling frameworks, including enhancements and configuration for the initial diagnostic testing, and present results of the initial diagnostic evaluations for the models. Key findings related to the model applications are discussed within the context of the overarching project objective and a path forward with the modeling effort is presented.

#### *4.3.1.1 Sediment Flux Model (SFM)*

*SFM – configuration and application to mesocosm cases*

The SFM was originally developed to simulate hydrophobic organic compounds (HOCs), such as PAHs and PCBs, and it is designed to simulate the adsorption of contaminants (including metals) to sediments via use of equilibrium partitioning/distribution coefficients (Kd), an approach commonly used in surface water models (e.g., USEPA's WASP framework, Ambrose et al. 1993). The key transport and exchange processes represented in the original SFM are

depicted in Figure 59. Although not reflected in this figure, a major advantage of the SFM with respect to representing capped sediments is that the model is explicitly designed to represent the varying physical and chemical partitioning characteristics of a heterogeneous sediment bed. Specifically, the SFM allows for cap materials and native/subsurface sediments to be represented as discrete layers that have varying porosity, dry bulk density, and, most importantly, Kd distribution coefficients for simulated contaminants. In addition to representing discrete layers in the initial sediment bed, the SFM creates a new, distinct layer during simulations to store formerly suspended sediments that have deposited from the water column to the sediment bed. This permits discrete tracking of deposited sediment and its associated physical and partitioning properties, as well as tracking of the contaminant mass associated with the deposited sediments (i.e., recontamination of sediments by deposition of particulate contaminants). Exchange of sediments between the formed "deposition" layer at the surface and the underlying layer can be simulated to occur over time via pore water diffusion and particle mixing. A guidance document, which serves as a brief user manual, was provided as part of the SFM final deliverable for project ER-1371.

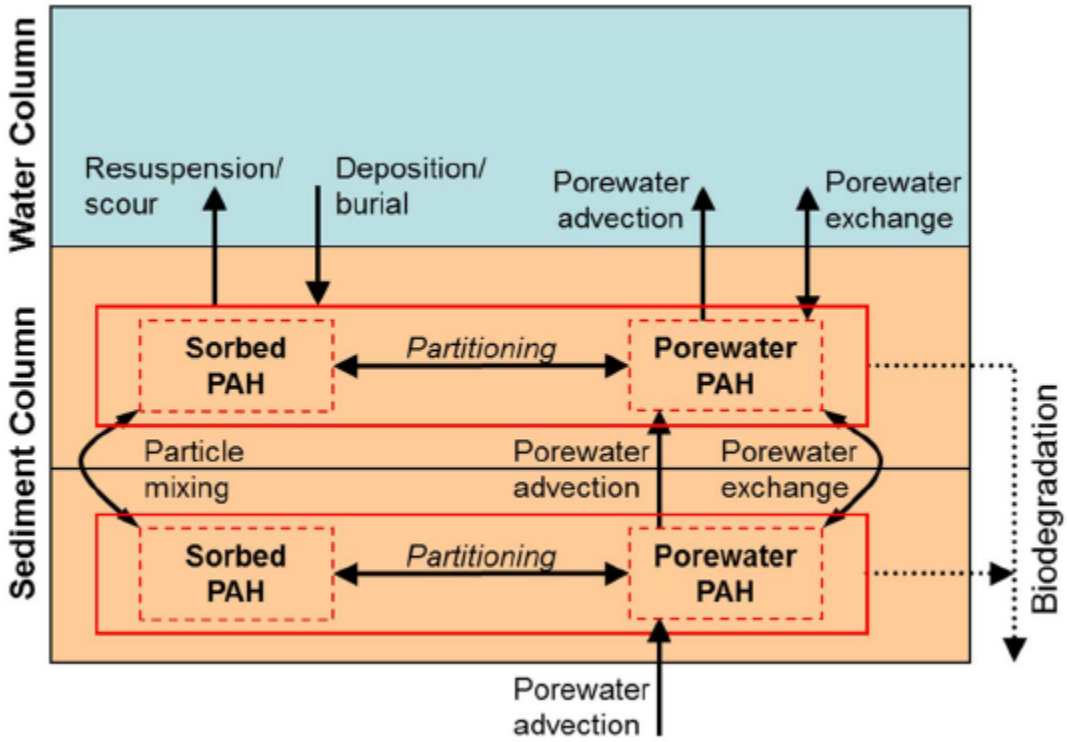



**Figure 59. Conceptual process diagram for original Sediment Flux Model.**

As part of SERDP project ER-1371, the SFM was successfully applied to reproduce laboratory results produced by the University of Michigan and vertical profiles of PAHs observed for sand cap-remediated sediments at the Anacostia River capping test site (Adriaens et al., 2009). It was recognized from the onset of the current project that metals speciation, precipitation, and adsorption dynamics are conceptually more complex than adsorption processes for HOCs, and that this may limit the effectiveness of the SFM in reproducing the transport and fate of heavy metals within an experimental or field environment. The capability of the model to represent the mesocosm environment and reproduce the observed profiles and time series of the metals of interest was thoroughly explored as part of the initial diagnostic testing.

*SFM framework enhancement*

A detailed review of the SFM framework within the context of the mesocosm experimental design revealed that some enhancements were needed to ensure that the SFM could be appropriately and efficiently configured to represent the experimental conditions. These enhancements are briefly described below:

1. **Dynamic simulation of the water column** - The original SFM framework represented the water column as a fixed boundary condition for the sediment bed, and it was quickly determined that a dynamic representation was critical to appropriately representing the mesocosms. The mesocosm experiments are initialized with deionized water overlying the various sediment bed configurations, and then the spike solution was introduced at a steady flow rate. We estimated that the hydraulic residence time in the mesocosm was on the order of 40 days, and so the time required for the water column to approach equilibrium with respect to metals concentrations was expected to be well over a month. In order to provide for a dynamic simulation of the water column, the SFM framework was modified so that the water column could be represented as a dynamic control volume, including simulation of the following inputs and processes:
    - Inflow, including associated boundary concentrations of metals (and potentially suspended sediments), and outflow from the control volume;
    - Input of sediments and associated contaminants resuspended from the sediment bed surficial layer (including their associated partitioning characteristics);
    - Equilibrium partitioning of contaminants between dissolved and particulate phases (i.e., based on the partitioning coefficients associated with suspended sediments); and
    - Settling/deposition of suspended sediments from the water column to the discrete, surficial “deposition” layer that is created by the SFM during simulations.
2. **Capability to simulate multiple metals simultaneously** – The original SFM framework could accommodate only a single contaminant in a given simulation, and a single set of Kd values or distribution coefficients for that contaminant was defined across the discrete sediment types represented in the sediment bed layers. For the sake of efficiency, the SFM

framework was revised to allow for 10 (or more) contaminants of interest to be represented in a single simulation along with a matrix of Kd values specified for those contaminants and the various sediment material types. This enhancement allowed for a single SFM simulation to be configured for each type of mesocosm experiment.

The enhancements described above were implemented and tested within the context of configuring the SFM framework to represent the various mesocosm experiments. A detailed discussion regarding the configuration of the SFM to the mesocosms follows.

*SFM configuration and calibration to mesocosm experiments*

Once the enhancements to the modeling framework described above were fully implemented and tested, SFM simulations were developed to represent the mesocosm experiments in Task 1, Subtask 1.1. The segmentation scheme in the model included a single cell to represent the water column and multiple cells/layers to represent the sediment bed. The water column was assumed to have a constant volume of 19,000 mL, based on the aquarium surface area of 825.8 $cm^2$ and water depth of approximately 23 cm. A constant inflow and outflow of 18 mL $h^{-1}$ was specified. The inflow represented the 10 metals of interest (As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Se, and Zn), each at a total concentration of 0.5 mg $L^{-1}$, consistent with the experimental design.

The number and characteristics of the sediment layers represented in the SFM varied depending on the design of each mesocosm experiment. The thickness of the individual sediment layers was consistently defined as 1.27 cm (0.5 in), which allowed for each 2.54 cm (1 in) cap layer to be represented by two discrete sediment cells/layers in the model. The top three 7.6 cm (3 in) of the "base" (i.e., parent) sediment was represented as six (6) discrete layers in the model. For example, a 2.54 cm sand cap case was represented by a total of 9 layers, including one water column layer, two layers representing the sand cap, and six layers representing the "base"/subsurface sediment.

Each SFM model simulation included a "menu" of sediment types intended to represent the individual cap materials, as well as the "base" sediment, and Kd values associated with those materials. Material types represented in the SFM included:

- "Base"/parent sediment type,
- Sand cap,
- Silty clay cap,
- Organoclay MRM,
- North Carolina apatite (NCA),
- Activated carbon (AC), and
- Multiple active amendment cap (MAAC).

Distribution coefficients (Kd) for the various sediment and cap materials were calculated and the mean values were specified in the baseline SFM model simulations (Table 41). Overall, a total of 70 unique "Kd" values were used to represent the various combinations of metal and sediment/cap material type. Lower and upper bounds of the "Kd" values were later used to test model sensitivity to this parameter.

**Table 41. Distribution coefficients (Kd, log(L $kg^{-1}$)) for sediment and cap materials.**

| Metal Species | Parent | Organoclay MRM | NCA | Sand[1] | Silty Clay | Actived Carbon | MAAC |
|---|---|---|---|---|---|---|---|
| As | 2.60 | 2.19 | 2.48 | -6.00 | 2.27 | 2.74 | 2.61 |
| Cd | 1.50 | 1.28 | 3.62 | 1.08 | 2.07 | 3.74 | 3.48 |
| Co | 1.54 | 0.85 | 3.17 | -6.00 | 1.63 | 3.42 | 3.25 |
| Cr | 3.74 | 2.67 | 3.51 | -6.00 | 3.65 | 3.20 | 3.24 |
| Cu | 2.92 | 2.60 | 3.58 | 0.40 | 3.03 | 3.41 | 3.35 |
| Hg | 2.67 | 4.24 | 2.66 | -6.00 | 3.07 | 3.82 | 4.49 |
| Ni | 1.63 | 0.94 | 3.25 | 1.40 | 1.73 | 3.41 | 3.31 |
| Pb | 3.34 | 2.81 | 3.69 | 1.34 | 3.94 | 3.86 | 3.46 |
| Se | 1.60 | 1.66 | 2.23 | -6.00 | 1.41 | 2.93 | 2.67 |
| Zn | 1.78 | 1.74 | 3.67 | -6.00 | 1.92 | 3.47 | 3.46 |

Exchange between the water column and the sediment bed was represented in the following ways:

- Diffusive exchange between the water column and surficial sediment bed layer;
- Resuspension from the sediment bed; and
- Deposition to the sediment bed from the water column.

Diffusive exchange between the water column and sediment bed for the base SFM simulations was represented using a rate of 1.0e-9 $m^2\ s^{-1}$, which is consistent with molecular diffusion. Likewise, the rate of diffusive exchange between adjacent sediment layers was input as 1.0e-9 $m^2\ s^{-1}$, and then internally corrected by the model for porosity. The SFM also provides the capability of simulating "particle mixing", which results in the exchange of particle-bound contaminants between adjacent bed layers. This process is typically included to represent the effects of bioturbation or other types of disturbances that would result in vertical mixing of the bed. For the mesocosm simulations, the particle mixing rate was defined as zero to reflect the fact that organisms were absent for the majority of the experiments and were confined to cages when later added to the experiments.

As described above, the water column simulation represents incoming flow and a total concentration of 0.5 mg $L^{-1}$ for each of the 10 metal species of interest. In addition to simulating the individual metal species, the enhanced SFM framework also simulates total suspended

sediment (TSS), including addition of TSS mass via inflow to the water column and resuspension from the sediment bed, and removal of TSS mass via outflow from the water column and deposition to the sediment bed. Turbidity data collected for the "spike solution only" mesocosms were in the range 0.5 – 2 NTU, suggesting that the incoming TSS concentrations in other mesocosms (i.e., those containing sediments) were very low. (Precipitation of metals likely contributed to the low-level turbidity observed in the "spike solution only" mesocosms.) The primary source of measured turbidity in the mesocosms therefore was the resuspension of material from the sediment bed, promoted by the air stone diffuser deployed in each mesocosm. Direct measurements of resuspension and deposition rates in the mesocosms were not attempted and likely would not have been possible under the circumstances. However, estimation of these rates was critical, given the importance of these processes in exchanging metals between the water column and the sediment bed in sediment-containing mesocosms.

The data available to constrain estimates of resuspension/deposition rates included the turbidity measurements available for the water column and the total and dissolved metals concentrations observed in the water column throughout the experiments. The turbidity data can serve as a proxy for (roughly) estimating the equilibrium TSS concentration in the water column (Figure 60). Given that water-sediment diffusive exchange is expected to be a minor process, the rate of decline of water column metals concentrations can be expected to reflect the "loss" of metals from the water column to the sediment bed via settling/deposition. For the base SFM simulations, resuspension and settling rates were initially roughly estimated based on spreadsheet calculations and then co-calibrated in the SFM simulations to provide an optimal match for the metals concentrations observed in the water column. TSS concentrations simulated by the SFM were also compared against the turbidity measurements to ensure that the model results were similar to observations. Because no paired turbidity/TSS measurements are available for the mesocosm, it was not possible to develop a correlation between turbidity and TSS. For the sake of rough comparison of predicted TSS to data, turbidity was assumed to provide a proxy for TSS by assuming that 1 NTU was representative of ~1 mg $L^{-1}$ of TSS.

Resuspension rates calibrated for the mesocosm experiments ranged from 6 to 60 mm $yr^{-1}$, and calibrated settling/deposition rates ranged from 0.25 to 0.50 m $day^{-1}$. The calibrated deposition rates appear to be reasonable given that they reflect actual deposition to the bed, as opposed to the settling rates of discrete particles (which would be much higher, particularly for sand and silt particles). We expect that the continuous operation of the air stones served to not only promote resuspension, but also to limit re-deposition of resuspended sediments. Although the estimated rates appear to be reasonable, they should be considered uncertain given that direct measurements were not available. The sensitivity of the model to assumed resuspension and deposition rates was briefly explored, and the results are presented and discussed in the "SFM Sensitivity to Parameter Assumptions" section included below.

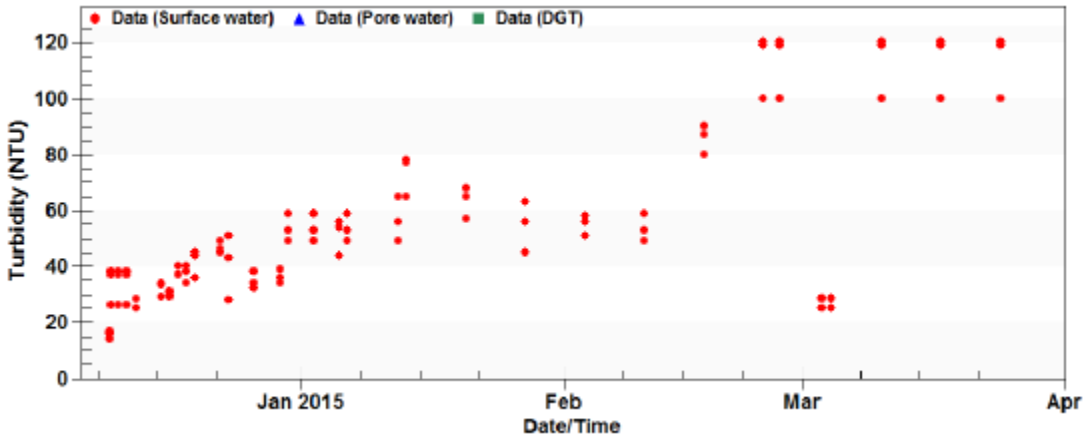



**Figure 60. Time series of turbidity observations for 5.1 cm sand cap mesocosms.**

*SFM baseline results for mesocosm application*

Although the SFM application represented all 10 metal species of interest for each of the nine unique mesocosm experiment types, particular focus was given to the five (5) metal species that were observed to provide the best recovery in the "spike solution only" experiments. The species that demonstrated strong recovery in these experiments included Cd, Zn, Cu, Ni, and As. (Lower recoveries for Hg, Pb, Co, Se, and Cr suggest that precipitates involving these metals may have formed in the spike solution.) For brevity, only results for As, Cd, and Ni are shown here; however, it should be noted that the observations and findings are generally applicable for other metals that demonstrated high recovery in the "spike solution only" experiments.

Calibration of the SFM to the mesocosm experiments was accomplished primarily through adjustment of resuspension and settling rates for each mesocosm case. The model simulates total, dissolved, and particulate concentrations of each metal species in the water column and within each sediment layer. Dissolved metal concentrations were compared against dissolved concentrations measured in the water column and in porewater samples. Total metal concentrations were compared against total concentrations measured in the water column. In addition, both total and dissolved concentrations were compared to concentrations estimated from the DGT devices that were deployed in the water column and at various depths within the sediment column during the latter portion of the experiments. The resin in the DGT devices strongly binds labile trace metals, and the near-field gradient these devices create also drives desorption of metals from particulates locally (Sochaczewski et al., 2005). Therefore, a desirable outcome from the model is that the simulated dissolved metal concentrations are somewhat lower than the DGT-derived concentrations, with the simulated total metal concentration expected to be higher than the DGT-derived concentrations.

As noted above, SFM simulations were developed for all mesocosm cases and for all metals of interest. For brevity, model-data comparisons shown here are only for dissolved As, Cd, and Ni

for the sand, NCA, organoclay MRM, activated carbon, and a mixed amendment cap (MAAC) mesocosms (2.54 cm cap thickness). The relevant figures included for day 3/5/15 of the experiment are outlined below (Task 1, subtask 1.1 experiments):

- Sand cap case: dissolved As, Cd, and Ni vertical profiles (Figure 61);
- NCA cap case: dissolved As, Cd, and Ni vertical profiles (Figure 62);
- Organoclay MRM cap case: dissolved As, Cd, and Ni vertical profiles (Figure 63);
- Activated carbon cap case: dissolved As, Cd, and Ni vertical profiles (Figure 64); and
- MAAC cap case: dissolved As, Cd, and Ni vertical profiles (Figure 65).

The plots provided in these figures include the simulated dissolved metal concentration in the bottom 2.54 cm of the water column and dissolved concentrations in each sediment layer for depths below the sediment-water interface greater than zero. The vertical profile represents simulation results and data collection roughly three months after the start of the experiment, which roughly corresponds to the end of the DGT deployment, as well as collection and analysis of surface water and pore water samples. Simulated concentrations are shown by the continuous blue line, and observed values are depicted by the discrete points, which are symbolized as follows:

- *Red circles* – water column (filtered) measurements;
- *Blue triangles* – pore water concentrations; and
- *Green squares* – DGT-based concentrations in water and sediment.

Key observations and findings based on visual comparisons of the model results and the individual data points plotted in vertical profiles are outlined below.

- The SFM reproduced the water column dissolved Cd and Ni concentrations reasonably well for most cap scenarios, but overpredicted the dissolved As concentration for most cap cases. The favorable comparisons for Cd and Ni suggest that the material-specific Kd values (which were computed based on prior sediment column experiments) and the selected resuspension and deposition rates captured the overall effect of the sorption and transport processes that drove water column concentrations. (Note that the Kd values used by the model to simulate adsorption in the water column were based on the type of cap material resuspended from the sediment bed; therefore, consistent Kd values were used in the water column and the cap layers for these simulations.)
- The model overpredicted dissolved As, Cd, and Ni concentrations for the sand cap case, which may suggest that the sand cap material should have a higher associated Kd value in the water column and/or in the sediment bed.
- The model reasonably reproduced dissolved As and Cd concentrations measured in the early March pore water samples; however, the model tended to overpredict dissolved Ni

concentrations in pore water. The dissolved-phase concentration simulated by the model reflected the Kd value assigned to the "base" sediment type for each metal.

- For each of the three metals shown, simulated dissolved concentrations in the active cap layers were lower than those simulated in the two cap layers for the (passive) sand cap case. Although not shown, the model simulated higher total metal concentrations in the uppermost active cap layer relative to the uppermost layer represented in the sand cap case, which reflected greater adsorption of metals in the water column and transfer to the sediment bed via settling/deposition for the active cap cases. These results were consistent with expectations and the use of Kd values for the active cap materials that were typically higher than those used for sand (Table 41).

- Simulated dissolved concentrations were consistently lower than the metal concentrations derived from the DGT probes. Although profiles of total metal concentrations are not shown, the DGT-based results fall between the dissolved and the total concentrations, which was an expected result. Perhaps the most useful comparison between the DGT-based concentrations and the simulation results is the trend with depth. Within the sediment column, the DGT-based concentrations were highest for the uppermost cap layer and then declined with depth, and the model reproduced this general trend. (Water column DGT results are shown for completeness, but it should be noted that the direct measurements of water column dissolved and total metal concentrations were relied on for calibration and evaluating model performance.)

The lack of direct measurements of dissolved, total, and/or particulate metal concentrations in the cap layers was limiting with respect to evaluating model performance. However, the observed water column, pore water, and DGT-based concentrations provided a basis for assessing the performance of the SFM model. Overall, the model simulations reflected the general observations and trends in the observations for most cap cases for the evaluated metals.

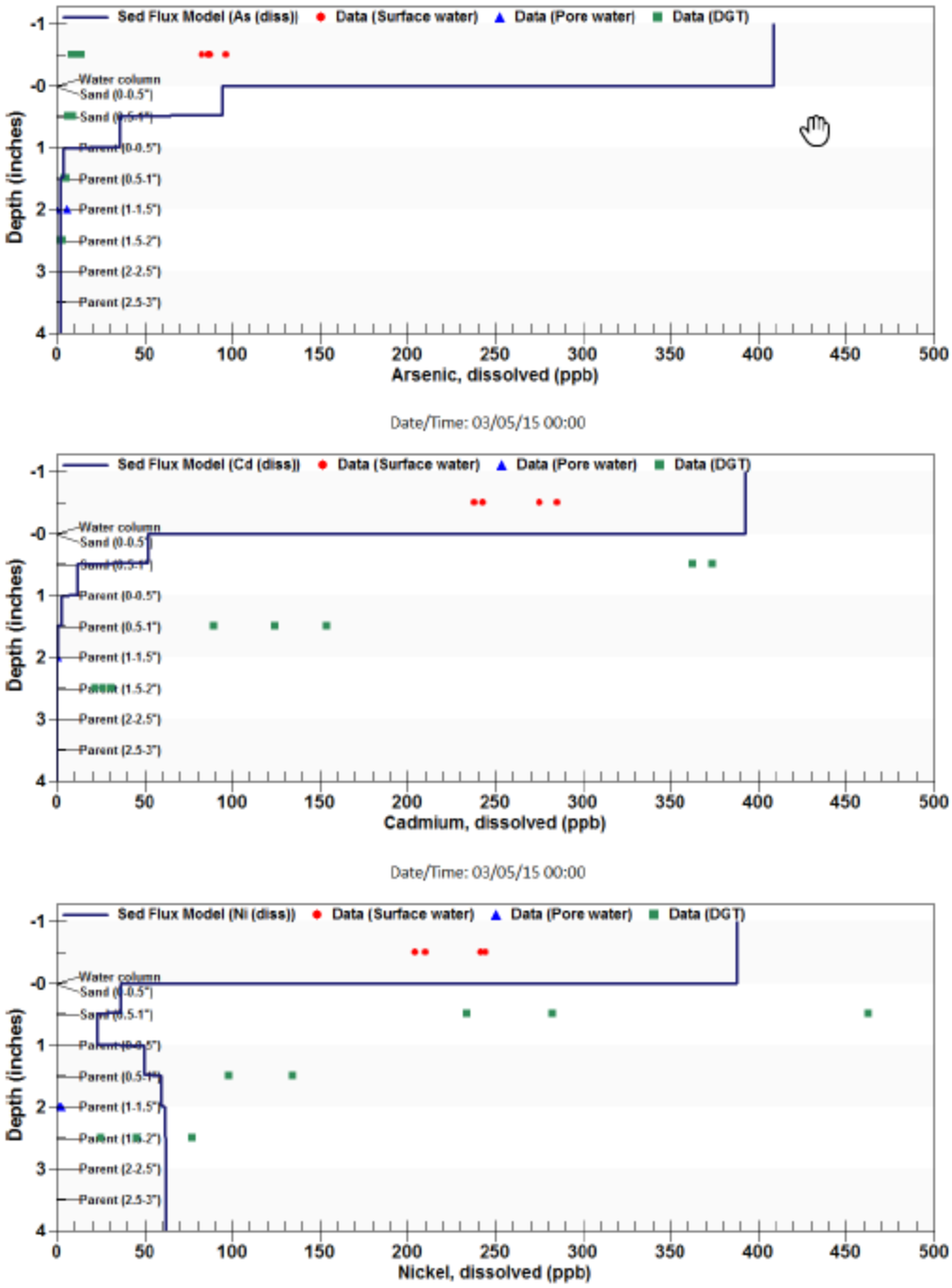



**Figure 61. Vertical profile of dissolved metal concentrations on 3/5/15 for sand (2.54 cm) cap: top panel – As, middle panel – Cd, bottom panel – Ni**

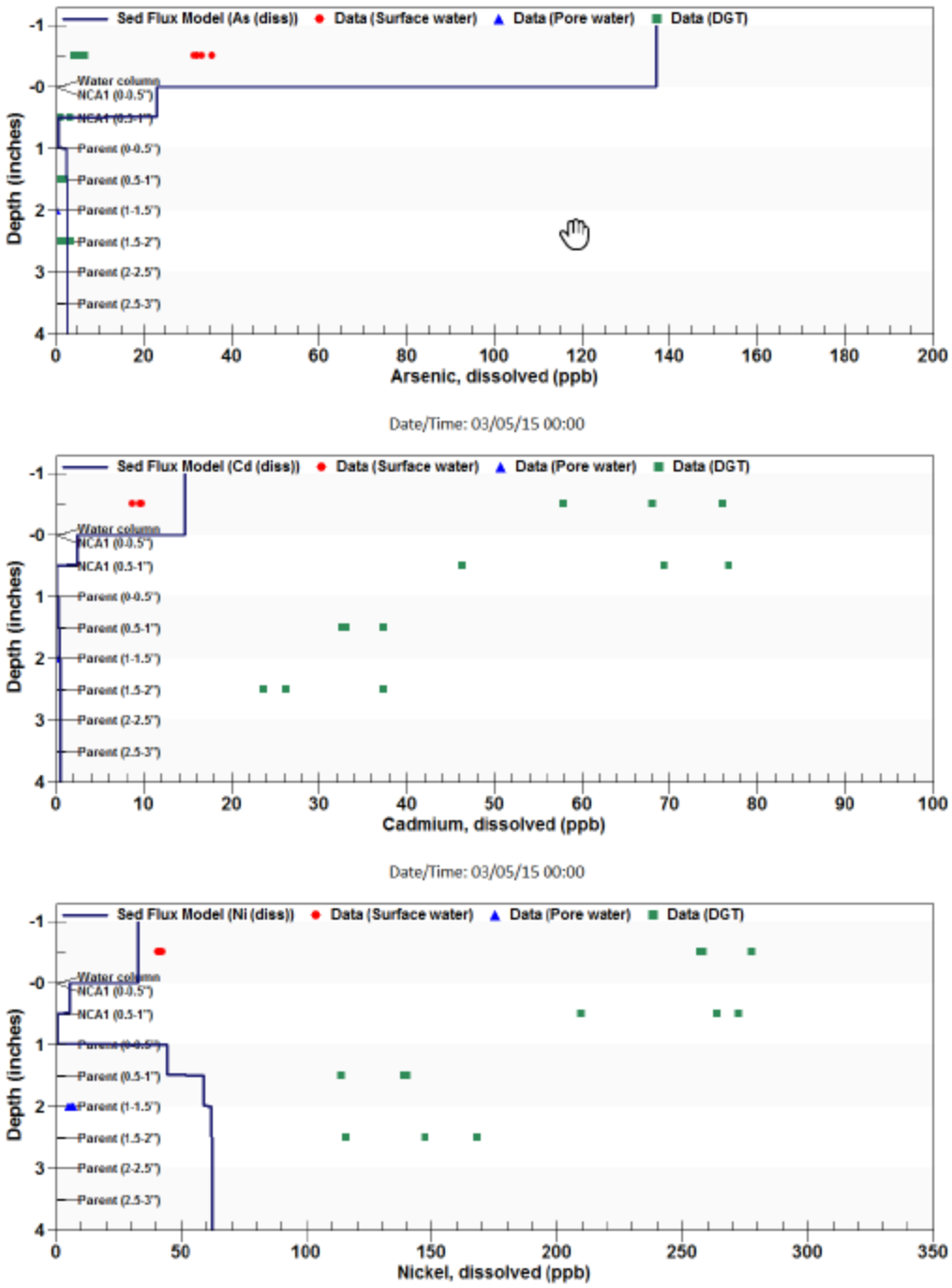



**Figure 62. Vertical profile of dissolved metal concentrations on 3/5/15 for NCA (2.54 cm) cap: top panel – As, middle panel – Cd, bottom panel – Ni.**

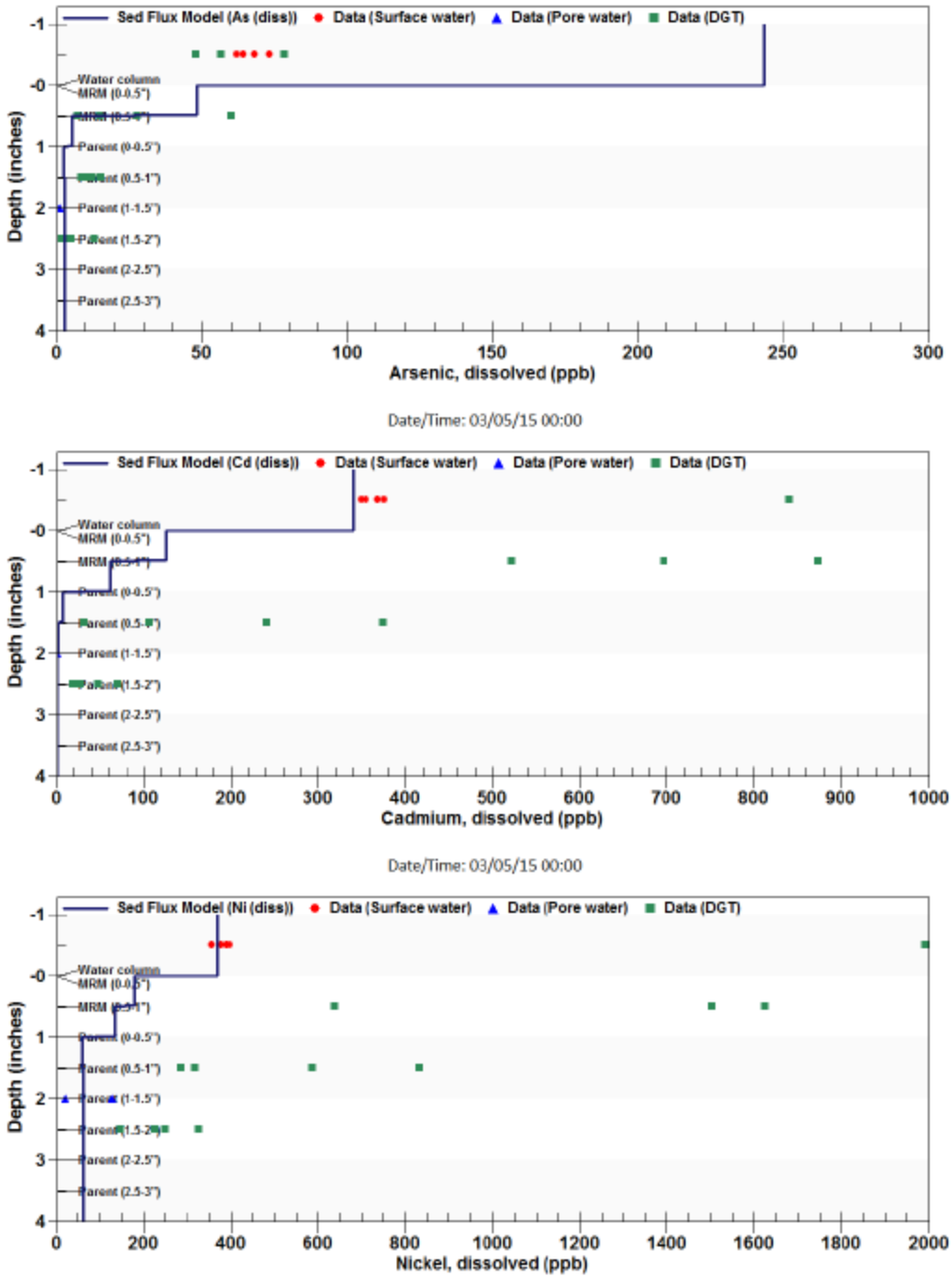



**Figure 63. Vertical profile of dissolved metal concentrations on 3/5/15 for organoclay MRM cap: top panel – As, middle panel – Cd, bottom panel – Ni.**

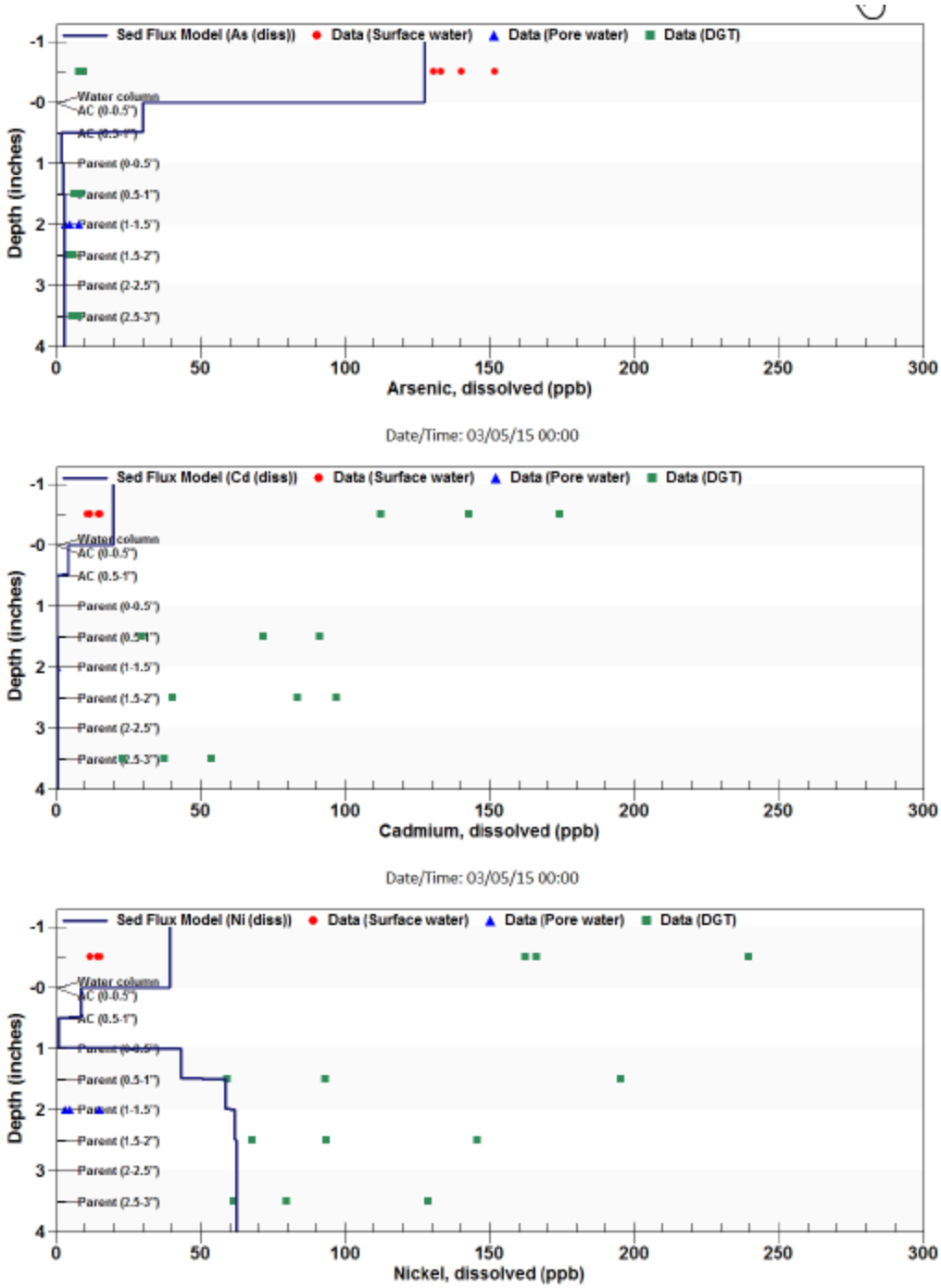



**Figure 64. Vertical profile of dissolved metal concentrations on 3/5/15 for activated carbon cap: top panel – As, middle panel – Cd, bottom panel – Ni.**

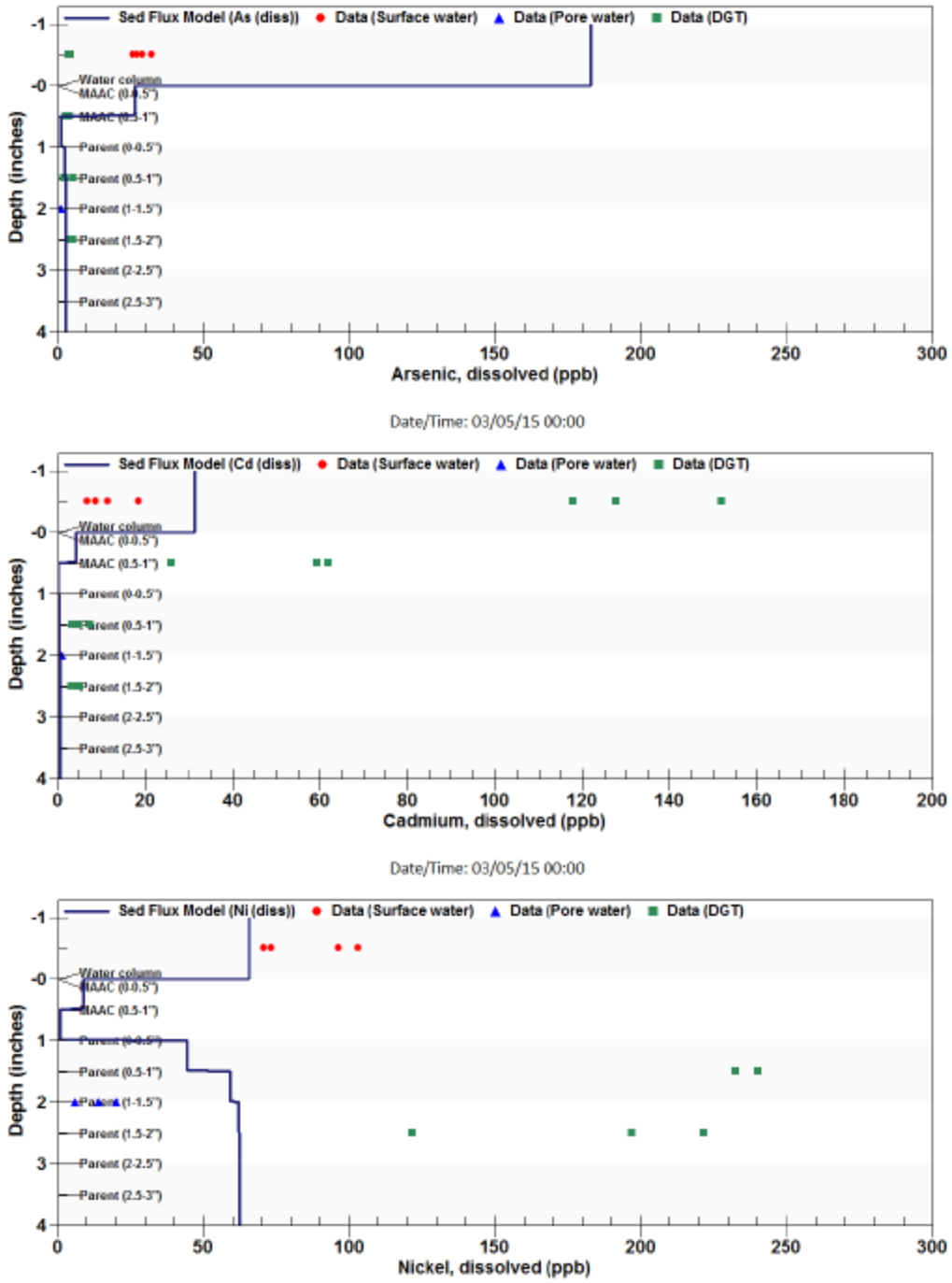



**Figure 65. Vertical profile of dissolved metal concentrations on 3/5/15 for MAAC: top panel – As, middle panel – Cd, bottom panel – Ni.**

*SFM sensitivity to parameters assumptions*

Following the development of baseline SFM simulations for the mesocosms, the sensitivity of the model to several parameter assumptions was evaluated. The input parameters that were evaluated included:

- Kd distribution coefficients specified for the various sediment types and metal species;
- Rate of diffusive/dispersive exchange across the water-sediment interface and between sediment layers; and
- Resuspension and settling rates.

For brevity, sensitivity results presented for these three evaluations were limited to simulated dissolved Ni and Cd concentrations for the sand, AC, and NCA (North Carolina apatite) cases (2.54 cm caps), which allowed for a comparative evaluation for active and passive cap cases. The results for each set of sensitivity simulations are discussed collectively following the presentation of the figures for each set. Each figure plots the vertical profile of dissolved Cd and Ni at the approximate end of the mesocosm experiments (4/2/2015), with water column results shown in the depth range 0 to (-2.5) cm (i.e., representing the bottom 2.5 cm of the water column).

The sensitivity of the SFM to Kd values was evaluated using the lower and upper bounds of the estimated range provided by SRNL for all sediment types represented in a given simulation (note that the mean value was used for the baseline runs presented in the last section). Results for activated carbon and NCA (2.54 cm) cap cases are provided in Figures 66 and 67, respectively.

The sensitivity of the model to the diffusion/dispersion rate was evaluated by increasing and decreasing the base rate (1.0e-9 $m^2/s$) by an order of magnitude for the sand (2.54 cm) and NCA (2.54 cm) cap cases. These results are provided in Figures 68 and 69, respectively.

The sensitivity analysis for the resuspension and deposition rates involved co-varying these input values, such that a reasonable TSS concentration (i.e., generally consistent with observed turbidity) could be obtained. The resuspension and deposition rates used for the sand and NCA cap cases were as follows:

- Sand cap case:
    - *Baseline* – resuspension: 6 mm $yr^{-1}$, settling: 0.3 m $day^{-1}$
    - *"Low" sensitivity* – resuspension: 2 mm $yr^{-1}$, settling: 0.1 m $day^{-1}$
    - *"High" sensitivity* – resuspension: 12 mm $yr^{-1}$, settling: 0.6 m $day^{-1}$

- NCA cap case:
    - *Baseline* – resuspension: 30 mm $yr^{-1}$, settling: 0.25 m $day^{-1}$
    - *"Low" sensitivity* – resuspension: 3.0 mm $yr^{-1}$, settling: 0.025 m $day^{-1}$

- *"High" sensitivity* – resuspension: 60 mm $yr^{-1}$, settling: 0.5 m $day^{-1}$

The results for the resuspension and settling sensitivity runs for the sand and NCA cap cases are provided in Figures 70 and 71, respectively.

The following observations can be made with respect to the results obtained for the parameter sensitivity analysis:

- Model results for the cap layers and the water column for the NCA cap scenario were relatively sensitive to the selection of the Kd values selected based on the information provided by SRNL (Figures 66 and 67). The NCA cap case demonstrated the highest level of sensitivity for simulated concentrations in the water column, reflecting the variability in measured Kd values for prior apatite experiments (e.g., 3589 – 4758 mL $g^{-1}$ for Cd). Model results (for both the water column and sediment) for the activated carbon cap case were less insensitive to the range of "Kd" values tested. The lower degree of sensitivity for the AC cap is likely due to the fact that the ranges of "Kd" values provided for Cd and Ni for this cap (e.g., 5023 – 6967 mL $g^{-1}$ for Cd for AC) were significantly higher than the corresponding ranges for apatite.

- The results of the diffusion/dispersion rate sensitivity (Figures 68 and 69) indicate that dissolved metal concentrations predicted for the sand cap case were much more sensitive to a one-order-of-magnitude variation in the rate than the results for the NCA case (with respect to the water column and the cap layers). This is an expected outcome given that lower Kd values used for sand will allow for diffusive/dispersive exchange of dissolved metals to play a more significant role than in the case of the active cap scenarios.

- With respect to resuspension and deposition rates (Figures 70 and 71), the NCA cap case demonstrated greater sensitivity than the sand cap case in terms of water column concentrations. This is expected as deposition of particle-bound metals would be more significant in the NCA case than for the passive sand cap scenario. Dissolved concentrations in the NCA cap layers were relatively insensitive to the resuspension and settling rates in the context of the 3-month time scale evaluated. However, it is anticipated that the model would demonstrate greater sensitivity to selection of resuspension and settling rates for a longer-term simulation due to differences in the time required to saturate the cap layers.

Not surprisingly, the results of the SFM sensitivity testing suggest that model simulations for active cap scenarios were most sensitive to the selection of a representative Kd value and the resuspension and settling rates.

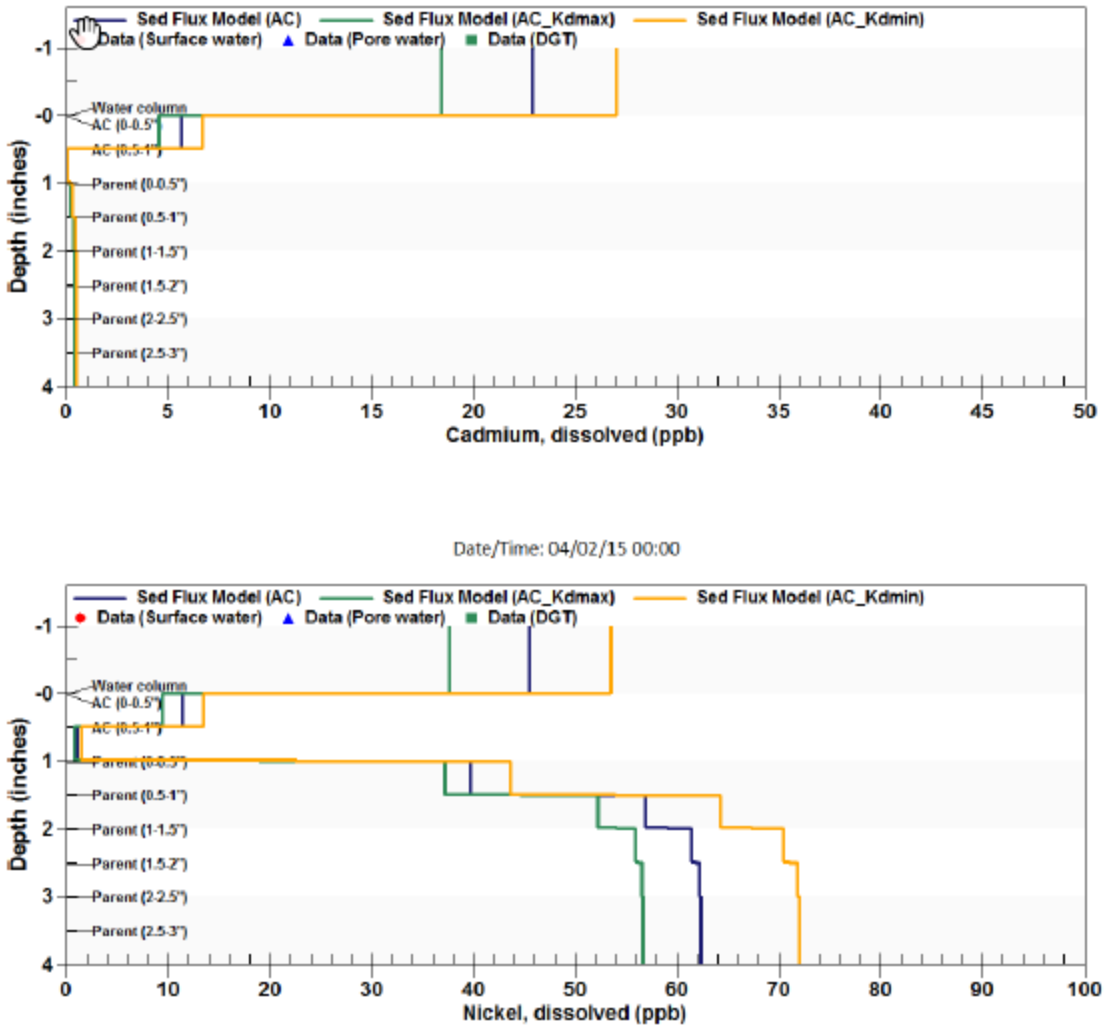



**Figure 66. Vertical profile results for Kd sensitivity simulations for activated carbon case for dissolved Cd (top panel) and dissolved Ni (bottom panel).**

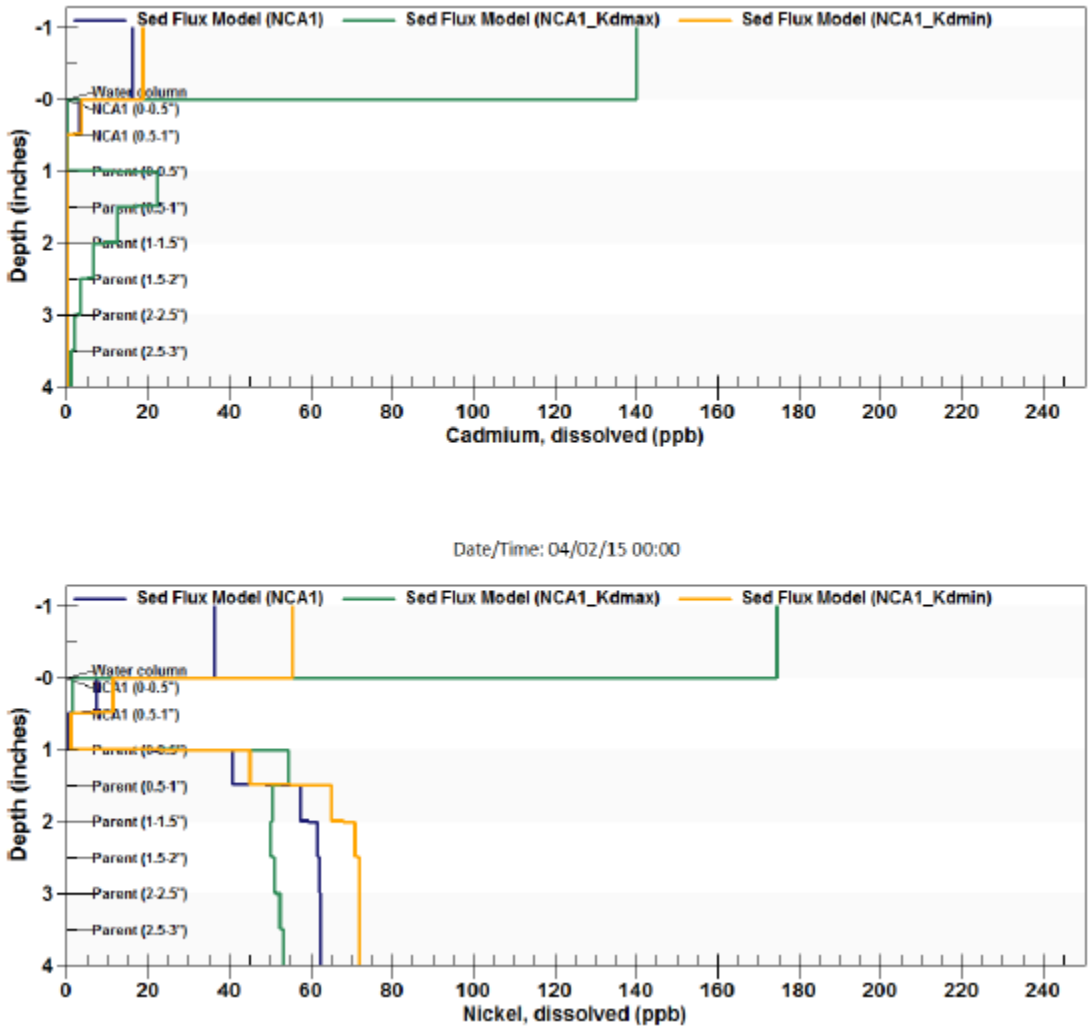



**Figure 67. Vertical profile results for Kd sensitivity simulations for NCA 2.54 cm cap for dissolved Cd (top panel) and dissolved Ni (bottom panel).**

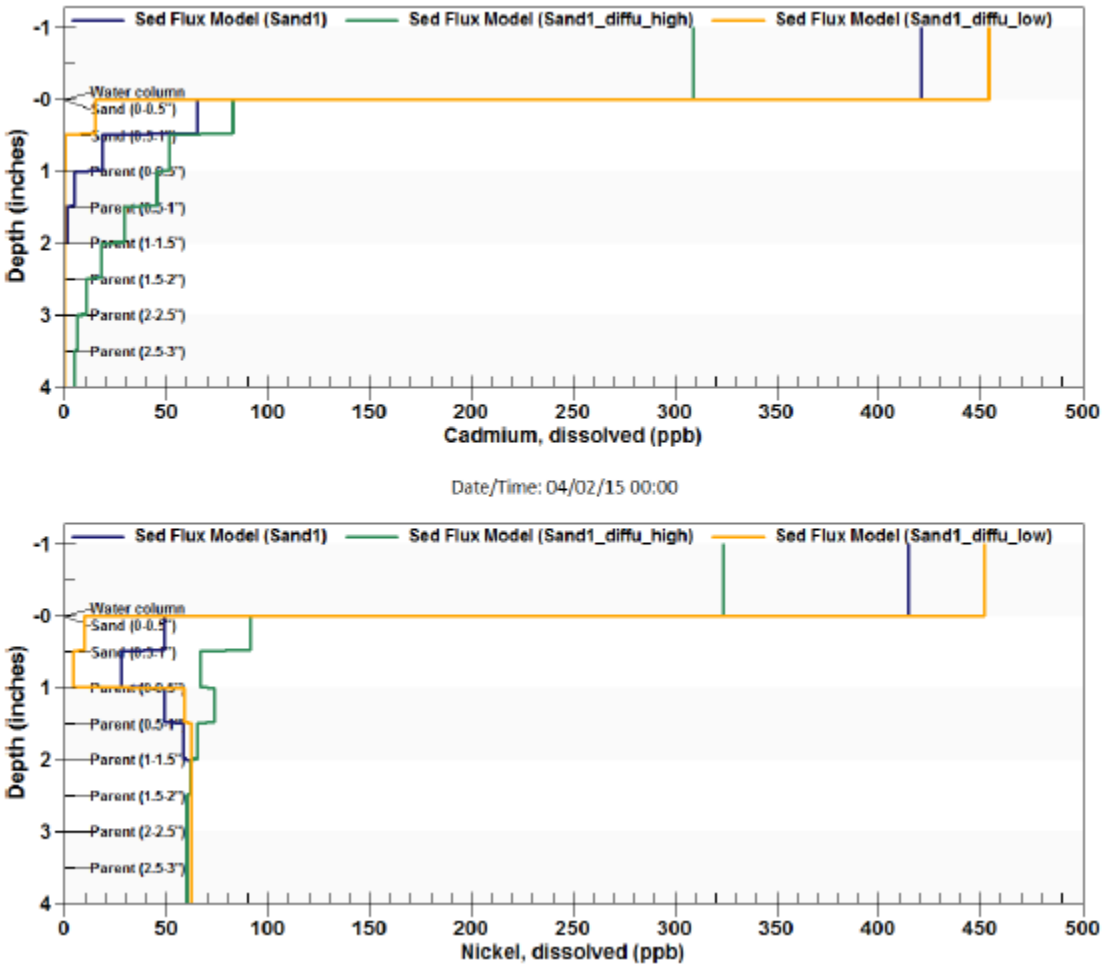



**Figure 68. Vertical profile results for diffusion rate sensitivity simulations for sand 2.54 cm cap for dissolved Cd (top panel) and dissolved Ni (bottom panel).**

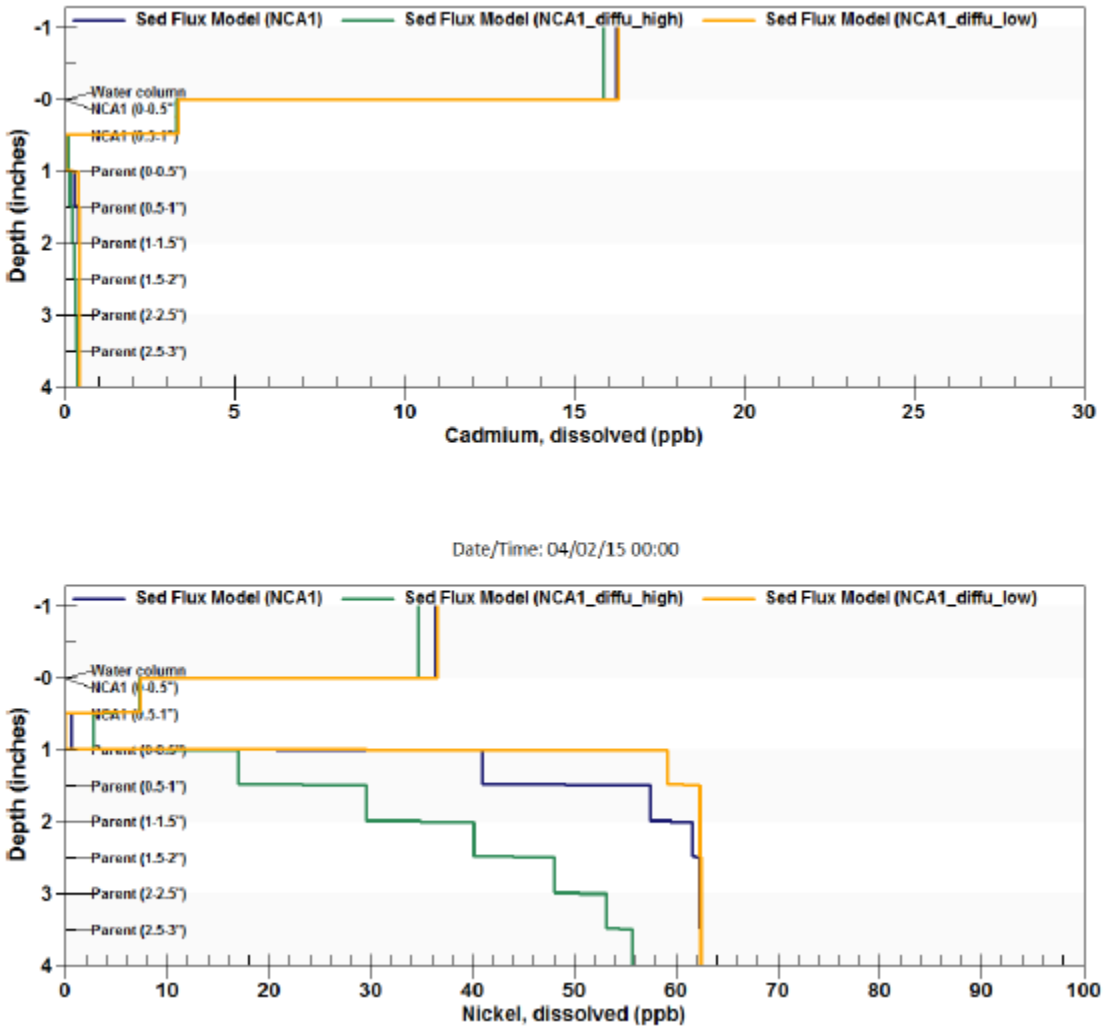



**Figure 69. Vertical profile results for diffusion rate sensitivity simulations for NCA 2.54 cm cap for dissolved Cd (top panel) and dissolved Ni (bottom panel).**

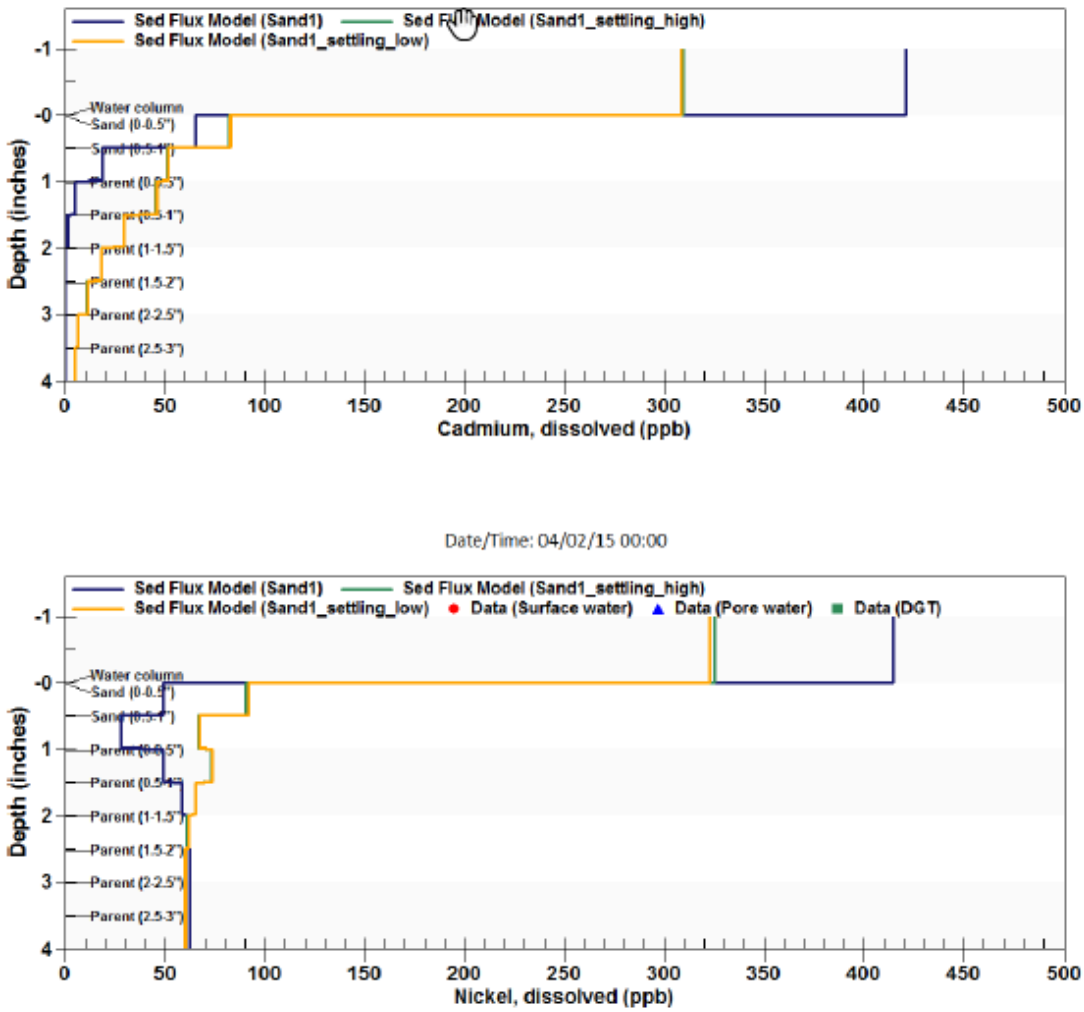



**Figure 70. Vertical profile results for resuspension/deposition rate sensitivity simulations for sand (2.54 cm) cap for dissolved Cd (top panel) and dissolved Ni (bottom panel).**

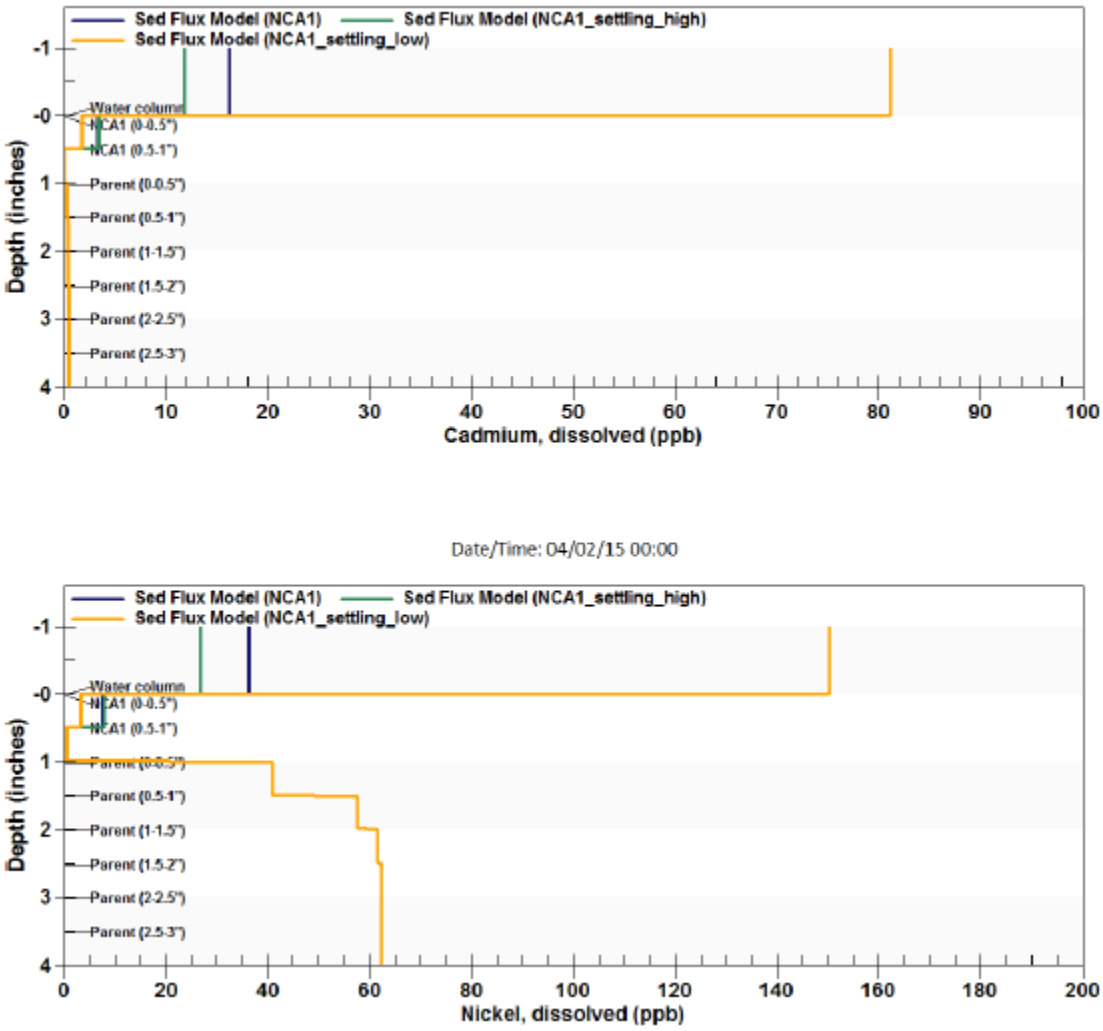



**Figure 71. Vertical profile results for resuspension/deposition rate sensitivity simulations for NCA (2.54 cm) cap for dissolved Cd (top panel) and dissolved Ni (bottom panel).**

#### *4.3.1.2 TICKET model*

*TICKET model – configuration and application to mesocosm cases*

The TICKET model (Farley et al., 2008, 2011) contains detailed algorithms to dynamically simulate metal speciation and precipitation via the tableau approach, which is also used by MINEQL and other similar chemical equilibrium models. From a chemical perspective, TICKET provides an appropriate framework for evaluating the speciation of metals. However, potential concerns regarding the use of the TICKET model were identified including:

1. The capability of TICKET to represent vertical variations in sediment physicochemical properties reflecting the presence of an active or passive cap layer, an underlying native sediment layer, and a potential recontamination layer above the cap.

2. The capability of TICKET to reproduce observed metals concentrations and Kd values from the mesocosm experiments.

The review and diagnostic evaluation of TICKET focused on evaluating those and other related concerns.

The TICKET model is available in two different versions, which have some significant differences. TICKET – Unit World Model (TICKET-UWM) is a version of the model that is specifically configured to provide a screening-level model for metals transport and fate in lake systems (Farley et al., 2011). This version represents a well-mixed water column segment and a single sediment segment. In addition to representing chemical speciation via the tableau approach, processes represented include mass inflow/outflow to/from the water column, resuspension, settling/deposition, sediment-water diffusive exchange, diagenesis, and burial. TICKET-UWM has a graphical user interface that can be downloaded from http://www.unitworldmodel.net/ (registration required), which makes it relatively easy to set up and run model simulations. Unfortunately, this version of the model does not provide the flexibility needed to define multiple, heterogeneous layers in the sediment bed, which is a firm requirement for representing the capping scenarios that the current project is focused on. Because of this limitation, it was determined that the TICKET-UWM version would not be evaluated.

The version of TICKET evaluated during Year 1 is a (Microsoft Excel) spreadsheet-based version that has the model algorithms coded in the Visual Basic for Applications (VBA) macro language that is embedded within Excel. The user is required to specify inputs to the model via a series of worksheets, including:

- A tableau to be used in the simulation;
- Model segmentation and transport parameters;
- Options for representing individual tableau components as either “fixed”, “static”, or “dynamic”; and
- Initial conditions and boundary conditions for the components included in the tableau.

The model algorithms and associated inputs are consistent with those reported by Farley et al. (2008). This version of TICKET provides greater flexibility in defining the model domain, and provides the opportunity for representing a multi-layer, vertically heterogeneous sediment bed. Options are available in the model to represent diffusive/dispersive, resuspension, and/or settling/deposition exchanges. The evaluation of TICKET focused solely on this version of TICKET because it appeared to be adaptable to represent capped sediment conditions in mesocosms or actual field sites. The use of the term "TICKET" will hereafter refer to the spreadsheet/VBA-based version of the model.

*Ticket framework enhancement*

Several key enhancements were made to the TICKET model framework to facilitate an efficient evaluation of the model. First, the TICKET simulation code was ported from Microsoft Excel VBA to an existing LimnoTech software tool called "WinModel.NET", which is coded in Visual Basic .NET. Although this required some effort, this step was necessary to efficiently run model simulations covering a multi-month period. (VBA is an interpreted language, which takes longer to execute than compiled Visual Basic .NET code.) Second, additional code was added to TICKET to produce a set of external, well-organized output files that could be linked to an existing LimnoTech visualization tool and used to evaluate the model results from individual simulations in an efficient matter. The original TICKET model reported results to a single worksheet for all chemical components and species for each output interval. No visualization tools of any kind were included with the model, and so processing the results from a single simulation was extremely time-consuming. This issue was remedied by implementing the new output processing/visualization approach. The improvements described above required considerable effort, but a complete evaluation of the TICKET model with the modeling resources would not have been possible without these enhancements.

*TICKET Configuration & Calibration to Mesocosm Experiments*

The configuration of the TICKET model to represent mesocosm conditions proved to be considerably more data- and time-intensive than the configuration of the "Sediment Flux Model." This section describes the configuration of the TICKET model domain to represent mesocosm conditions and efforts made to develop simulations to represent select mesocosm conditions.

Consistent with the SFM configuration, the segmentation scheme in the TICKET model included a single cell to represent the water column and multiple cells/layers to represent the sediment bed. The water column was assumed to have a constant volume of 19,000 mL, based on the aquarium surface area of 825.8 $cm^2$ and a water depth of approximately 23 cm. A constant inflow and outflow of 18 $mLhr^{-1}$ was specified. The inflow represented the total concentration of a given metal as 0.5 mg $L^{-1}$ (0.5 ppm), consistent with the experimental design. The number of the sediment layers represented in the TICKET simulations varied depending on the design of each mesocosm experiment. The thickness of the individual sediment layers was consistently defined as 1.27 cm, which allowed for each 2.54 cm cap layer to be represented by two discrete sediment cells/layers in the model. The top 7.62 cm of the "base" (i.e., parent) sediment was

represented as six (6) discrete layers in the model. For example, a 2.54 cm sand cap case was represented by a total of 9 layers, including one water column layer, two layers representing the sand cap, and six layers representing the "base"/subsurface sediment.

The specification of initial chemical component/species concentrations required by TICKET proved to be very challenging. The concentrations of major cations and anions present in the cap materials, as well as in the "base"/parent sediment, were largely unknown and had to be assumed. The initial total concentrations of metals in the "base" sediment material were known and specified consistent with data collected during the experiment. Metals concentrations in cap materials were unknown, and so were assumed to be negligible initially. Of greatest concern, information regarding the nature and quantities of sequestration agents associated with the passive and active cap materials was generally lacking. The sequestration agents assumed to be most important for each cap type are outlined below:

- Sand cap – adsorption to (limited) particulate organic carbon associated with sand particles;
- Clay - adsorption to clay/silt particles;
- NCA – adsorption to apatite (e.g., hydroxylapatite) and dissolution of apatite and subsequent formation of phosphate-metal precipitates (Knox et al., 2006);
- Organoclay MRM – adsorption to and ion replacement with bentonite-type compounds; and
- Activated carbon – adsorption to sites available on carbon compounds.

The thermodynamic database that is currently used to support TICKET does not appear to provide an adequate representation of the role of "natural" organic carbon or activated carbon as sequestering agents, nor does it include a representation of bentonite/montmorillonite as a precipitate. This does not reflect a problem with the model per se, but rather reflects the limited data available to represent the behavior of the sequestering agents described above within a chemical speciation model such as TICKET. The TICKET database does include several forms of apatite precipitate, which provided the potential for configuring a NCA cap case (i.e., representing replacement of Ca ions in favor metal cations). However, numerous attempts to execute TICKET simulations including phosphate and apatite failed due to convergence issues. Considerable effort was expended in testing various combinations of initial conditions to overcome the convergence issues, but unfortunately without success.

Ultimately, the data limitations and challenges in obtaining stable model simulations made it infeasible to develop mesocosm-specific simulations with the TICKET model. However, a simpler demonstration of the TICKET model was developed by using salicylate as a proxy for particulate organic carbon and Ni as a metal species. (Attempts were made to incorporate multiple metal species into a single simulation, but convergence problems were consistently encountered, and it was not feasible to work through these issues.) The choice of salicylate for a demonstration was arbitrary, and it is important to recognize that it provides only a very simplistic attempt at representing adsorption to organic carbon. Despite the simplifications described above, convergence issues were still consistently encountered with TICKET unless pH

was simulated as a "fixed" (time-invariant) component. Therefore, pH was fixed at 7.0 for the water column and 6.0 for the sediment column based on pH observations from the mesocosm experiments.

An expanded discussion of the challenges involved with configuring and executing the TICKET model is provided in the "Discussion of TICKET Limitations & Concerns" section provided below.

*TICKET baseline and sensitivity results for mesocosm application*

For the reasons discussed above, only limited results were obtained from the diagnostic testing of the TICKET model. However, a limited number of simulations were conducted using salicylate to represent a sequestering agent and including Ni as a trace metal. These simulations were intended to roughly represent a 5.1 cm sand cap case, with relatively low quantities (~0.2%) of particulate organic carbon (POC) in the cap layers and higher levels of POC in the "base"/parent layer underlying the cap.

Unexpected results were encountered with the model when diffusion/dispersion and resuspension/settling rates were defined consistent with the rates used in the SFM simulations. In the case of diffusion/dispersion, a rate of 1.0e-9 $m^2 s^{-1}$ , which is representative of molecular diffusion, produced an unrealistic amount of exchange between the water column and the sediment bed, resulting in rapid saturation of the cap layers. Ultimately, it was necessary to reduce the diffusion/dispersion rate by three orders of magnitude to appropriately limit the dissolved exchange between the water column and the upper layer of the sediment bed, as well as between sediment layers. A detailed investigation of the diffusion/dispersion issue would be needed to better understand the causes and appropriate solutions, prior to attempting additional TICKET simulation development. However, this was beyond the scope of the modeling effort.

The resuspension and settling rates specified in the model appeared to produce no discernible difference in simulation results relative to a simulation with these rates set to zero. Representation of resuspension and settling in TICKET presents a challenge because inorganic sediment is not represented in the model for either the water column or the sediment bed. As a result, it is necessary to instruct the model on which chemical species should be subjected to settling and resuspension, diffusion, and advection. The final model simulations allowed for resuspension and settling of all precipitates plus the Ni[Salicylate] complex. Simulations that included resuspension of all other salicylate complexes (e.g., with iron and magnesium) were attempted, but no results were obtained due to convergence issues. It is possible that resuspension and settling would function correctly if the model could be successfully run with more species subjected to these processes. As for the diffusion issues, a detailed investigation of this issue would be needed prior to attempting additional TICKET simulation development; however, this was beyond the scope of the modeling effort.

The "baseline" TICKET simulation developed for the sand cap case included salicylate levels of 0.021 mol $L^{-1}$ in the sand cap layers and 50 mol $L^{-1}$ in the "base"/parent bed layers. The former value was estimated based on the organic carbon content of ~0.14% in sand measured in the experiments. The latter value was roughly calibrated to provide a reasonable dissolved Ni concentration in the parent bed (i.e., consistent with the SFM). The vertical profile of dissolved

Ni simulated by the model roughly three months after the start of the experiment is shown in Figure 72, and a comparison of the dissolved and total Ni profiles is shown in Figure 73. Note that the profile in Figure 72 can be roughly compared to the SFM-simulated dissolved Ni profile included in Figure 61. The TICKET and SFM simulations produced similar water column concentrations for dissolved Ni (> 400 µg $L^{-1}$) and overpredicted the measured dissolved concentrations. In the top sand cap layer (1.27 cm thickness), TICKET simulated a dissolved Ni concentration of ~20 µg $L^{-1}$, while SFM predicted a concentration of roughly 40 µg $L^{-1}$. This difference between the two model simulations is not surprising, however, because adsorption of Ni to organic carbon in the sand matrix is only coarsely estimated by including the 0.021 mol $L^{-1}$ of salicylate. The comparison of the dissolved and total Ni concentration profiles in Figure 73 highlights that Ni is simulated by TICKET as being roughly 100% in the dissolved phase in both the water column and in the layers representing the sand cap. This result is inconsistent with a conceptual understanding of the importance of the particulate phase in the mesocosm experiments, and it reflects the difficulties in implementing resuspension and settling processes within TICKET.

A limited set of sensitivity simulations were conducted to highlight the relative importance of diffusion and resuspension/settling processes and the role of salicylate in the baseline simulation presented above. Comparisons of the dissolved Ni vertical profiles simulated by TICKET for the baseline and sensitivity simulations are provided as follows:

- Baseline compared to sensitivity run with diffusion rate set to 1.0e-9 $m^2$ $s^{-1}$ (representative of molecular diffusion; 1000x larger than the value used in the baseline run) (Figure 74);
- Baseline compared to sensitivity run with resuspension and settling rates set to zero (Figure 75); and
- Baseline compared to sensitivity run with initial salicylate concentration in the sand cap layers increased from 0.021 mol $L^{-1}$ to 100 mol $L^{-1}$ (Figure 76).

(Note that for figures, the blue line represents the baseline simulation result, and the green line represents the result obtained for the sensitivity run.)

The results of the diffusion rate sensitivity highlight the issue described previously where a seemingly appropriate diffusion rate (1.0e-9 $m^2$ $s^{-1}$) produced unrealistic mass transfer of dissolved Ni from the water column to the sediment bed. Dissolved Ni concentrations in the water column were roughly an order of magnitude lower for the sensitivity run, and dissolved concentrations in the sediment bed were greater than 150 µg $L^{-1}$ after only three months elapsed, reflecting rapid saturation of the salicylate present in the sand cap layers.

The results of the resuspension/settling rate sensitivity highlight that specifying the resuspension and settling rates as zero produced virtually the same results as when specifying the values used for the baseline SFM simulations. The difficulties associated with configuring resuspension and settling for the baseline run were discussed earlier in this section.

The sensitivity run for “organic carbon” content involved increasing the initial salicylate concentration in the sand cap layers by several orders of magnitude (from 0.021 mol $L^{-1}$ to 100

mol $L^{-1}$), with the intent of demonstrating that the model would be responsive to varying levels of this or another sequestering agent proxy. The results in Figure 76 indicate that increasing the "organic carbon" content in the cap layers results in a lower dissolved Ni concentration in the water column, as well as lower dissolved Ni concentrations in the cap layers relative to the baseline profile. This reflects strong binding of Ni to salicylate in the cap layers, which induces a more significant water-sediment gradient in dissolved Ni. This gradient results in more rapid depletion of dissolved Ni from the water column via diffusive exchange.

The results of the sensitivity test for salicylate concentration in the sand cap layers suggest that it may be possible to use TICKET in a simplified fashion to represent the net effect of adsorption / ion exchange – i.e., by using a proxy compound to represent the net effect of sequestering agents present in the various cap materials. However, this approach would be conceptually equivalent to using the Kd-based approach implemented in the SFM for representing adsorption/exchange with sequestering agents. In this case, the only advantage provided by TICKET is the representation of multiple aquatic species for each metal and potential precipitates, including potential metal-to-metal interactions. However, based on the challenges encountered with implementing more advanced TICKET simulations during diagnostic testing and inherent limitations in the supporting datasets, it appears that a more explicit representation of adsorption to sequestering agents in the various caps is unlikely to be successful.

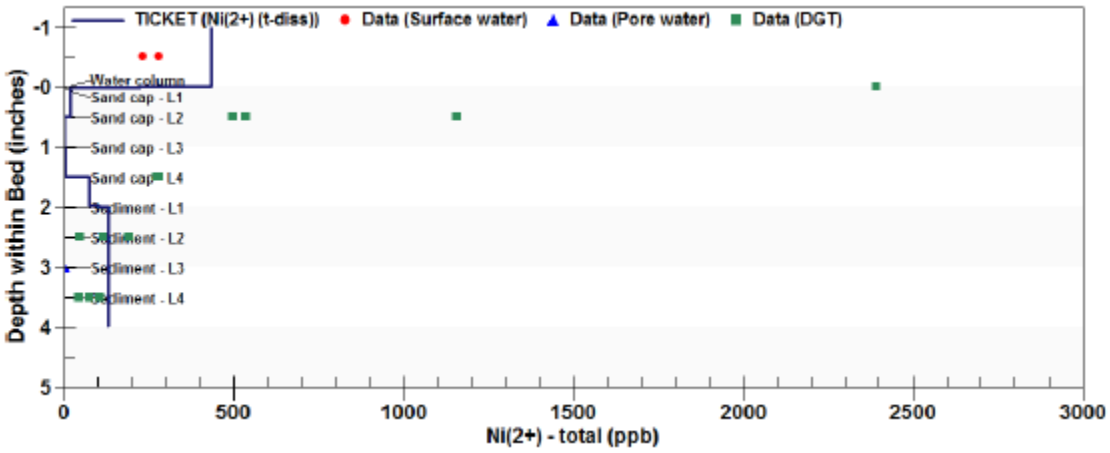



**Figure 72. TICKET-simulated vertical profile of dissolved Ni on 3/5/15 for generic sand cap case (including observed concentrations).**

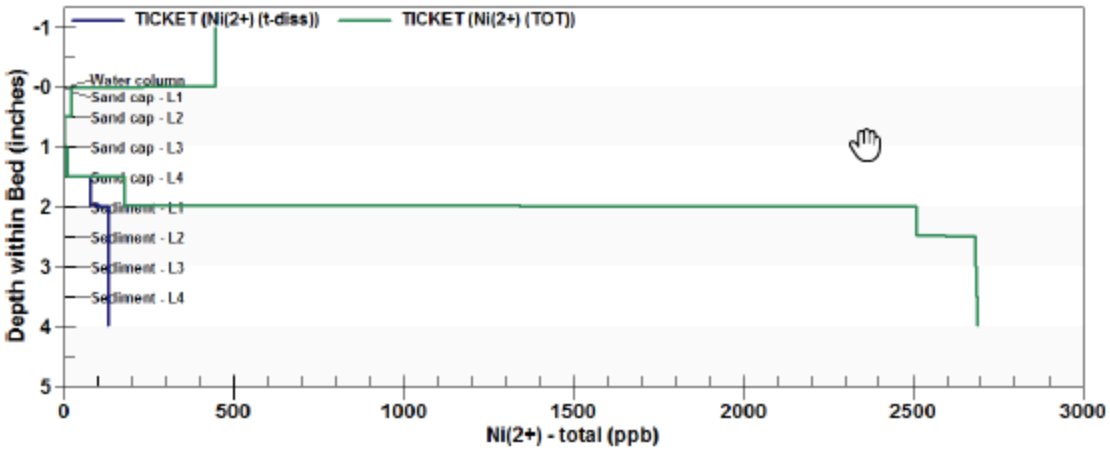



**Figure 73. TICKET-simulated vertical profiles of dissolved and total Ni on 3/5/15 for generic sand cap case.**

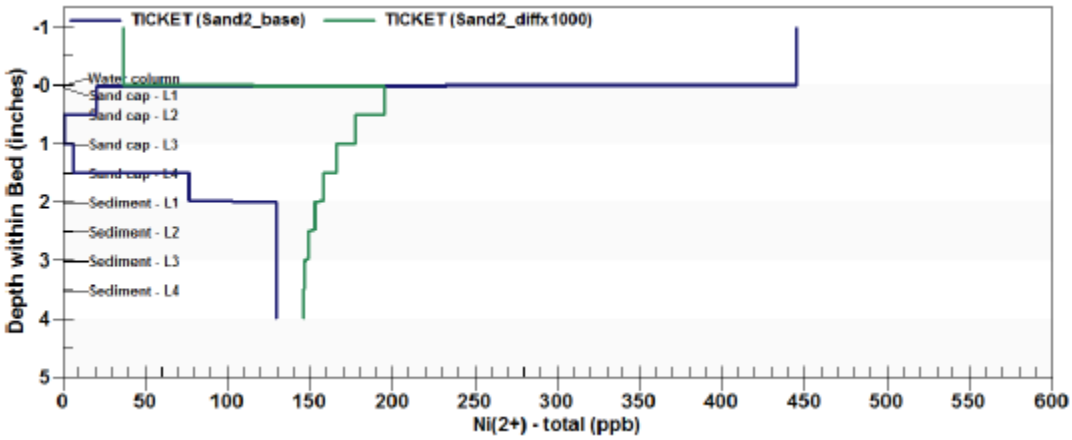



**Figure 74. TICKET-simulated vertical profiles of dissolved Ni on 3/5/15 for baseline simulation and sensitivity run for diffusion rate.**

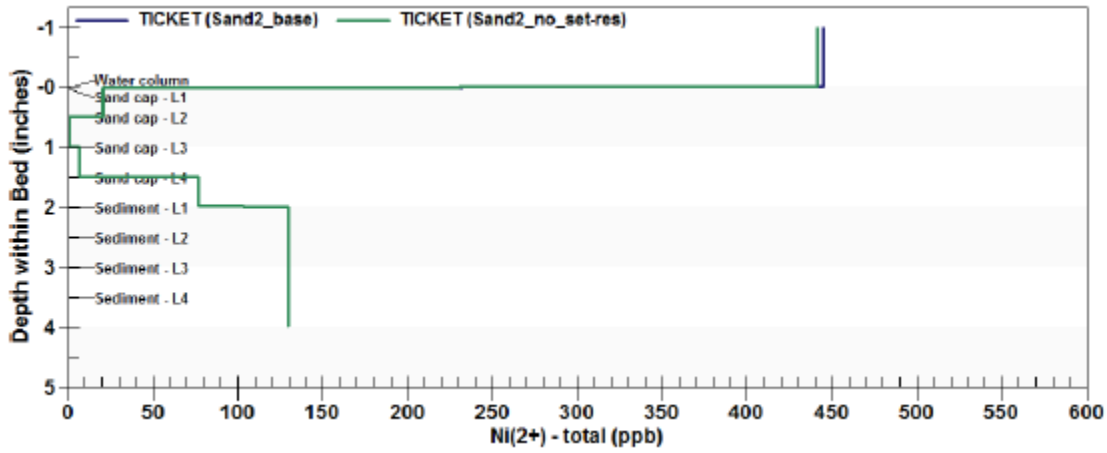



**Figure 75. TICKET-simulated vertical profiles of dissolved Ni on 3/5/15 for baseline simulation and sensitivity run for resuspension/settling rate.**

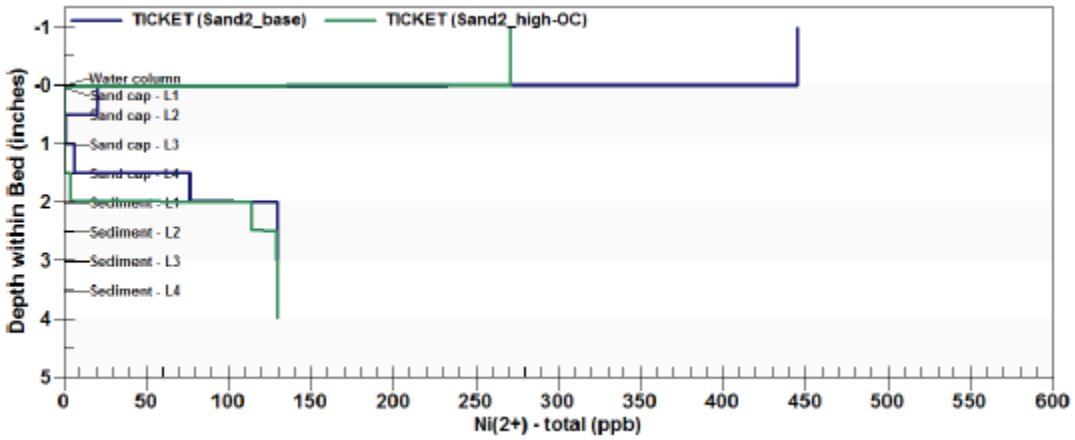



**Figure 76. TICKET-simulated vertical profiles of dissolved Ni on 3/5/15 for baseline simulation and sensitivity run for initial salicylate concentration in the sand cap layers.**

*Discussion of TICKET limitations and concerns*

As alluded to previously, several concerns regarding the application of the TICKET model to represent the mesocosm experiments and/or field conditions were identified during the exercise of configuring and applying the model. These concerns are summarized below.

- General data limitations/constraints – TICKET is a data-intensive model that requires data (or, at a minimum, assumptions) concerning all major cations, anions, and precipitates that are expected to play an important role in a particular model simulation. The data necessary to initialize major cation and anion concentrations were generally not available for the mesocosm experiments, and it seems unlikely that such detailed data would be available for a typical contaminated site where it may be desirable to apply the model to evaluate in-situ cap performance.

- Representation of adsorption, including the role of organic carbon – TICKET provides a framework that is ideally suited to simulate the speciation (including the potential precipitation) of metals in aquatic environments that have well-defined or "idealized" chemistry. In the case of passive cap materials (e.g., sand), adsorption to organic carbon is likely to play a key role in the (limited) sequestration of trace metals. For active caps, adsorption to complex sorbents (including organic carbon compounds) and/or ion exchange (e.g., in the case of apatite) are the processes that will drive sequestration of metals. A detailed, explicit representation of adsorption in a sediment column by TICKET is problematic for a couple of reasons, which are further discussed below.

- Potential issues with transport process representation – Although the inflow/outflow boundary conditions appeared to work as expected, the behavior of the diffusion/dispersion, resuspension, and settling processes in the model was concerning. Our tests indicated that a typical rate for representing molecular diffusion (1.0e-9 $m^2/s$) resulted in a significant and unrealistic transfer of metals from the water column to the sediment bed and between sediment bed layers. We ultimately found that it was necessary to scale down the diffusion/dispersion rate by several orders of magnitude in order to obtain reasonable results. In addition, sensitivity testing with the resuspension and settling rates suggested that the metals concentrations in water predicted by the model were insensitive to these parameters. This response does not make intuitive sense, and it is inconsistent with the findings from the SFM simulations. Resources were insufficient to examine these issues in detail, but they would need to be thoroughly investigated and resolved if the TICKET model were to be used as the basis for the modeling work in this study.

- Model convergence issues – Our testing and diagnostic work suggested that the TICKET solution is quite rigid, as we experienced many issues with the model failing to converge on a solution midway through simulations. This resulted in the need to attempt many iterations and ultimately to place some significant constraints on the simulations to ensure that the model would converge and produce useful results. As noted above, those constraints included representing only a single trace metal species at a time, fixing pH in the water column and sediment bed, and avoiding the use of phosphate.

- Model efficiency – TICKET simulations require relatively long runtimes (e.g., in comparison the SFM), with the runtime dependent on a number of factors, including: 1) the number of chemical components and species represented in the tableau, and 2) the number of iterations required for the model to converge on a solution at each time step during the simulation. Although the runtime for the ~3-month mesocosm simulations ultimately was not excessive (~15 minutes within the compiled Visual Basic .NET version), major simplifications were needed to allow for this (e.g., fixed pH and limited number of components). Given the model convergence challenges noted above, we anticipate that the runtime for multi-year / decadal-scale TICKET simulations is likely to be excessive, particularly if more complicated model simulations are pursued (e.g., including more metal species). It should be noted that, if pursued, the incorporation of the WHAM (Windermere Humic Aqueous Model) V database would add interactions between each metal species and ~50 organic compounds, resulting in further extension of runtimes.

- Lack of model documentation – Given the complexity of the model, the lack of a user manual or guidance for TICKET presents a challenge even for seasoned modelers, and it is likely to present a significant impediment to broader application of this model for various types of applications.

An especially challenging aspect of the TICKET model in its current form is the lack of direct representation of carbon-based sequestering agents or an explicit representation of adsorption to sorbents present in caps. This concern has relevance to all mesocosm cases and especially those where carbon-based ligands play an important role as a sequestrating agent (e.g., as coatings on hydroxide precipitates). The TICKET-UWM model described above incorporated the WHAM V model to treat organic carbon. This approach requires a large number (~50) functional groups to be included in the model to represent binding sites on fulvic and humic acid compounds. To date, the WHAM V model has not been incorporated into the (VBA-based) TICKET model by its authors, and it was beyond the scope of this study to pursue this update to the model framework. It is important to recognize that even if the WHAM V model database was incorporated into TICKET, the lack of data to support a detailed representation organic material and/or other sorbents in the model for various sediment types is a major limiting factor in applying the TICKET to simulate adsorption to organic particles, coatings, etc. For example, the TICKET chemical database does not include any representation of bentonite, which is present in the organoclay.

Experts in the field of aquatic chemistry have noted the many difficulties with explicitly and accurately representing the highly complex role of organic carbon in the complexation and adsorption of metals in natural aquatic systems (Morel and Hering, 1993, Stumm and Morgan, 1996). A representative complexing agent, such as ethylenediaminetetraacetic acid (EDTA), is typically used to illustrate the potential behavior of organic complexing agents. An approach suggested in these books for representing site-specific conditions is essentially to conduct titration experiments and to use the results of those experiments to define the distribution of metal under various conditions. In essence this is what a Kd-based approach accomplishes with a much lower degree of complexity. The key point here is that the additional complexity introduced by TICKET for cap evaluations is not commensurate with the data available to support the model, and therefore use of TICKET in place of a simpler model framework, such as the SFM, cannot be expected to reduce uncertainty in projecting cap performance.

### 4.3.2 Development and evaluation of final model

#### *4.3.2.1 Evaluating long-term performance of caps*

The TICKET model does not provide an explicit representation of (inorganic or organic) sediment, nor does it provide any sediment bed handling algorithm. Layers that are input to the model remain static with respect to porosity (i.e., the pore water volume represented does not vary), and any chemical species matter that is deposited from the water column to the topmost bed layer is simply incorporated into the surficial cap layer. In contrast, the SFM framework explicitly accounts for deposited sediments by forming new layer(s) containing the deposited sediment mass above the cap. Upon deposition, the sediment added to those layers will be characterized by physicochemical parameters that will generally differ from those of the underlying cap – including porosity, bulk density, Kd distribution coefficients, and chemical concentrations (i.e., based on the particle-bound contaminant concentration at the time of deposition). The "deposition" layer(s) remain distinct from the cap layers throughout the simulation. However, if particle mixing is represented in the model (e.g., to represent the effects of bioturbation), gradual vertical mixing can occur between the uppermost cap layer and the bottommost layer containing deposited sediments. This mixing process can comingle the sediment types, and the physicochemical properties of each layer are adjusted accordingly. In addition, diffusive/dispersive exchange can serve to redistribute dissolved contaminant mass across adjacent "deposition" and cap layers.

We believe the bed handling approach implemented in the SFM can account for the gradual deposition of sediment over reactive caps. The SFM was previously applied successfully under project ER-1371 to simulate the long-term (i.e., multi-decadal) performance of cap materials for the Anacostia capping test site for total PAH (Adriaens et al., 2009). Although "long-term" (e.g., decadal scale) data were not available to corroborate model performance, the model successfully reproduced contaminant (total PAH) profiles for the sand cap site two years following cap placement.

The baseline SFM model simulations developed for the sand- and apatite-treated mesocosms were both run for a period of 50 years to provide an illustration of the utility of the model to evaluate and differentiate between long-term performance of passive and active caps. The results are shown in a series of figures that plot the vertical profiles of dissolved Cd and Ni at the following intervals within the simulation period: 5 years elapsed (Figure 77), 10 years elapsed (Figure 78), 20 years elapsed (Figure 79), and 50 years elapsed (Figure 80). A comparison of the Cd and Ni profiles in these figures highlights that the NCA cap provides a much higher degree of sequestration for Cd than for Ni, which is expected based on the apatite-specific Kd values for these metals (Cd: 3589 mL $g^{-1}$, Ni: 1103 mL $g^{-1}$). The breakthrough of Ni through the NCA cap roughly mirrors breakthrough for the sand cap after 20 years. On the other hand, the NCA cap significantly delays breakthrough for dissolved Cd relative to the sand cap. After 50 years, the dissolved Cd concentration simulated in the top parent ("base") sediment layer for the NCA cap case (~100 μg $L^{-1}$) is roughly half of the concentration simulated in the top parent layer for sand cap case (~225 μg $L^{-1}$).

Although preliminary and specific to the mesocosm configurations, these results demonstrate the potential of the SFM framework to simulate the timing and degree of breakthrough of individual metal species through various cap types. It is apparent from the findings of Dixon and Knox (2012) that long-term cap performance will be strongly dependent on the combination of cap material (e.g., apatite) and the metal species of interest. Therefore, if an active cap is to be used at a contaminated site, it is important to identify which metal species are of greatest interest for that site and then evaluate which active cap technology/material would be most appropriate to deploy. The SFM and similar Kd-based models effectively represent sequestration capacity and can be used to efficiently run multi-decadal simulations, and so provide tools that can be used to evaluate long-term cap performance based on various assumptions (e.g., metals concentrations in the water column, resuspension and settling rates, etc.). It is important to recognize that, regardless of the model applied, there will be considerable uncertainty in multi-decadal projections of cap performance. Not only are data generally not available to corroborate long-term model predictions, but environmental conditions, including contaminant loading, may vary considerably from the assumptions used in the model.

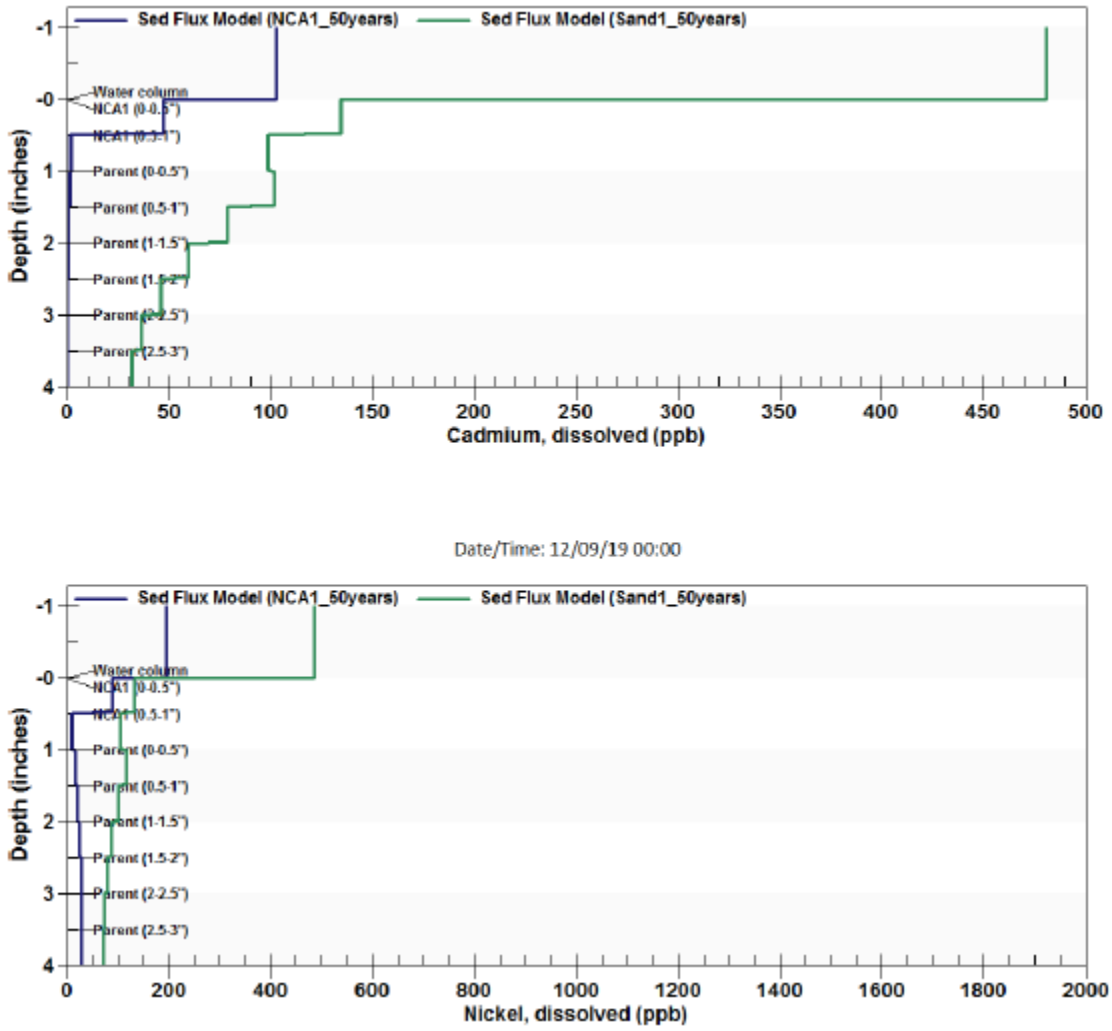



**Figure 77. Vertical profile comparison for sand and NCA cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after five years.**

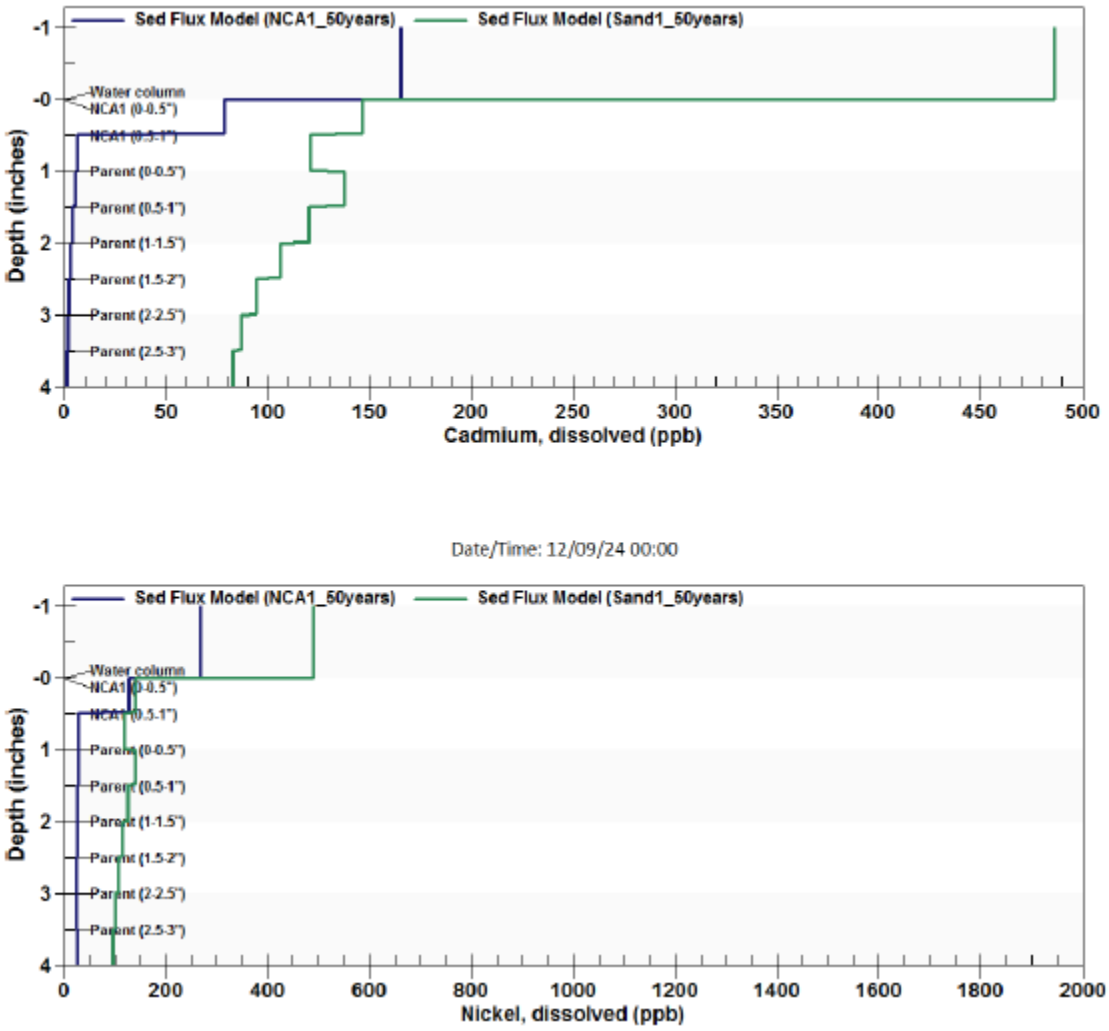



**Figure 78. Vertical profile comparison for sand and NCA cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after 10 years.**

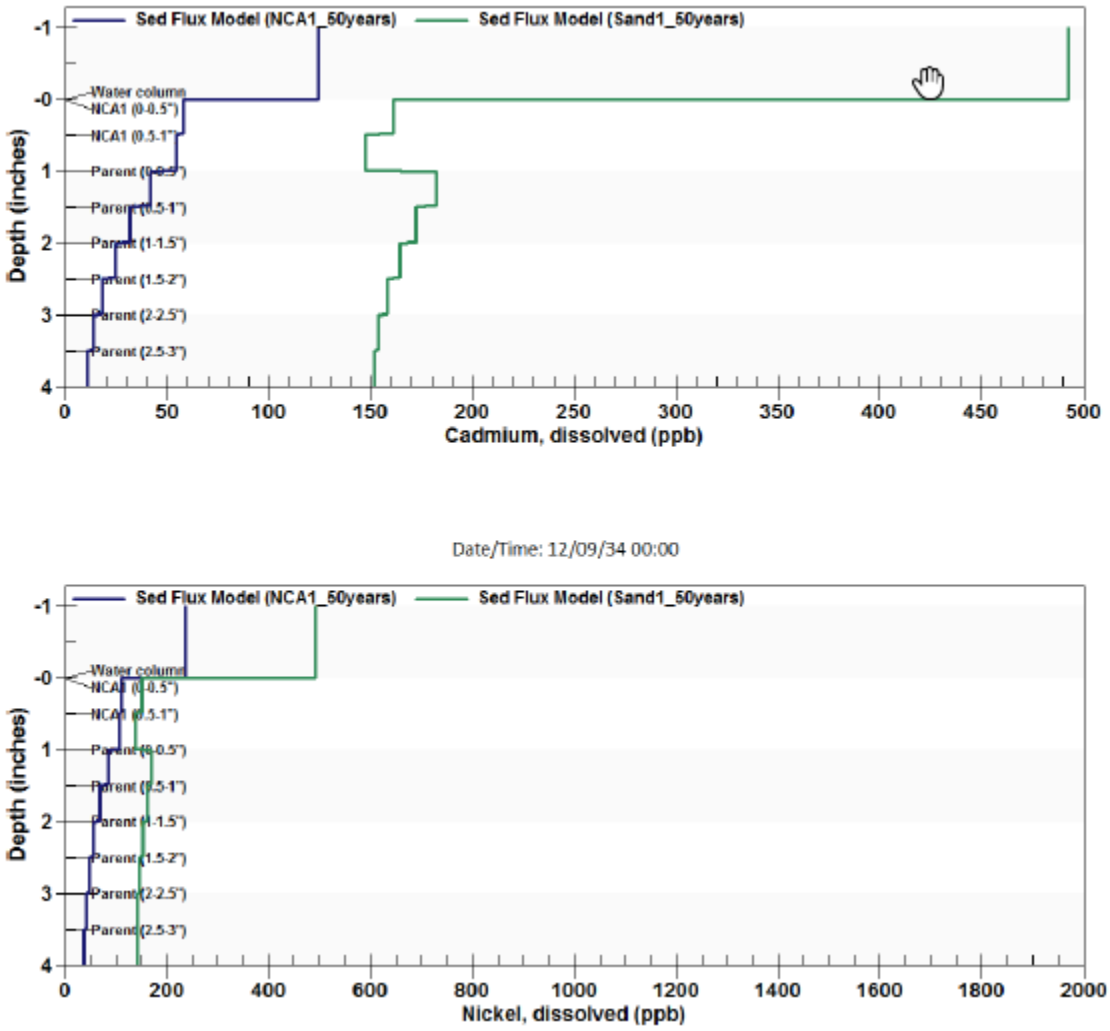



**Figure 79. Vertical profile comparison for sand and NCA cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after 20 years.**

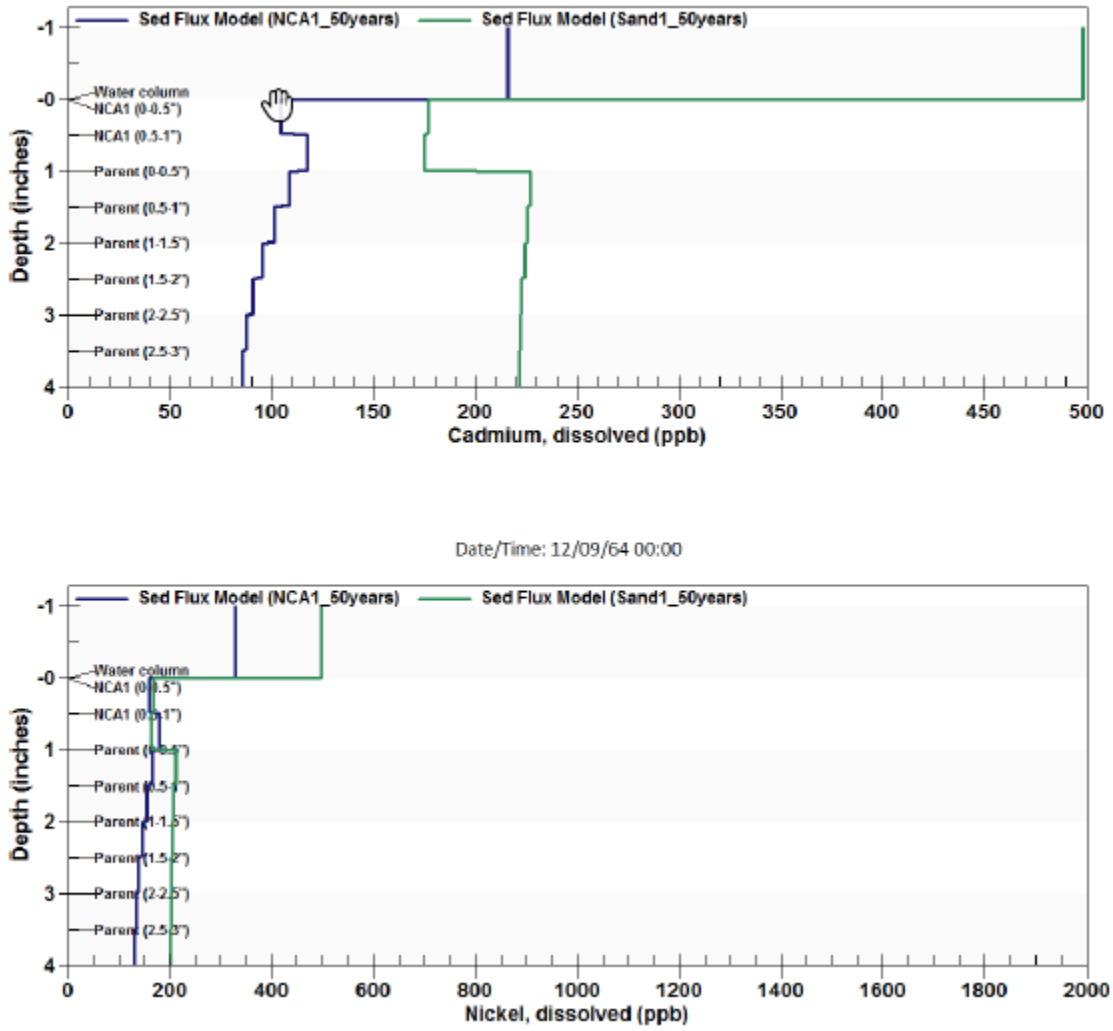



**Figure 80. Vertical profile comparison for sand and NCA cap cases for dissolved Cd (top panel) and dissolved Ni (bottom panel) after 50 years.**

#### *4.3.2.2 Recommendation for modeling framework*

As discussed in this document, we encountered and documented numerous limitations and areas of concern with respect to applying the TICKET model to the simulation of the mesocosm experiments and predicting the long-term response for cap-remediated sediments. However, the diagnostic testing effort for the SFM demonstrated that this framework can reasonably reproduce metals concentrations observed in the mesocosms. The SFM framework does not provide an "ideal" representation of trace metal speciation, transport, and fate through caps, as Kd values are a surrogate for representing a number of complex reactions that occur in the actual system. However, we conclude that, given data and model framework limitations, the TICKET model would not provide a significant improvement over the SFM framework with respect to improving simulation accuracy and reducing uncertainty for evaluations of cap performance.

In consideration of the findings from the model evaluation, we decided to rely primarily on the "Sediment Flux Model" but to incorporate several features from the TICKET model to account for metal speciation. The existing version of the *Sediment Flux Model* (SFM) provided a robust and well-tested representation of transport within the bed (i.e., particle mixing and porewater diffusion) and exchange processes between the bed and the water column (i.e., porewater diffusion, resuspension, settling). However, the representation of chemical dynamics was previously limited to equilibrium partitioning between the dissolved phase and the particulate organic fraction in the sediment bed or water column. While this approach is standard for hydrophobic organic compounds (HOCs), it does not provide the capability to represent the more complex speciation of metals. To address this limitation for the case of metals, we enhanced the SFM code by incorporating the tableau approach used in TICKET and other chemical equilibrium models (e.g., MINEQL) into SFM, which made the SFM framework capable of representing speciation of metals and other chemical components while retaining the vertical transport components from the original version of the SFM.

To simplify the solution approach and achieve better model stability than observed with TICKET, the transport equations were solved independently from the chemical equilibrium equations for each simulation time step within the enhanced SFM. In addition, chemical equilibrium was solved in a steady-steady manner that neglected kinetic transformations, which promoted better stability without sacrificing the benefits of using the tableau-based approach to represent speciation. The outcome of this effort was a combined SFM-TICKET model framework that was more consistently stable than the standalone TICKET model when simulating multiple metal species along with relevant inorganic species and sequestering agents. In addition, because the SFM-TICKET framework was executed via compiled Visual Basic.NET code, simulations were run in less time than the original version of the TICKET model, which is coded in Excel Visual Basic for Applications (VBA).

### 4.3.3 SFM-TICKET simulation results

SFM-TICKET simulation results are provided for illustrative applications to the control case (native sediment only) and apatite cap case, based on the Task 1, Subtask 1.2 mesocosm experiments. The "recipe" of chemical components maintained the water column pH at 6.0-7.0 throughout the simulations.

In order to provide a point of comparison, Figures 81 and 82 plot the time series of total and dissolved concentrations, respectively, for Cu, Cd, and Zn for the control (i.e., native sediment only) case. As shown in these plots, the SFM-TICKET simulation reproduced both total and dissolved concentrations of these metals very well, based on carbon content of ~0.15% and initial metals concentration representation of native sediment material used in this experiment. The apatite cap case simulated with SFM-TICKET differed from the control (native sediment) simulation in the following respects: a 2.54 cm apatite cap is represented at the top of the sediment bed; the apatite layers are assumed to contain approximately 10.5 moles $L^{-1}$ of sequestering agent; and these layers are assumed to initially contain negligible concentrations of Cu, Cd, Pb, and Zn. Figures 83 and 84 plot the time series of total and dissolved concentrations, respectively, for Cu, Cd, and Zn for the apatite cap case. The simulation results for the apatite cap case reasonably reproduced the maximum total and dissolved concentrations of Cu, Cd, and Zn.

As discussed above, the SFM-TICKET apatite cap simulation represented the sediment bed using a total of 8 bed layers, each initially 1.3 cm in thickness. The top two layers collectively represented the 2.54 cm of apatite cap material, and the lower six layers represent 7.62 cm of native sediment material. (Note that the bottom 5 cm of native sediment are intentionally not represented to reduce model runtimes.) Dissolved metal concentrations were available for pore water samples taken at two time points following the start of the experiments, and DGT results were also available for approximately 60 days following experiment initiation. Figures 85 and 86 plot the vertical profile simulated for 4/5/2017 (DGT endpoint) for total and dissolved metal concentrations, respectively, for Cu, Cd, and Zn. The total concentration profiles in Figure 85 illustrate that there is a very significant build-up of metal mass in the top cap layer due to sediment and pore water exchange processes with the water column. Less significant increases in metals concentration/mass are evident in the 1.27-2.54 cm apatite layer and are due to pore water exchange and particle mixing with both the top 1.27 cm layer and the underlying native sediment layers. The vertical profile plots for dissolved metal concentrations (Figure 86, including DGT data) demonstrate that simulated dissolved concentrations in the apatite cap material (and in the underlying native sediment) are very low due to binding of the metals by the sequestering agents. Figures 87 and 88 show the simulated dissolved metal profiles on the dates of pore water sampling events PW2 (on 4/11/17) and PW3 (on 6/6/17), respectively. Collectively, Figures 86 - 87 illustrate that the SFM-TICKET simulated profiles for dissolved Cu, Cd, and Zn were all generally consistent with the sediment DGT results and the dissolved concentrations measured for pore water samples.

The control and apatite cap case simulations highlighted here were constructed based on available mesocosm data and a number of supporting assumptions regarding the "recipe" of representative inorganic and sequestering agents, as well as estimated process rates for

resuspension, deposition, and porewater diffusion. As illustrated in Figures 83 - 86, the SFM-TICKET application reproduced water column concentrations and vertical profiles of total and dissolved Cu, Cd, and Zn reasonably well. These results indicate that the combined SFM-TICKET model has resolved model issues related to stability, efficiency, and accuracy/reliability of the transport algorithms. They show that the integrated transport-equilibrium model is capable of simulating the effect of pH on free metal activity, adsorption to representative sequestering components, and competition between metal and hardness cations for ligand binding sites.

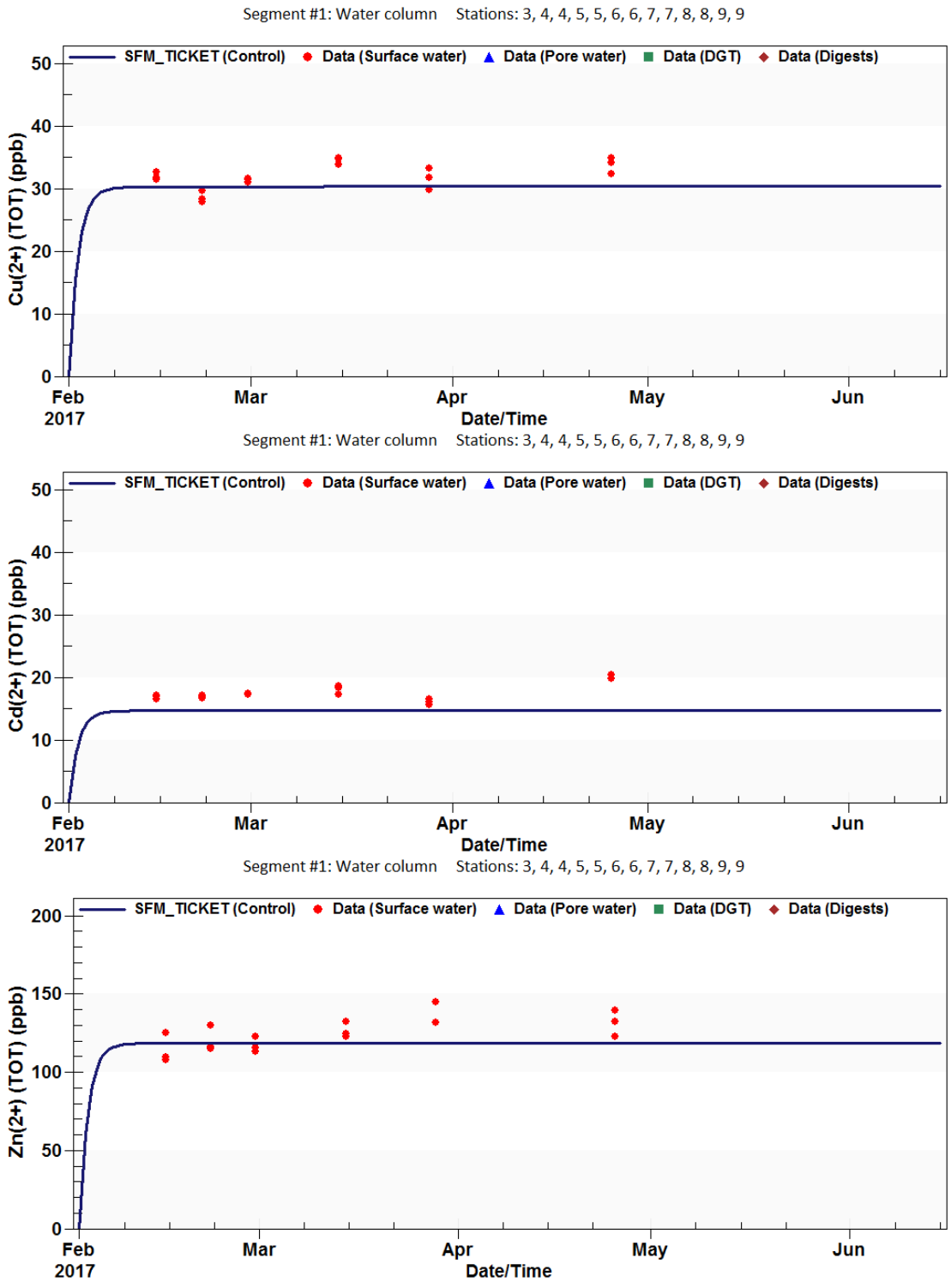



**Figure 81. Time series of total metal concentrations in water column for control/native sediment case (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

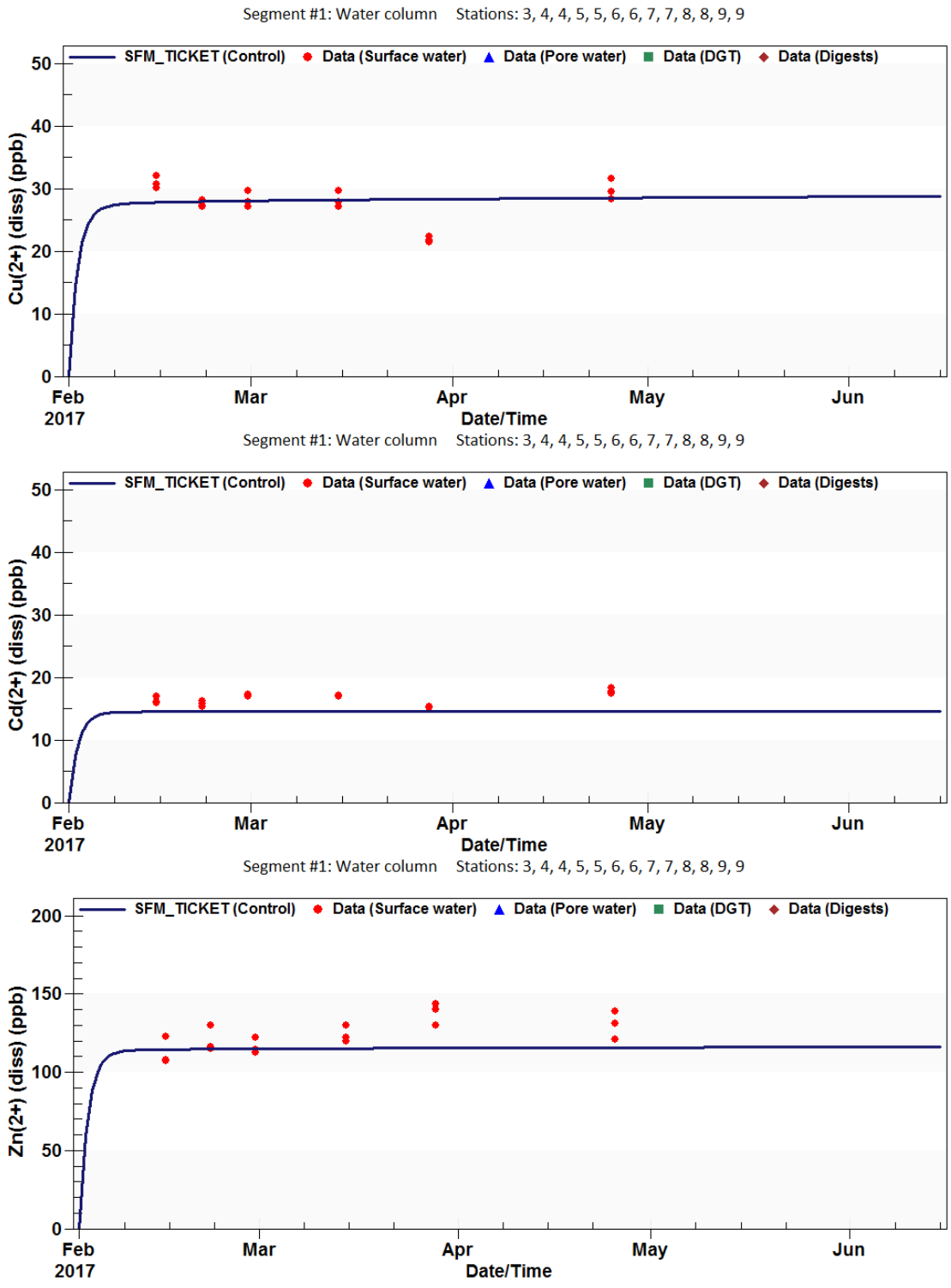



**Figure 82. Time series of dissolved metal concentrations in water column for control/native sediment case (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

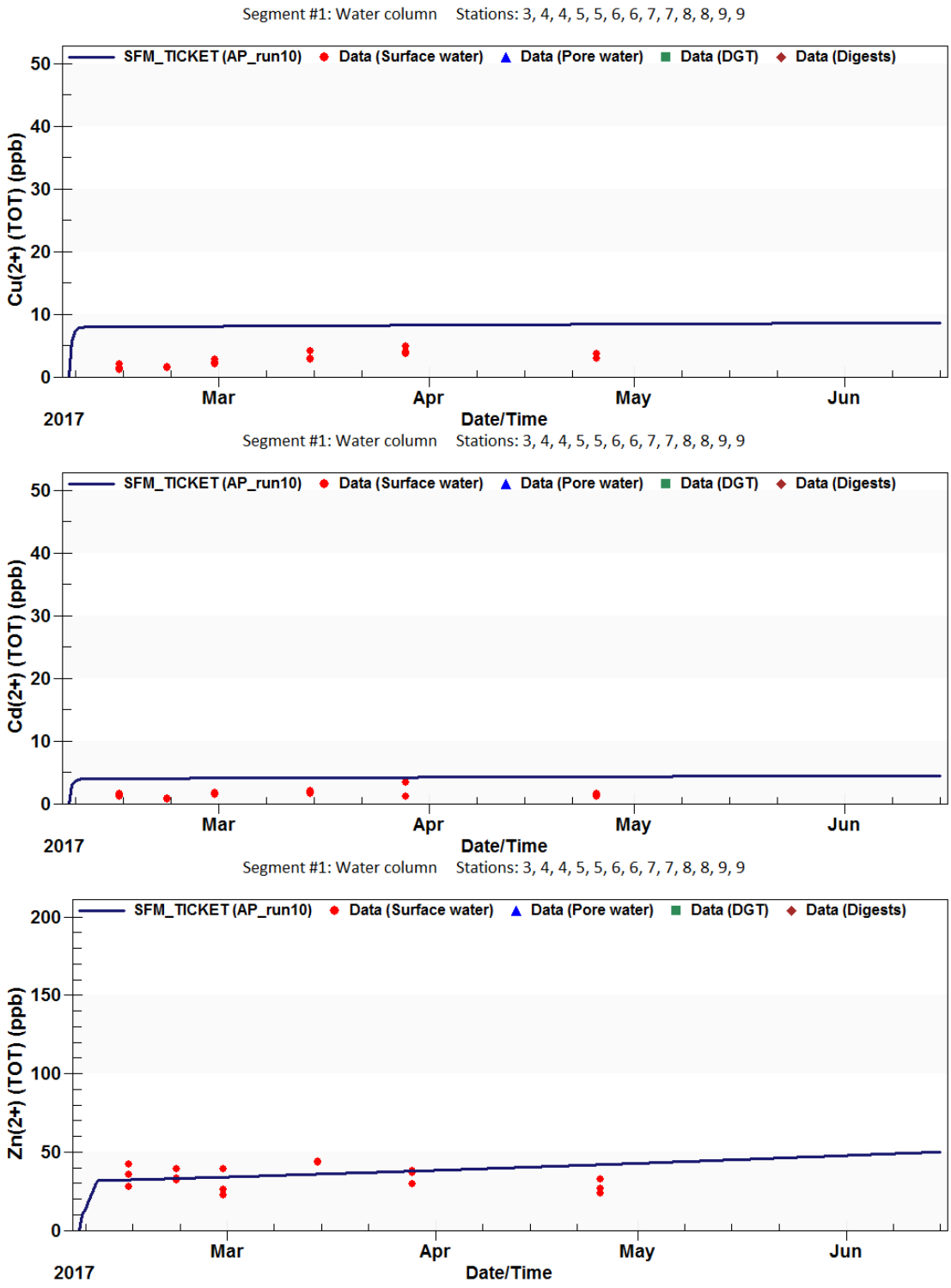



**Figure 83. Time series of total metal concentrations in water column for the apatite cap case (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

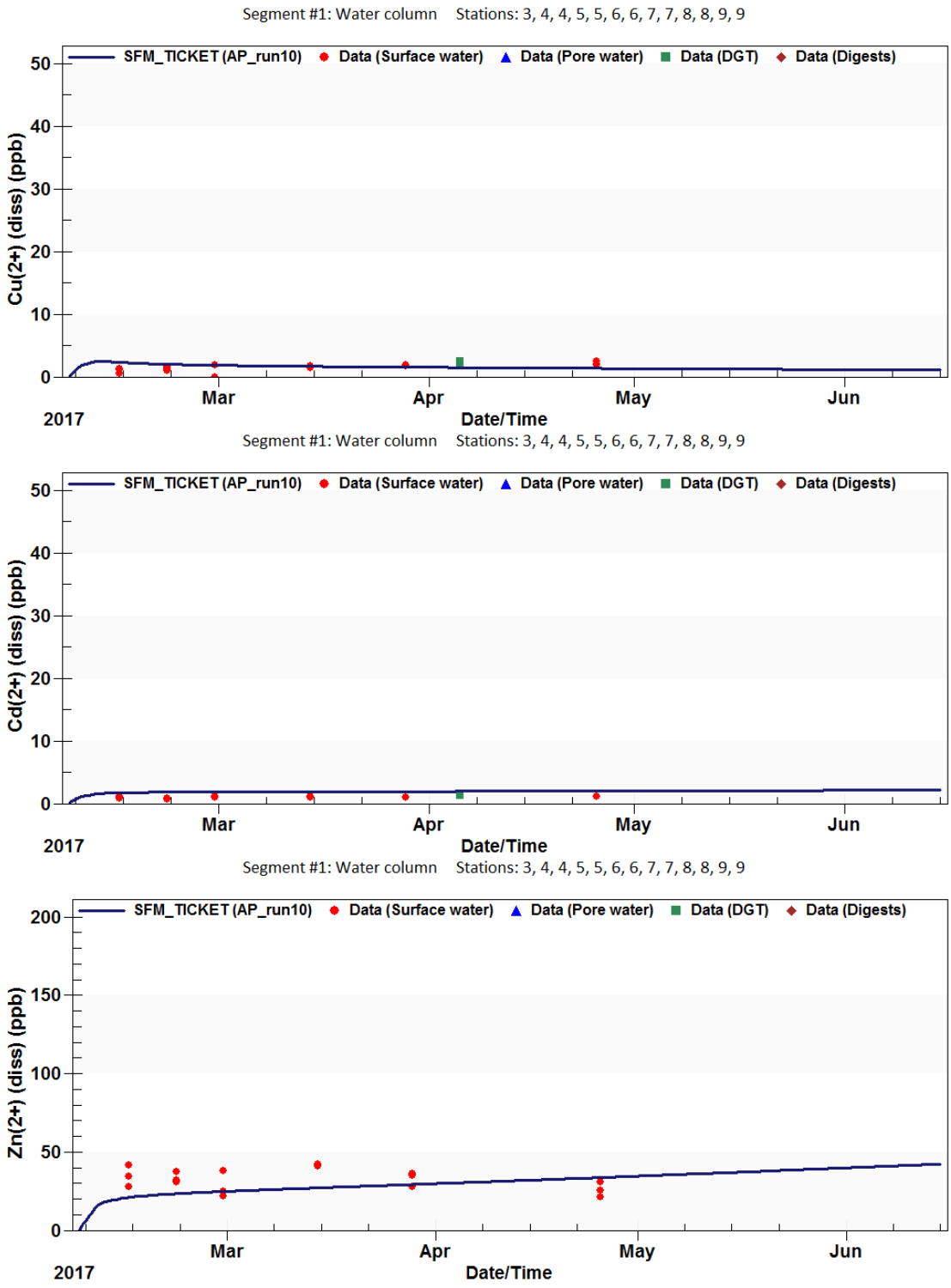



**Figure 84. Time series of dissolved metal concentrations in water column for the apatite cap case (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

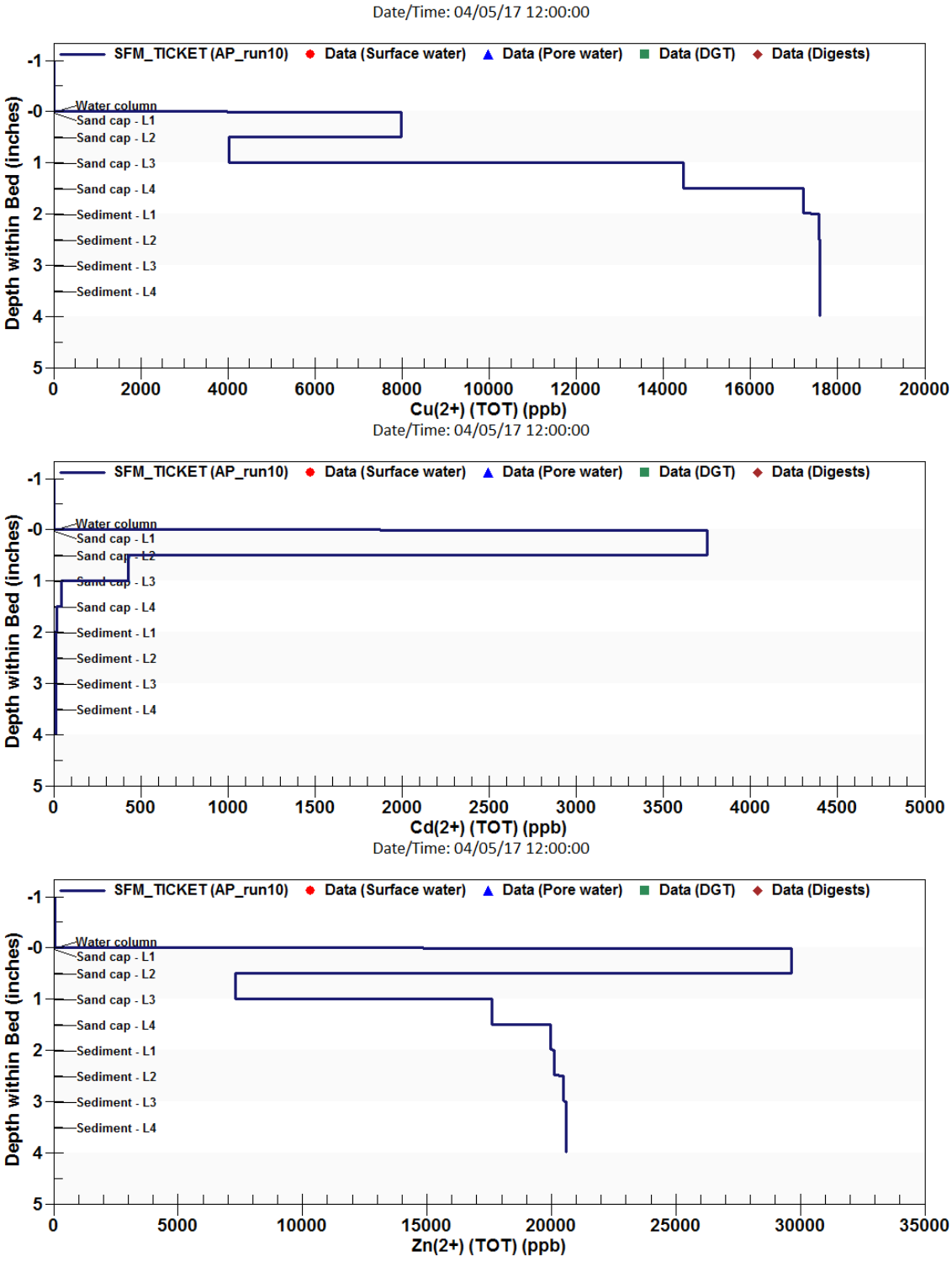



**Figure 85. Water-sediment vertical profile simulated at 4/5/2017 for total metal concentrations for the apatite cap case (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

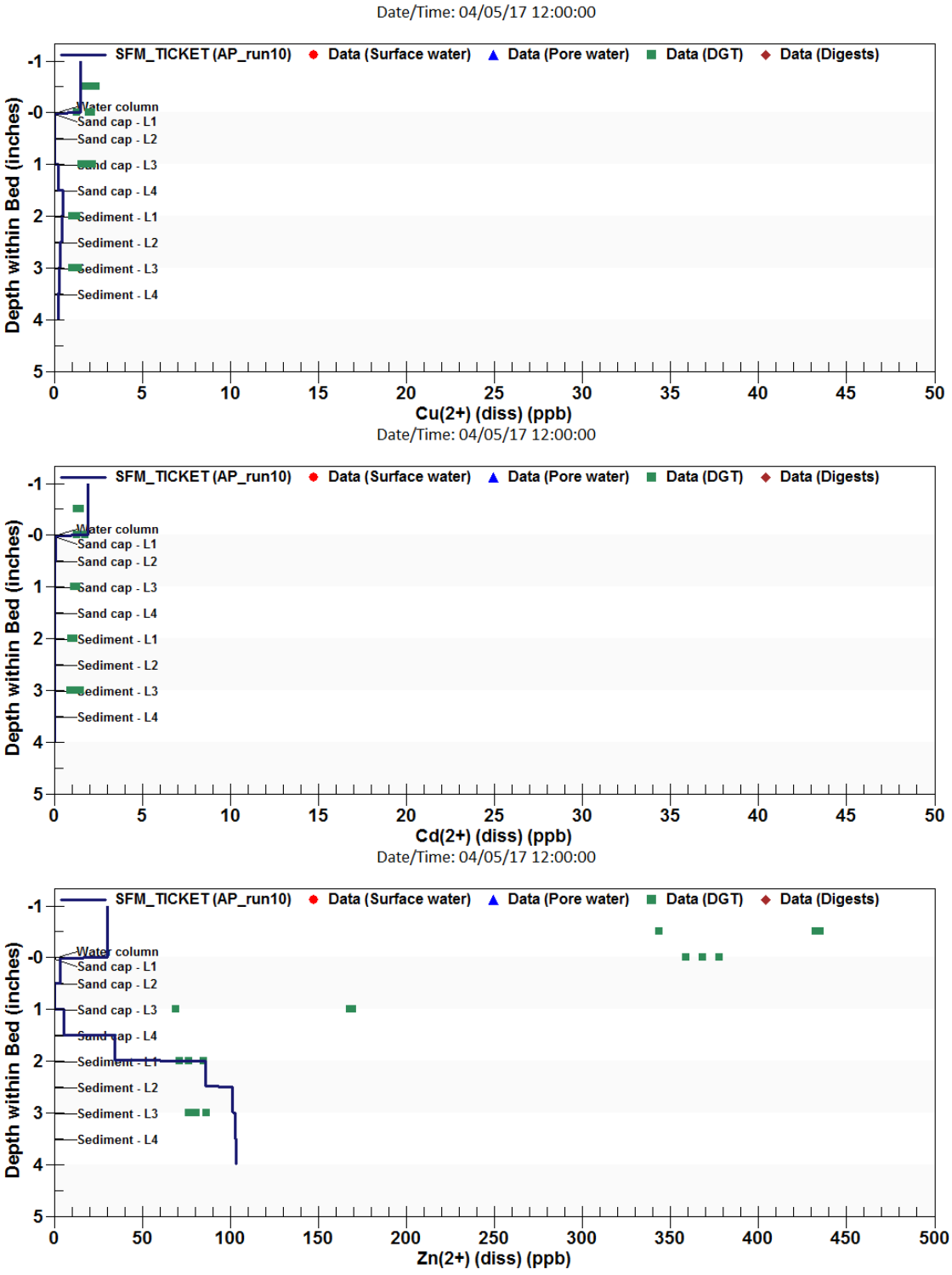



**Figure 86. Water-sediment vertical profile simulated at 4/5/2017 for dissolved metal concentrations for the apatite cap case, with DGT comparisons (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

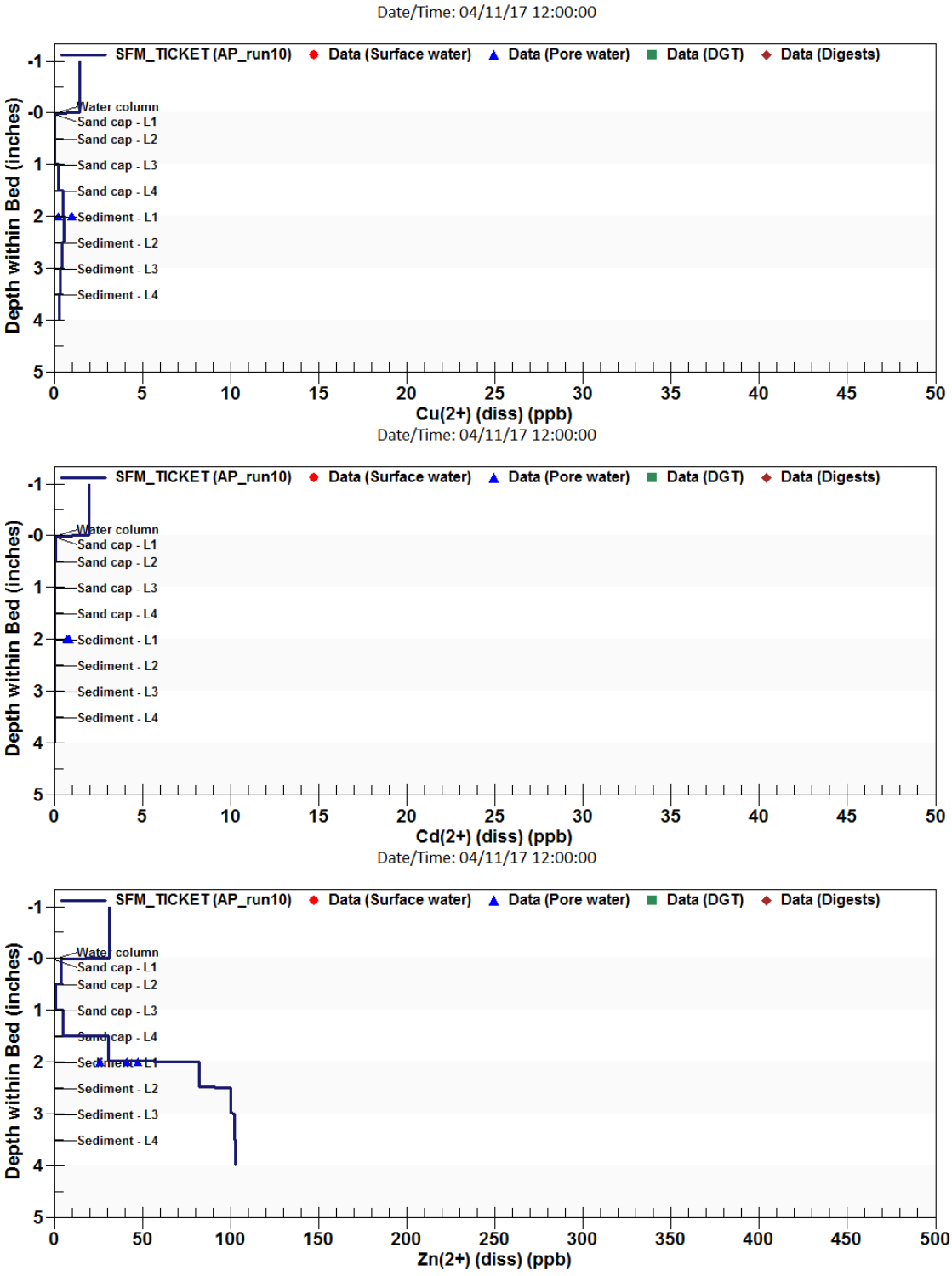



**Figure 87. Water-sediment vertical profile simulated at 4/11/2017 for dissolved metal concentrations for the apatite cap case, with comparison to PW2 sampling event data (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

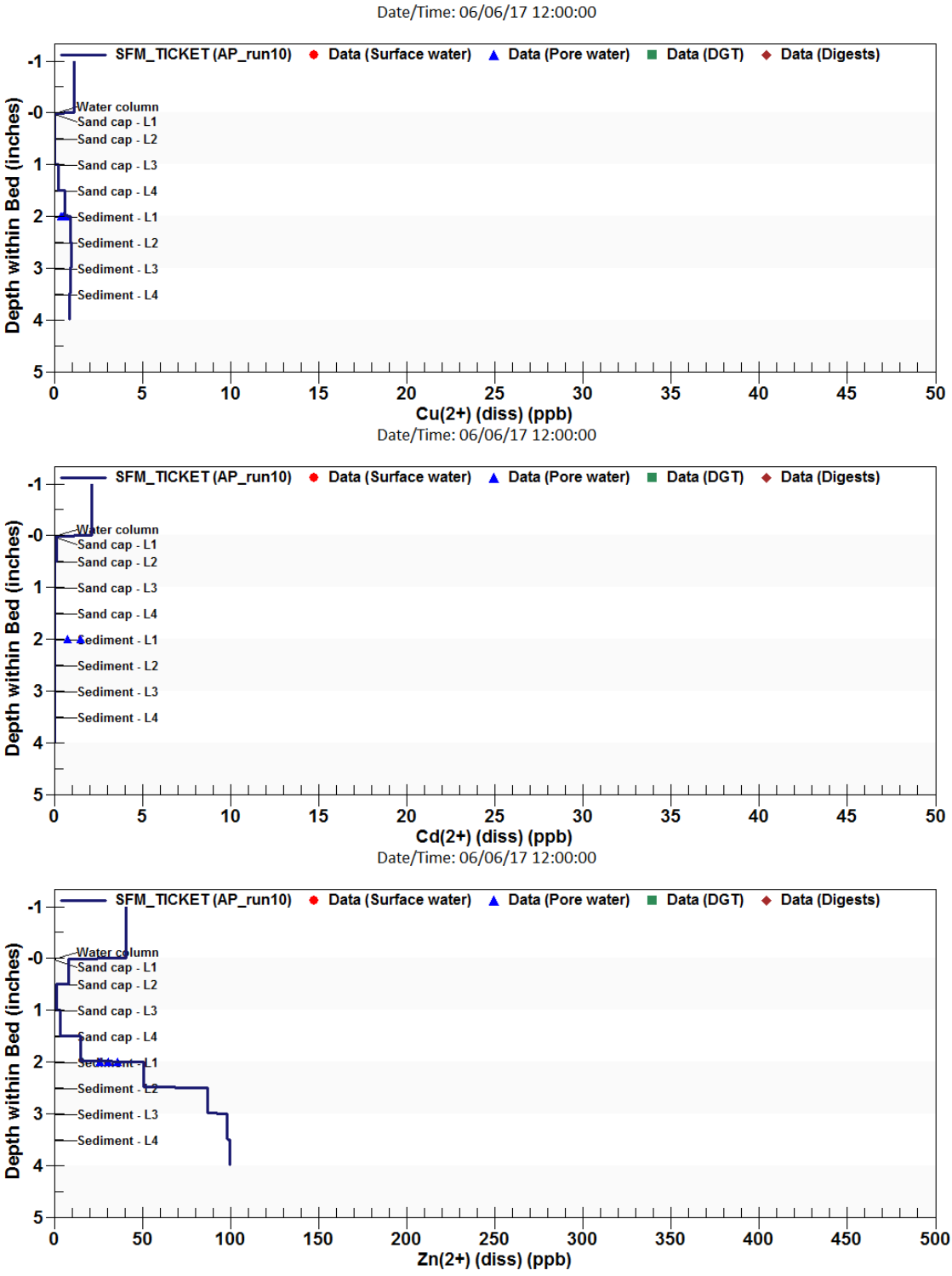



**Figure 88. Water-sediment vertical profile simulated at 6/6/2017 for dissolved metal concentrations for the apatite cap case, with comparison to PW3 sampling event data (top panel – Cu, middle panel – Cd, bottom panel – Zn).**

### 4.3.4 Conclusions

Significant progress has been made with the mathematical modelling approach by integrating the tableau approach used in the TICKET model into SFM. The resulting combined SFM-TICKET has resolved model issues related to stability, efficiency, and accuracy/reliability of the transport algorithms. The integrated transport-equilibrium model is capable of simulating the effect of pH on free metal activity, adsorption to representative sequestering components, and competition between metal and hardness cations for ligand binding sites. The SFM-TICKET framework is well-suited to represent the diffusive exchange, particle mixing, and sequestration processes relevant to the Task 2 experiments (i.e., cap materials overlain with contaminated sediment).

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# APPENDIX 1 – ADDITIONAL DATA

Table A1.1. Surface water properties for each sample at time zero

| | **SW- surface water before addition of spike solution** | | **Sample ID** | **Sample ID** | **TEMP oC** | **DO mg/L** | **Cond us/m** | **pH** | **Turb NTU** |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/9/2014 | | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 |
| Sampling time | 9:30AM Time 0 hrs | | 0 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |
| Treatment | Treatment description | No | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW1-F | 1-SW1-NF | 20.7 | 6.69 | 1.72 | 6.64 | 0.4 |
| | | 3 | 3-SW1-F | 3-SW1-NF | 20.7 | 6.78 | 1.79 | 6.67 | 0.54 |
| II | sediment only | 4 | 4-SW1-F | 4-SW1-NF | 20.7 | 6.52 | 13.62 | 6.84 | 150 |
| | | 5 | 5-SW1-F | 5-SW1-NF | 20.5 | 6.54 | 12.13 | 6.79 | 91.2 |
| | | 6 | 6-SW1-F | 6-SW1-NF | 20.5 | 6.54 | 13.44 | 6.78 | 126 |
| III | sand/passive material | 7 | 7-SW1-F | 7-SW1-NF | 20.4 | 6.65 | 8.88 | 6.63 | 28.8 |
| | | 8 | 8SW1-F | 8SW1-NF | 20.4 | 6.7 | 8.691 | 6.59 | 20.5 |
| | | 9 | 9-SW1-F | 9-SW1-NF | 20.4 | 6.8 | 10.47 | 6.68 | 23.4 |
| IV | sand/passive material | 10 | 10-SW1-F | 10-SW1-NF | 20.4 | 6.9 | 11.15 | 6.74 | 16.6 |
| | | 11 | 11-SW1-F | 11-SW1-NF | 20.3 | 6.8 | 10.991 | 6.8 | 16 |
| | | 12 | 12-SW1-F | 12-SW1-NF | 20.3 | 6.9 | 10.9 | 6.74 | 14.1 |
| V | silty clay/passive material | 13 | 13-SW1-F | 13-SW1-NF | 20.2 | 6.96 | 58.5 | 6.9 | 74.6 |
| | | 14 | 14-SW1-F | 14-SW1-NF | 20.2 | 6.99 | 60 | 6.9 | 28.5 |
| | | 15 | 15-SW1-F | 15-SW1-NF | 20.3 | 7 | 61 | 7 | 25 |
| VI | apatite/active material | 16 | 16-SW1-F | 16-SW1-NF | 20.3 | 7.1 | 397 | 7.76 | 25.9 |
| | | 17 | 17-SW1-F | 17-SW1-NF | 20.4 | 7.2 | 398 | 7.74 | 25.5 |
| | | 18 | 18-SW1-F | 18-SW1-NF | 20.4 | 7.2 | 400 | 7.8 | 11.1 |
| VII | apatite/active material | 19 | 19-SW1-F | 19-SW1-NF | 20.8 | 6.8 | 539 | 7.92 | 9.13 |
| | | 20 | 20-SW1-F | 20-SW1-NF | 20.8 | 6.71 | 561 | 7.75 | 9.86 |
| | | 21 | 21-SW1-F | 21-SW1-NF | 20.9 | 7 | 545 | 7.91 | 12.1 |
| VIII | activated carbon | 22 | 22-SW1-F | 22-SW1-NF | 20.8 | 7 | 139 | 8.28 | 40.3 |
| | | 23 | 23-SW1-F | 23-SW1-NF | 20.7 | 7.2 | 120 | 8.14 | 37.6 |
| | | 24 | 24-SW1-F | 24-SW1-NF | 20.6 | 7.18 | 131 | 8.05 | 30.4 |
| IX | organoclay MRM/active | 25 | 25-SW1-F | 25-SW1-NF | 20.7 | 7.2 | 1632 | 7.49 | 12.6 |
| | | 26 | 26-SW1-F | 26-SW1-NF | 20.8 | 7.3 | 1600 | 7.46 | 9.16 |
| | | 27 | 27-SW1-F | 27-SW1-NF | 20.8 | 7.18 | 1341 | 7.44 | 16.8 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW1-F | 28-SW1-NF | 20.7 | 6.99 | 979 | 7.97 | 17.9 |
| | | 29 | 29-SW1-F | 29-SW1-NF | 20.8 | 7.2 | 930 | 8.08 | 17.9 |
| | | 30 | 30-SW1-F | 30-SW1-NF | 20.8 | 6.94 | 1053 | 7.98 | 12.7 |

Table A1.2. Surface water properties for each sample at time three h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/9/2014 | | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 | 12/9/2014 |
| Sampling time | 2 PM Time 3 hrs | | 3 hrs | 3 hrs | 3 hrs | 3 hrs | 3 hrs | 3 hrs | 3 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW2-F | 1-SW2-NF | 20.7 | 6.66 | 1.716 | 6.79 | 0.43 |
| | | 3 | 3-SW2-F | 3-SW2-NF | 20.7 | 6.59 | 1.826 | 6.68 | 0.3 |
| II | sediment only | 4 | 4-SW2-F | 4-SW2-NF | 20.7 | 6.85 | 13.9 | 6.82 | 280 |
| | | 5 | 5-SW2-F | 5-SW2-NF | 20.5 | 6.8 | 13.23 | 6.92 | 240 |
| | | 6 | 6-SW2-F | 6-SW2-NF | 20.5 | 6.6 | 13.9 | 6.87 | 294 |
| III | sand/passive material | 7 | 7-SW2-F | 7-SW2-NF | 20.1 | 7 | 8.482 | 6.72 | 37.4 |
| | | 8 | 8-SW2-F | 8-SW2-NF | 20 | 7.2 | 8.28 | 6.84 | 28.3 |
| | | 9 | 9-SW2-F | 9-SW2-NF | 20 | 7.3 | 8.527 | 6.73 | 35 |
| IV | sand/passive material | 10 | 10-SW2-F | 10-SW2-NF | 20 | 7.3 | 8.282 | 6.6 | 26.3 |
| | | 11 | 11-SW2-F | 11-SW2-NF | 20 | 7.28 | 8.28 | 6.6 | 37 |
| | | 12 | 12-SW2-F | 12-SW2-NF | 20 | 7.35 | 7.39 | 6.6 | 38 |
| V | silty clay/passive material | 13 | 13-SW2-F | 13-SW2-NF | 19.9 | 7 | 58.43 | 6.85 | 161 |
| | | 14 | 14-SW2-F | 14-SW2-NF | 20 | 7 | 57.19 | 6.96 | 157 |
| | | 15 | 15-SW2-F | 15-SW2-NF | 19.8 | 6.8 | 59.68 | 6.96 | 150 |
| VI | apatite/active material | 16 | 16-SW2-F | 16-SW2-NF | 20.1 | 7 | 379.3 | 7.63 | 48 |
| | | 17 | 17-SW2-F | 17-SW2-NF | 20.1 | 7 | 395.3 | 7.69 | 44 |
| | | 18 | 18-SW2-F | 18-SW2-NF | 20 | 7 | 452.9 | 7.73 | 40.8 |
| VII | apatite/active material | 19 | 19-SW2-F | 19-SW2-NF | 20 | 6.8 | 553.4 | 7.82 | 48 |
| | | 20 | 20-SW2-F | 20-SW2-NF | 20 | 7 | 577.9 | 7.92 | 45 |
| | | 21 | 21-SW2-F | 21-SW2-NF | 20 | 7.07 | 554.2 | 7.98 | 50 |
| VIII | activated carbon | 22 | 22-SW2-F | 22-SW2-NF | 19.9 | 7.1 | 126 | 8.03 | 167 |
| | | 23 | 23-SW2-F | 23-SW2-NF | 20 | 7.2 | 116.2 | 8.1 | 178 |
| | | 24 | 24-SW2-F | 24-SW2-NF | 20 | 7.2 | 128.3 | 8.1 | 150 |
| IX | organoclay MRM/active | 25 | 25-SW2-F | 25-SW2-NF | 20.1 | 6.82 | 1582 | 7.6 | 26.4 |
| | | 26 | 26-SW2-F | 26-SW2-NF | 20.2 | 7.2 | 1568 | 7.54 | 23.4 |
| | | 27 | 27-SW2-F | 27-SW2-NF | 20.1 | 7 | 1344 | 7.64 | 31.5 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW2-F | 28-SW2-NF | 20.1 | 7 | 977.8 | 7.87 | 33.3 |
| | | 29 | 29-SW2-F | 29-SW2-NF | 20.1 | 7.1 | 921.8 | 7.98 | 35.6 |
| | | 30 | 30-SW2-F | 30-SW2-NF | 20.1 | 7 | 1046 | 8 | 36 |

Table A1.3. Surface water properties for each sample at time 24 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/10/2014 | | 12/10/2014 | 12/10/2014 | 12/10/2014 | 12/10/2014 | 12/10/2014 | 12/10/2014 | 12/10/2014 |
| Sampling time | 11AM Time 24hrs | | 24 hrs | 24 hrs | 24 hrs | 24 hrs | 24 hrs | 24 hrs | 24 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW3-F | 1-SW3-NF | 20.6 | 7.7 | 2.9 | 6.7 | 0.43 |
| | | 3 | 3-SW3-F | 3-SW3-NF | 20.6 | 7.6 | 2.9 | 6.81 | 0.3 |
| II | sediment only | 4 | 4-SW3-F | 4-SW3-NF | 20.5 | 7.6 | 14.7 | 6.89 | 280 |
| | | 5 | 5-SW3-F | 5-SW3-NF | 20.6 | 7.77 | 14.81 | 6.95 | 240 |
| | | 6 | 6-SW3-F | 6-SW3-NF | 20.5 | 7.74 | 14.99 | 6.96 | 294 |
| III | sand/passive material | 7 | 7-SW3-F | 7-SW3-NF | 20.5 | 7.08 | 10.6 | 6.77 | 37.4 |
| | | 8 | 8-SW3-F | 8-SW3-NF | 20.5 | 7.4 | 10.28 | 6.74 | 28.3 |
| | | 9 | 9-SW3-F | 9-SW3-NF | 20.5 | 7.49 | 10.93 | 6.86 | 35 |
| IV | sand/passive material | 10 | 10-SW3-F | 10-SW3-NF | 20.5 | 7.09 | 9.64 | 6.78 | 26.3 |
| | | 11 | 11-SW1-F | 11-SW3-NF | 20.5 | 7.49 | 9.623 | 6.84 | 37 |
| | | 12 | 12-SW3-F | 12-SW3-NF | 20.5 | 7.08 | 8.506 | 6.97 | 38 |
| V | silty clay/passive material | 13 | 13-SW3-F | 13-SW3-NF | 20.6 | 6.82 | 58.41 | 6.99 | 161 |
| | | 14 | 14-SW3-F | 14-SW3-NF | 20.6 | 6.81 | 58.82 | 6.84 | 157 |
| | | 15 | 15-SW3-F | 15-SW3-NF | 20.6 | 6.98 | 60.04 | 6.89 | 150 |
| VI | apatite/active material | 16 | 16-SW3-F | 16-SW3-NF | 20.6 | 6.71 | 397.6 | 7.52 | 48 |
| | | 17 | 17-SW3-F | 17-SW3-NF | 20.6 | 6.95 | 423.3 | 7.77 | 44 |
| | | 18 | 18-SW3-F | 18-SW3-NF | 20.6 | 6.87 | 470.9 | 7.77 | 40.8 |
| VII | apatite/active material | 19 | 19-SW3-F | 19-SW3-NF | 20.7 | 6.9 | 586.3 | 7.8 | 48 |
| | | 20 | 20-SW2-F | 20-SW3-NF | 20.5 | 7.05 | 610.5 | 7.95 | 45 |
| | | 21 | 21-SW3-F | 21-SW3-NF | 20.5 | 6.97 | 580.1 | 7.7 | 50 |
| VIII | activated carbon | 22 | 22-SW3-F | 22-SW3-NF | 20.4 | 6.87 | 122.5 | 8.06 | 167 |
| | | 23 | 23-SW3-F | 23-SW3-NF | 20.5 | 7.06 | 120.9 | 8.13 | 178 |
| | | 24 | 24-SW3-F | 24-SW3-NF | 20.5 | 7.06 | 129.1 | 8.04 | 150 |
| IX | organoclay MRM/active | 25 | 25-SW3-F | 25-SW3-NF | 20.4 | 6.74 | 1591 | 7.55 | 26.4 |
| | | 26 | 26-SW3-F | 26-SW3-NF | 20.4 | 6.95 | 1613 | 7.69 | 23.4 |
| | | 27 | 27-SW3-F | 27-SW3-NF | 20.4 | 7.02 | 1372 | 7.68 | 31.5 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW3-F | 28-SW3-NF | 20.5 | 7.08 | 1021 | 7.84 | 33.3 |
| | | 29 | 29-SW3-F | 29-SW3-NF | 20.5 | 7.1 | 927.4 | 7.95 | 35.6 |
| | | 30 | 30-SW1-F | 30-SW3-NF | 20.5 | 6.99 | 1066 | 7.97 | 36 |

Table A.1.4. Surface water properties for each sample at time 48 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/11/2014 | | 12/11/2014 | 12/11/2014 | 12/11/2014 | 12/11/2014 | 12/11/2014 | 12/11/2014 | 12/11/2014 |
| Sampling time | 11AM Time 48 hrs | | 48 hrs | 48 hrs | 48 hrs | 48 hrs | 48 hrs | 48 hrs | 48 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW4-F | 1-SW4-NF | 19.80 | 7.00 | 3.72 | 6.71 | 0.43 |
| | | 3 | 3-SW4-F | 3-SW4-NF | 19.7 | 7.1 | 3.75 | 6.8 | 0.3 |
| II | sediment only | 4 | 4-SW4-F | 4-SW4-NF | 19.7 | 7.01 | 17.8 | 6.76 | 280 |
| | | 5 | 5-SW4-F | 5-SW4-NF | 19.7 | 7.1 | 16.68 | 6.94 | 240 |
| | | 6 | 6-SW4-F | 6-SW4-NF | 19.7 | 7.1 | 17.25 | 6.96 | 294 |
| III | sand/passive material | 7 | 7-SW4-F | 7-SW4-NF | 19.6 | 7.2 | 12.47 | 6.99 | 37.4 |
| | | 8 | 8-SW4-F | 8-SW4-NF | 19.6 | 7.2 | 12.03 | 6.7 | 28.3 |
| | | 9 | 9-SW4-F | 9-SW4-NF | 19.6 | 7.1 | 12.12 | 6.83 | 35 |
| IV | sand/passive material | 10 | 10-SW4-F | 10-SW4-NF | 19.7 | 7.2 | 13.06 | 6.87 | 26.3 |
| | | 11 | 11-SW4-F | 11-SW4-NF | 19.6 | 7.3 | 11.53 | 6.85 | 37 |
| | | 12 | 12-SW4-F | 12-SW4-NF | 19.6 | 7.17 | 11.03 | 6.75 | 38 |
| V | silty clay/passive material | 13 | 13-SW4-F | 13-SW4-NF | 19.6 | 7.2 | 58.86 | 6.89 | 161 |
| | | 14 | 14-SW4-F | 14-SW4-NF | 19.5 | 7.18 | 59.15 | 6.82 | 157 |
| | | 15 | 15-SW4-F | 15-SW4-NF | 19.5 | 7.2 | 61.36 | 6.86 | 150 |
| VI | apatite/active material | 16 | 16-SW4-F | 16-SW4-NF | 19.5 | 6.74 | 407.5 | 7.54 | 48 |
| | | 17 | 17-SW4-F | 17-SW4-NF | 19.5 | 6.96 | 430 | 7.57 | 44 |
| | | 18 | 18-SW4-F | 18-SW4-NF | 19.5 | 6.85 | 470 | 7.63 | 40.8 |
| VII | apatite/active material | 19 | 19-SW4-F | 19-SW4-NF | 19.5 | 7.1 | 603 | 7.67 | 48 |
| | | 20 | 20-SW4-F | 20-SW4-NF | 19.5 | 6.99 | 607 | 7.81 | 45 |
| | | 21 | 21-SW4-F | 21-SW4-NF | 19.5 | 7 | 610 | 7.7 | 50 |
| VIII | activated carbon | 22 | 22-SW4-F | 22-SW4-NF | 19.7 | 7.2 | 134 | 8.14 | 167 |
| | | 23 | 23-SW4-F | 23-SW4-NF | 19.5 | 7.2 | 123.3 | 8.13 | 178 |
| | | 24 | 24-SW4-F | 24-SW4-NF | 19.5 | 7.22 | 131.8 | 8.16 | 150 |
| IX | organoclay MRM/active | 25 | 25-SW4-F | 25-SW4-NF | 19.6 | 7.02 | 1718 | 7.53 | 26.4 |
| | | 26 | 26-SW4-F | 26-SW4-NF | 19.6 | 7.1 | 1676 | 7.85 | 23.4 |
| | | 27 | 27-SW4-F | 27-SW4-NF | 19.5 | 6.9 | 1382 | 7.88 | 31.5 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW4-F | 28-SW4-NF | 19.5 | 7.1 | 992.7 | 7.89 | 33.3 |
| | | 29 | 29-SW4-F | 29-SW4-NF | 19.5 | 7.26 | 935.9 | 7.93 | 35.6 |
| | | 30 | 30-SW4-F | 30-SW4-NF | 19.6 | 7.07 | 1086 | 8.03 | 36 |

Table A1.5. Surface water properties for each sample at time 72 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Sampling date | 12/12/2014 | | 1212/2014 | 1212/2014 | 1212/2014 | 1212/2014 | 1212/2014 | 1212/2014 | 1212/2014 |
| Sampling time | 11AM Time 72 hrs | | 72 hrs | 72 hrs | 72 hrs | 72 hrs | 72 hrs | 72 hrs | 72 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW5-F | 1-SW5-NF | 20.9 | 6.97 | 8.25 | 6.8 | 0.26 |
| | | 3 | 3-SW5-F | 3-SW5-NF | 20.9 | 7 | 8.689 | 6.78 | 0.37 |
| II | sediment only | 4 | 4-SW5-F | 4-SW5-NF | 20.8 | 7.01 | 23.09 | 6.87 | 153 |
| | | 5 | 5-SW5-F | 5-SW5-NF | 20.8 | 6.9 | 19.7 | 6.99 | 154 |
| | | 6 | 6-SW5-F | 6-SW5-NF | 20.8 | 7 | 20.02 | 6.97 | 178 |
| III | sand/passive material | 7 | 7-SW5-F | 7-SW5-NF | 19.6 | 7.2 | 13.82 | 6.88 | 27.3 |
| | | 8 | 8-SW5-F | 8-SW5-NF | 19.6 | 7.2 | 14.5 | 6.75 | 25.3 |
| | | 9 | 9-SW5-F | 9-SW5-NF | 19.5 | 7.3 | 15.29 | 6.7 | 26.8 |
| IV | sand/passive material | 10 | 10-SW5-F | 10-SW5-NF | 19.4 | 6.91 | 14.9 | 6.74 | 28.4 |
| | | 11 | 11-SW5-F | 11-SW5-NF | 19.4 | 6.95 | 13.47 | 6.93 | 28.4 |
| | | 12 | 12-SW5-F | 12-SW5-NF | 19.4 | 7 | 13.49 | 6.69 | 25 |
| V | silty clay/passive material | 13 | 13-SW5-F | 13-SW5-NF | 19.4 | 6.9 | 72.98 | 6.8 | 123 |
| | | 14 | 14-SW5-F | 14-SW5-NF | 19.4 | 6.98 | 61.54 | 7 | 63.3 |
| | | 15 | 15-SW5-F | 15-SW5-NF | 19.4 | 6.98 | 62.78 | 7 | 72.9 |
| VI | apatite/active material | 16 | 16-SW5-F | 16-SW5-NF | 19.3 | 6.98 | 435.1 | 7.53 | 53 |
| | | 17 | 17-SW5-F | 17-SW5-NF | 19.3 | 7 | 446.1 | 7.65 | 42.7 |
| | | 18 | 18-SW5-F | 18-SW5-NF | 19.3 | 7 | 492.1 | 7.58 | 36.8 |
| VII | apatite/active material | 19 | 19-SW5-F | 19-SW5-NF | 19.3 | 6.9 | 608 | 7.75 | 33.9 |
| | | 20 | 20-SW5-F | 20-SW5-NF | 19.2 | 6.99 | 647 | 7.68 | 22.7 |
| | | 21 | 21-SW5-F | 21-SW5-NF | 19.3 | 6.8 | 628 | 7.97 | 34.5 |
| VIII | activated carbon | 22 | 22-SW5-F | 22-SW5-NF | 19.4 | 6.75 | 134 | 8.1 | 84.2 |
| | | 23 | 23-SW5-F | 23-SW5-NF | 19.4 | 6.88 | 122 | 8 | 85.2 |
| | | 24 | 24-SW5-F | 24-SW5-NF | 19.5 | 6.8 | 132.9 | 8 | 76.2 |
| IX | organoclay MRM/active | 25 | 25-SW5-F | 25-SW5-NF | 19.4 | 6.91 | 1708 | 7.65 | 26.87 |
| | | 26 | 26-SW5-F | 26-SW5-NF | 19.4 | 7 | 1717 | 7.57 | 23 |
| | | 27 | 27-SW5-F | 27-SW5-NF | 19.4 | 6.91 | 1403 | 7.6 | 22 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW5-F | 28-SW5-NF | 19.4 | 6.9 | 1095 | 7.88 | 21.6 |
| | | 29 | 29-SW5-F | 29-SW5-NF | 19.5 | 7.05 | 961 | 7.86 | 26 |
| | | 30 | 30-SW5-F | 30-SW5-NF | 19.5 | 7 | 1130 | 8.08 | 29.9 |

Table A1.6. Surface water properties for each sample at time 144 hours.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/15/2014 | | 12/15/2014 | 12/15/2014 | 12/15/2014 | 12/15/2014 | 12/15/2014 | 12/15/2014 | 12/15/2014 |
| Sampling time | 11AM Time 144 hrs | | 144 hrs | 144 hrs | 144 hrs | 144 hrs | 144 hrs | 144 hrs | 144 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW6-F | 1-SW6-NF | 20.3 | 7.01 | 14.01 | 7 | 0.29 |
| | | 3 | 3-SW6-F | 3-SW6-NF | 20.3 | 7 | 13.82 | 7 | 0.28 |
| II | sediment only | 4 | 4-SW6-F | 4-SW6-NF | 20.3 | 6.99 | 24.19 | 6.89 | 197 |
| | | 5 | 5-SW6-F | 5-SW6-NF | 20.3 | 6.98 | 23.32 | 6.83 | 146 |
| | | 6 | 6-SW6-F | 6-SW6-NF | 20.3 | 6.9 | 24.13 | 6.92 | 185 |
| III | sand/passive material | 7 | 7-SW6-F | 7-SW6-NF | 20.3 | 6.88 | 19.83 | 6.85 | 29.4 |
| | | 8 | 8-SW6-F | 8-SW6-NF | 20.1 | 7 | 20.19 | 6.84 | 20.9 |
| | | 9 | 9-SW6-F | 9-SW6-NF | 20.1 | 7 | 19.99 | 6.72 | 29.4 |
| IV | sand/passive material | 10 | 10-SW6-F | 10-SW6-NF | 20.1 | 7 | 20.17 | 6.85 | 33.1 |
| | | 11 | 11-SW6-F | 11-SW6-NF | 20 | 7 | 17.03 | 6.84 | 29.3 |
| | | 12 | 12-SW6-F | 12-SW6-NF | 20 | 6.98 | 17.34 | 6.72 | 34.2 |
| V | silty clay/passive material | 13 | 13-SW6-F | 13-SW6-NF | 20 | 7.1 | 64.8 | 6.8 | 111 |
| | | 14 | 14-SW6-F | 14-SW6-NF | 20 | 7.08 | 63.72 | 6.91 | 55.1 |
| | | 15 | 15-SW6-F | 15-SW6-NF | 20 | 6.98 | 65.72 | 6.99 | 55 |
| VI | apatite/active material | 16 | 16-SW6-F | 16-SW6-NF | 20 | 7.04 | 445.7 | 7.44 | 54.7 |
| | | 17 | 17-SW6-F | 17-SW6-NF | 20 | 7.1 | 454.7 | 7.55 | 48.2 |
| | | 18 | 18-SW6-F | 18-SW6-NF | 20 | 6.9 | 493.8 | 7.68 | 23.6 |
| VII | apatite/active material | 19 | 19-SW6-F | 19-SW6-NF | 20.2 | 7.07 | 629.4 | 7.77 | 40 |
| | | 20 | 20-SW6-F | 20-SW6-NF | 20.2 | 7.1 | 664.9 | 7.85 | 26.8 |
| | | 21 | 21-SW6-F | 21-SW6-NF | 20.1 | 6.9 | 638 | 7.9 | 35.8 |
| VIII | activated carbon | 22 | 22-SW6-F | 22-SW6-NF | 20.1 | 7.07 | 120 | 8.18 | 79.1 |
| | | 23 | 23-SW6-F | 23-SW6-NF | 20.1 | 7 | 124.8 | 8.09 | 90.9 |
| | | 24 | 24-SW6-F | 24-SW6-NF | 20.1 | 7 | 133.9 | 8.09 | 92.3 |
| IX | organoclay MRM/active | 25 | 25-SW6-F | 25-SW6-NF | 20.1 | 7 | 1687 | 7.8 | 43 |
| | | 26 | 26-SW6-F | 26-SW6-NF | 20.1 | 7.08 | 1748 | 7.75 | 38 |
| | | 27 | 27-SW6-F | 27-SW6-NF | 20.1 | 7.05 | 1490 | 7.75 | 36.7 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW6-F | 28-SW6-NF | 20 | 7.09 | 1152 | 7.98 | 42 |
| | | 29 | 29-SW6-F | 29-SW6-NF | 20 | 6.99 | 989 | 7.9 | 35 |
| | | 30 | 30-SW6-F | 30-SW6-NF | 20 | 7 | 1100 | 8 | 36.7 |

Table A1.7. Surface water properties for each sample at time 168 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/16/2014 | | 12/16/2014 | 12/16/2014 | 12/16/2014 | 12/16/2014 | 12/16/2014 | 12/16/2014 | 12/16/2014 |
| Sampling time | 11AM Time 168hrs | | 168 hrs | 168 hrs | 168 hrs | 168 hrs | 168 hrs | 168 hrs | 168 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW7-F | 1-SW7-NF | 20.3 | 6 | 15.02 | 7.16 | 0.2 |
| | NOT avaluated | 2 | | | | | | | |
| | | 3 | 3-SW7-F | 3-SW7-NF | 20.3 | 6 | 15.12 | 7.12 | 0.2 |
| II | sediment only | 4 | 4-SW7-F | 4-SW7-NF | 20.2 | 6.18 | 25.3 | 7.18 | 127 |
| | | 5 | 5-SW7-F | 5-SW7-NF | 20.2 | 6.3 | 24.51 | 7.2 | 122 |
| | | 6 | 6-SW7-F | 6-SW7-NF | 20.2 | 6.3 | 25.6 | 7.13 | 123 |
| III | sand/passive material | 7 | 7-SW7-F | 7-SW7-NF | 20.2 | 6.8 | 19.56 | 7.2 | 38 |
| | | 8 | 8-SW7-F | 8-SW7-NF | 20.1 | 6.8 | 20.55 | 7.18 | 26 |
| | | 9 | 9-SW7-F | 9-SW7-NF | 20.1 | 6.81 | 21.08 | 7.2 | 28 |
| IV | sand/passive material | 10 | 10-SW7-F | 10-SW7-NF | 20.1 | 6.6 | 21.7 | 7.3 | 31 |
| | | 11 | 11-SW7-F | 11-SW7-NF | 20 | 6.8 | 18.65 | 7.3 | 30 |
| | | 12 | 12-SW7-F | 12-SW7-NF | 20 | 6.8 | 19.42 | 7.35 | 29 |
| V | silty clay/passive material | 13 | 13-SW7-F | 13-SW7-NF | 20 | 6.98 | 64.76 | 7.47 | 85 |
| | | 14 | 14-SW7-F | 14-SW7-NF | 20 | 6.88 | 65.02 | 7.25 | 80 |
| | | 15 | 15-SW7-F | 15-SW7-NF | 20 | 6.8 | 66.65 | 7.5 | 62 |
| VI | apatite/active material | 16 | 16-SW7-F | 16-SW7-NF | 20 | 6.98 | 448.5 | 7.85 | 50 |
| | | 17 | 17-SW7-F | 17-SW7-NF | 20 | 6.88 | 437.7 | 8.4 | 51 |
| | | 18 | 18-SW7-F | 18-SW7-NF | 20 | 6.8 | 497.6 | 7.98 | 52 |
| VII | apatite/active material | 19 | 19-SW7-F | 19-SW7-NF | 20 | 6.8 | 641 | 7.97 | 40 |
| | | 20 | 20-SW7-F | 20-SW7-NF | 20 | 6.78 | 651 | 8.25 | 40 |
| | | 21 | 21-SW7-F | 21-SW7-NF | 20 | 6.8 | 640.5 | 8.25 | 45 |
| VIII | activated carbon | 22 | 22-SW7-F | 22-SW7-NF | 20.1 | 6.8 | 128.2 | 8.3 | 93 |
| | | 23 | 23-SW7-F | 23-SW7-NF | 20.1 | 6.9 | 126.5 | 8.25 | 100 |
| | | 24 | 24-SW7-F | 24-SW7-NF | 20.1 | 6.84 | 133.8 | 8.02 | 120 |
| IX | organoclay MRM/active | 25 | 25-SW7-F | 25-SW7-NF | 20.1 | 6.7 | 1746 | 7.36 | 22 |
| | | 26 | 26-SW7-F | 26-SW7-NF | 20.1 | 6.8 | 1780 | 7.7 | 23 |
| | | 27 | 27-SW7-F | 27-SW7-NF | 20.1 | 6.8 | 1454 | 7.77 | 27 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW7-F | 28-SW7-NF | 20.1 | 6.9 | 1141 | 8.08 | 34 |
| | | 29 | 29-SW7-F | 29-SW7-NF | 20.1 | 6.87 | 992.4 | 8.02 | 42 |
| | | 30 | 30-SW7-F | 30-SW7-NF | 20.1 | 6.9 | 1151 | 8.21 | 34 |

Table A1.8. Surface water properties for each sample at time 192 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/17/2014 | | 12/17/2014 | 12/17/2014 | 12/17/2014 | 12/17/2014 | 12/17/2014 | 12/17/2014 | 12/17/2014 |
| Sampling time | 11AM Time 192hrs | | 192 hrs | 192 hrs | 192 hrs | 192 hrs | 192 hrs | 192 hrs | 192 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW8-F | 1-SW8-NF | 19.9 | 6.99 | 15.99 | 6.99 | 0.2 |
| | | 2 | | | | | | | |
| | | 3 | 3-SW8-F | 3-SW8-NF | 19.9 | 7 | 16.81 | 6.88 | 0.2 |
| II | sediment only | 4 | 4-SW8-F | 4-SW8-NF | 19.8 | 7.2 | 25.78 | 6.75 | 100 |
| | | 5 | 5-SW8-F | 5-SW8-NF | 19.8 | 7.1 | 25.51 | 6.87 | 120 |
| | | 6 | 6-SW8-F | 6-SW8-NF | 19.8 | 7 | 26.73 | 7.05 | 125 |
| III | sand/passive material | 7 | 7-SW8-F | 7-SW8-NF | 19.7 | 7.2 | 20.78 | 6.93 | 32 |
| | | 8 | 8-SW8-F | 8-SW8-NF | 19.7 | 7 | 21.76 | 7 | 25 |
| | | 9 | 9-SW8-F | 9-SW8-NF | 19.7 | 7.1 | 21.97 | 7.1 | 23 |
| IV | sand/passive material | 10 | 10-SW8-F | 10-SW8-NF | 19.9 | 7.08 | 22.58 | 7.2 | 40 |
| | | 11 | 11-SW8-F | 11-SW8-NF | 19.9 | 7 | 20.16 | 7.09 | 37 |
| | | 12 | 12-SW8-F | 12-SW8-NF | 19.9 | 7.1 | 20.84 | 7.18 | 37 |
| V | silty clay/passive material | 13 | 13-SW8-F | 13-SW8-NF | 19.9 | 7.2 | 64.95 | 6.92 | 70 |
| | | 14 | 14-SW8-F | 14-SW8-NF | 19.9 | 7.1 | 64.44 | 7.13 | 67 |
| | | 15 | 15-SW8-F | 15-SW8-NF | 20 | 7.2 | 65.54 | 7.2 | 77 |
| VI | apatite/active material | 16 | 16-SW8-F | 16-SW8-NF | 20 | 7.2 | 428.4 | 7.99 | 40 |
| | | 17 | 17-SW8-F | 17-SW8-NF | 20 | 7.2 | 449.1 | 8 | 42 |
| | | 18 | 18-SW8-F | 18-SW8-NF | 20 | 7.1 | 486.7 | 8.1 | 41 |
| VII | apatite/active material | 19 | 19-SW8-F | 19-SW8-NF | 20 | 7.1 | 614.2 | 8.33 | 45 |
| | | 20 | 20-SW8-F | 20-SW8-NF | 20.1 | 7.2 | 655.9 | 8.32 | 33 |
| | | 21 | 21-SW8-F | 21-SW8-NF | 20.1 | 7 | 617 | 8.31 | 34 |
| VIII | activated carbon | 22 | 22-SW8-F | 22-SW8-NF | 20.3 | 7.08 | 130.1 | 8.51 | 78 |
| | | 23 | 23-SW8-F | 23-SW8-NF | 20.3 | 7.1 | 127.1 | 8.6 | 77 |
| | | 24 | 24-SW8-F | 24-SW8-NF | 20.3 | 7 | 131.9 | 8.4 | 87 |
| IX | organoclay MRM/active | 25 | 25-SW8-F | 25-SW8-NF | 20.3 | 7 | 1730 | 7.22 | 23 |
| | | 26 | 26-SW8-F | 26-SW8-NF | 20.3 | 7 | 1783 | 7.34 | 25 |
| | | 27 | 27-SW8-F | 27-SW8-NF | 20.3 | 7.05 | 1548 | 7.2 | 24 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW8-F | 28-SW8-NF | 20.3 | 7 | 1103 | 8.2 | 33 |
| | | 29 | 29-SW8-F | 29-SW8-NF | 20.3 | 7 | 1043 | 8.27 | 43 |
| | | 30 | 30-SW8-F | 30-SW8-NF | 20.3 | 7.05 | 1173 | 8.3 | 43 |

Table A1.9. Surface water properties for each sample at time 216 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/18/2014 | | 12/18/2014 | 12/18/2014 | 12/18/2014 | 12/18/2014 | 12/18/2014 | 12/18/2014 | 12/18/2014 |
| Sampling time | 11AM Time 216 hrs | | 216 hrs | 216 hrs | 216 hrs | 216 hrs | 216 hrs | 216 hrs | 216 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW9-F | 1-SW9-NF | 20.5 | 7.3 | 17.39 | 7 | 0.25 |
| | | 2 | | | | | | | |
| | | 3 | 3-SW9-F | 3-SW9-NF | 20.5 | 7.2 | 18.55 | 6.98 | 0.21 |
| II | sediment only | 4 | 4-SW9-F | 4-SW9-NF | 20.5 | 7.1 | 27.73 | 7 | 135 |
| | | 5 | 5-SW9-F | 5-SW9-NF | 20.4 | 7 | 27.11 | 7.15 | 120 |
| | | 6 | 6-SW9-F | 6-SW9-NF | 20.5 | 7 | 28.83 | 7.12 | 118 |
| III | sand/passive material | 7 | 7-SW9-F | 7-SW9-NF | 20.4 | 7 | 22.87 | 6.98 | 37 |
| | | 8 | 8-SW9-F | 8-SW9-NF | 20.4 | 7 | 22.98 | 6.99 | 27 |
| | | 9 | 9-SW9-F | 9-SW9-NF | 20.4 | 7.1 | 23.73 | 7.1 | 28 |
| IV | sand/passive material | 10 | 10-SW9-F | 10-SW9-NF | 20.4 | 7 | 24.37 | 7.09 | 38 |
| | | 11 | 11-SW9-F | 11-SW9-NF | 20.4 | 7 | 22.75 | 7.1 | 34 |
| | | 12 | 12-SW9-F | 12-SW9-NF | 20.4 | 7.2 | 22.07 | 7.12 | 40 |
| V | silty clay/passive material | 13 | 13-SW9-F | 13-SW9-NF | 20.4 | 7 | 63.29 | 7 | 60 |
| | | 14 | 14-SW9-F | 14-SW9-NF | 20.4 | 7 | 66.84 | 7.1 | 55 |
| | | 15 | 15-SW9-F | 15-SW9-NF | 20.4 | 7 | 66.54 | 7 | 56 |
| VI | apatite/active material | 16 | 16-SW9-F | 16-SW9-NF | 20.4 | 7.2 | 428.4 | 7.99 | 40 |
| | | 17 | 17-SW9-F | 17-SW9-NF | 20.4 | 7.2 | 449.1 | 8 | 42 |
| | | 18 | 18-SW9-F | 18-SW9-NF | 20.4 | 7.1 | 486.7 | 8.1 | 41 |
| VII | apatite/active material | 19 | 19-SW9-F | 19-SW9-NF | 20.4 | 7.1 | 614.2 | 8.33 | 33 |
| | | 20 | 20-SW9-F | 20-SW9-NF | 20.4 | 7.2 | 655.9 | 8.32 | 33 |
| | | 21 | 21-SW9-F | 21-SW9-NF | 20.4 | 7 | 617 | 8.31 | 34 |
| VIII | activated carbon | 22 | 22-SW9-F | 22-SW9-NF | 20.4 | 7.08 | 130.1 | 8.51 | 78 |
| | | 23 | 23-SW9-F | 23-SW9-NF | 20.4 | 7.1 | 127.1 | 8.6 | 77 |
| | | 24 | 24-SW9-F | 24-SW9-NF | 20.4 | 7 | 131.9 | 8.4 | 87 |
| IX | organoclay MRM/active | 25 | 25-SW9-F | 25-SW9-NF | 20.4 | 7 | 1730 | 7.22 | 23 |
| | | 26 | 26-SW9-F | 26-SW9-NF | 20.4 | 7 | 1783 | 7.34 | 25 |
| | | 27 | 27-SW9-F | 27-SW9-NF | 20.4 | 7.05 | 1548 | 7.2 | 24 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW9-F | 28-SW9-NF | 20.4 | 7 | 1110 | 7.57 | 36 |
| | | 29 | 29-SW9-F | 29-SW9-NF | 20.4 | 7.1 | 1056 | 7.7 | 45 |
| | | 30 | 30-SW9-F | 30-SW9-NF | 20.4 | 7.1 | 1195 | 8.01 | 45 |

Table A1.10. Surface water properties for each sample at time 240 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/19/2014 | | 12/19/2014 | 12/19/2014 | 12/19/2014 | 12/19/2014 | 12/19/2014 | 12/19/2014 | 12/19/2014 |
| Sampling time | 11AM Time 240 hrs | | 240hrs | 240 hrs | 240 hrs | 240 hrs | 240 hrs | 240 hrs | 240 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW10-F | 1-SW10-NF | 19.7 | 6.8 | 19.24 | 7 | 0.27 |
| | | 2 | | | | | | | |
| | | 3 | 3-SW10-F | 3-SW10-NF | 19.6 | 6.8 | 20.55 | 7.1 | 0.26 |
| II | sediment only | 4 | 4-SW10-F | 4-SW10-NF | 19 | 7.1 | 29.19 | 7.2 | 127 |
| | | 5 | 5-SW10-F | 5-SW10-NF | 19 | 7 | 28.49 | 7.3 | 110 |
| | | 6 | 6-SW10-F | 6-SW10-NF | 19 | 7.13 | 30.51 | 7.04 | 108 |
| III | sand/passive material | 7 | 7-SW10-F | 7-SW10-NF | 19.1 | 7 | 24.61 | 7.05 | 35 |
| | | 8 | 8-SW10-F | 8-SW10-NF | 19 | 7.1 | 24.8 | 7.12 | 40 |
| | | 9 | 9-SW10-F | 9-SW10-NF | 19.1 | 7.2 | 26.07 | 7.04 | 34 |
| IV | sand/passive material | 10 | 10-SW10-F | 10-SW10-NF | 19.1 | 6.9 | 26.81 | 6.99 | 36 |
| | | 11 | 11-SW10-F | 11-SW10-NF | 19 | 7 | 23.77 | 7.05 | 45 |
| | | 12 | 12-SW10-F | 12-SW10-NF | 19 | 7 | 24.63 | 6.99 | 44 |
| V | silty clay/passive material | 13 | 13-SW10-F | 13-SW10-NF | 19.1 | 7.06 | 66.98 | 6.98 | 60 |
| | | 14 | 14-SW10-F | 14-SW10-NF | 19 | 7 | 67.74 | 6.99 | 58 |
| | | 15 | 15-SW10-F | 15-SW10-NF | 19 | 7.09 | 69.16 | 6.99 | 58 |
| VI | apatite/active material | 16 | 16-SW10-F | 16-SW10-NF | 19.1 | 6.9 | 447.6 | 7.29 | 28 |
| | | 17 | 17-SW10-F | 17-SW10-NF | 19.2 | 6.9 | 457.2 | 7.6 | 25 |
| | | 18 | 18-SW10-F | 18-SW10-NF | 19.3 | 6.9 | 498.1 | 7.63 | 28 |
| VII | apatite/active material | 19 | 19-SW10-F | 19-SW10-NF | 19.4 | 6.8 | 646.6 | 8.16 | 29 |
| | | 20 | 20-SW10-F | 20-SW10-NF | 19.4 | 6.7 | 679.1 | 7.96 | 28 |
| | | 21 | 21-SW10-F | 21-SW10-NF | 19.4 | 6.7 | 625 | 8.04 | 30 |
| VIII | activated carbon | 22 | 22-SW10-F | 22-SW10-NF | 19.3 | 6.8 | 148.7 | 8.51 | 100 |
| | | 23 | 23-SW10-F | 23-SW10-NF | 19.3 | 6.8 | 128 | 8.57 | 100 |
| | | 24 | 24-SW10-F | 24-SW10-NF | 19.3 | 6.9 | 134.3 | 8.3 | 110 |
| IX | organoclay MRM/active | 25 | 25-SW10-F | 25-SW10-NF | 19.5 | 6.8 | 1756 | 7.21 | 23 |
| | | 26 | 26-SW10-F | 26-SW10-NF | 19.5 | 6.9 | 1795 | 7.29 | 23 |
| | | 27 | 27-SW10-F | 27-SW10-NF | 19.5 | 7 | 1690 | 7.5 | 23 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW10-F | 28-SW10-NF | 19.7 | 6.8 | 1152 | 7.87 | 29 |
| | | 29 | 29-SW10-F | 29-SW10-NF | 19.7 | 7 | 1084 | 7.92 | 25 |
| | | 30 | 30-SW10-F | 30-SW10-NF | 19.7 | 6.8 | 1193 | 8.1 | 28 |

Table A1.11. Surface water properties for each sample at time 312 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/22/2014 | | 12/22/2014 | 12/22/2014 | 12/22/2014 | 12/22/2014 | 12/22/2014 | 12/22/2014 | 12/22/2014 |
| Sampling time | 11AM Time 312 hrs | | 312hrs | 312hrs | 312hrs | 312hrs | 312hrs | 312hrs | 312hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW11-F | 1-SW11-NF | 17.5 | 7.5 | 26 | 6.8 | 0 |
| | | 3 | 3-SW11-F | 3-SW11-NF | 17.5 | 7.5 | 25 | 6.8 | 0 |
| II | sediment only | 4 | 4-SW11-F | 4-SW11-NF | 17.4 | 7.5 | 32 | 7.1 | 145 |
| | | 5 | 5-SW11-F | 5-SW11-NF | 17.4 | 7.6 | 35 | 7.1 | 150 |
| | | 6 | 6-SW11-F | 6-SW11-NF | 17.4 | 7.6 | 35 | 6.9 | 153 |
| III | sand/passive material | 7 | 7-SW11-F | 7-SW11-NF | 17.4 | 7.6 | 30 | 9.9 | 50 |
| | | 8 | 8-SW11-F | 8-SW11-NF | 17.4 | 7.6 | 29 | 7.0 | 49 |
| | | 9 | 9-SW11-F | 9-SW11-NF | 17.4 | 7.4 | 28 | 6.9 | 48 |
| IV | sand/passive material | 10 | 10-SW11-F | 10-SW11-NF | 17.4 | 7.8 | 31 | 7.0 | 46 |
| | | 11 | 11-SW11-F | 11-SW11-NF | 17.5 | 7.6 | 28 | 7.0 | 49 |
| | | 12 | 12-SW11-F | 12-SW11-NF | 17.5 | 7.9 | 29 | 7.0 | 45 |
| V | silty clay/passive material | 13 | 13-SW11-F | 13-SW11-NF | 17.5 | 7.8 | 69 | 7.1 | 100 |
| | | 14 | 14-SW11-F | 14-SW11-NF | 17.5 | 7.6 | 69 | 7.1 | 85 |
| | | 15 | 15-SW11-F | 15-SW11-NF | 17.5 | 7.7 | 72 | 7.2 | 86 |
| VI | apatite/active material | 16 | 16-SW11-F | 16-SW11-NF | 17.5 | 7.8 | 442 | 7.9 | 55 |
| | | 17 | 17-SW11-F | 17-SW11-NF | 17.5 | 7.9 | 452 | 8.0 | 50 |
| | | 18 | 18-SW11-F | 18-SW11-NF | 17.5 | 7.8 | 548 | 7.8 | 47 |
| VII | apatite/active material | 19 | 19-SW11-F | 19-SW11-NF | 17.5 | 7.9 | 626 | 8.3 | 48 |
| | | 20 | 20-SW11-F | 20-SW11-NF | 17.5 | 7.9 | 667 | 8.1 | 45 |
| | | 21 | 21-SW11-F | 21-SW11-NF | 17.5 | 7.9 | 625 | 8.3 | 47 |
| VIII | activated carbon | 22 | 22-SW11-F | 22-SW11-NF | 17.5 | 7.9 | 137 | 8.7 | 120 |
| | | 23 | 23-SW11-F | 23-SW11-NF | 17.5 | 7.8 | 129 | 8.6 | 150 |
| | | 24 | 24-SW11-F | 24-SW11-NF | 17.5 | 7.9 | 135 | 8.6 | 145 |
| IX | organoclay MRM/active | 25 | 25-SW11-F | 25-SW11-NF | 17.5 | 7.8 | 1771 | 7.2 | 29 |
| | | 26 | 26-SW11-F | 26-SW11-NF | 17.5 | 7.9 | 1839 | 7.3 | 22 |
| | | 27 | 27-SW11-F | 27-SW11-NF | 17.5 | 8.0 | 1624 | 7.5 | 23 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW11-F | 28-SW11-NF | 17.5 | 8.0 | 1162 | 8.2 | 50 |
| | | 29 | 29-SW11-F | 29-SW11-NF | 17.5 | 7.9 | 1114 | 8.3 | 45 |
| | | 30 | 30-SW11-F | 30-SW11-NF | 17.5 | 8.0 | 1218 | 8.2 | 44 |

Table A1.12. Surface water properties for each sample at time 336 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/23/2014 | | 12/23/2014 | 12/23/2014 | 12/23/2014 | 12/23/2014 | 12/23/2014 | 12/23/2014 | 12/23/2014 |
| Sampling time | 11AM Time 240 hrs | | 336hrs | 336 hrs | 336 hrs | 336 hrs | 336 hrs | 336 hrs | 336 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW12-F | 1-SW12-NF | 16.8 | 8.5 | 25 | 6.9 | 0 |
| | | 3 | 3-SW12-F | 3-SW12-NF | 16.8 | 8.5 | 27 | 6.9 | 0 |
| II | sediment only | 4 | 4-SW12-F | 4-SW12-NF | 17.0 | 8.5 | 34 | 6.8 | 150 |
| | | 5 | 5-SW12-F | 5-SW12-NF | 17.0 | 8.8 | 34 | 6.8 | 135 |
| | | 6 | 6-SW12-F | 6-SW12-NF | 17.0 | 8.8 | 37 | 7.0 | 152 |
| III | sand/passive material | 7 | 7-SW12-F | 7-SW12-NF | 17.0 | 8.8 | 30 | 7.0 | 40 |
| | | 8 | 8-SW12-F | 8-SW12-NF | 17.0 | 8.4 | 31 | 7.1 | 40 |
| | | 9 | 9-SW12-F | 9-SW12-NF | 17.0 | 8.5 | 28 | 7.0 | 48 |
| IV | sand/passive material | 10 | 10-SW12-F | 10-SW12-NF | 17.0 | 8.5 | 33 | 7.0 | 43 |
| | | 11 | 11-SW12-F | 11-SW12-NF | 17.0 | 8.5 | 31 | 7.0 | 51 |
| | | 12 | 12-SW12-F | 12-SW12-NF | 17.0 | 8.4 | 31 | 7.1 | 28 |
| V | silty clay/passive material | 13 | 13-SW12-F | 13-SW12-NF | 17.0 | 8.5 | 71 | 6.9 | 77 |
| | | 14 | 14-SW12-F | 14-SW12-NF | 17.0 | 8.5 | 71 | 7.2 | 68 |
| | | 15 | 15-SW12-F | 15-SW12-NF | 17.0 | 8.3 | 71 | 7.2 | 92 |
| VI | apatite/active material | 16 | 16-SW12-F | 16-SW12-NF | 17.0 | 8.2 | 450 | 7.6 | 44 |
| | | 17 | 17-SW12-F | 17-SW12-NF | 17.0 | 8.2 | 460 | 7.6 | 50 |
| | | 18 | 18-SW12-F | 18-SW12-NF | 17.0 | 8.2 | 491 | 7.6 | 40 |
| VII | apatite/active material | 19 | 19-SW12-F | 19-SW12-NF | 17.0 | 8.2 | 627 | 7.9 | 39 |
| | | 20 | 20-SW12-F | 20-SW12-NF | 17.0 | 8.4 | 665 | 7.8 | 49 |
| | | 21 | 21-SW12-F | 21-SW12-NF | 17.0 | 8.3 | 620 | 8.0 | 50 |
| VIII | activated carbon | 22 | 22-SW12-F | 22-SW12-NF | 17.0 | 8.4 | 158 | 8.1 | 100 |
| | | 23 | 23-SW12-F | 23-SW12-NF | 17.0 | 8.3 | 134 | 8.2 | 110 |
| | | 24 | 24-SW12-F | 24-SW12-NF | 17.0 | 8.2 | 138 | 8.2 | 110 |
| IX | organoclay MRM/active | 25 | 25-SW12-F | 25-SW12-NF | 17.0 | 8.3 | 1793 | 7.5 | 22 |
| | | 26 | 26-SW12-F | 26-SW12-NF | 17.0 | 8.3 | 1753 | 7.4 | 23 |
| | | 27 | 27-SW12-F | 27-SW12-NF | 17.0 | 8.3 | 1634 | 7.3 | 22 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW12-F | 28-SW12-NF | 17.0 | 8.0 | 1176 | 7.8 | 36 |
| | | 29 | 29-SW12-F | 29-SW12-NF | 17.0 | 8.0 | 1172 | 7.9 | 45 |
| | | 30 | 30-SW12-F | 30-SW12-NF | 17.0 | 8.0 | 1252 | 7.8 | 30 |

Table A1.13. Surface water properties for each sample at time 408 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/26/2014 | | 12/26/2014 | 12/26/2014 | 12/26/2014 | 12/26/2014 | 12/26/2014 | 12/26/2014 | 12/26/2014 |
| Sampling time | 11AM Time 408 hrs | | 408 hrs | 408 hrs | 408 hrs | 408 hrs | 408 hrs | 408 hrs | 408 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW13-F | 1-SW13-NF | 17.3 | 8.0 | 30 | 6.9 | 0 |
| | | 3 | 3-SW13-F | 3-SW13-NF | 17.3 | 8.0 | 30 | 6.9 | 0 |
| II | sediment only | 4 | 4-SW13-F | 4-SW13-NF | 17.3 | 8.0 | 39 | 6.8 | 157 |
| | | 5 | 5-SW13-F | 5-SW13-NF | 17.3 | 8.0 | 38 | 7.0 | 120 |
| | | 6 | 6-SW13-F | 6-SW13-NF | 17.3 | 8.0 | 39 | 7.0 | 127 |
| III | sand/passive material | 7 | 7-SW13-F | 7-SW13-NF | 17.4 | 8.0 | 35 | 6.9 | 42 |
| | | 8 | 8-SW13-F | 8-SW13-NF | 17.4 | 8.0 | 34 | 7.0 | 32 |
| | | 9 | 9-SW13-F | 9-SW13-NF | 17.4 | 8.0 | 29 | 7.1 | 37 |
| IV | sand/passive material | 10 | 10-SW13-F | 10-SW13-NF | 17.4 | 8.0 | 37 | 7.1 | 32 |
| | | 11 | 11-SW13-F | 11-SW13-NF | 17.4 | 8.0 | 34 | 7.0 | 38 |
| | | 12 | 12-SW13-F | 12-SW13-NF | 17.4 | 8.0 | 35 | 7.1 | 34 |
| V | silty clay/passive material | 13 | 13-SW13-F | 13-SW13-NF | 17.5 | 8.0 | 72 | 7.4 | 65 |
| | | 14 | 14-SW13-F | 14-SW13-NF | 17.5 | 8.1 | 74 | 7.6 | 70 |
| | | 15 | 15-SW13-F | 15-SW13-NF | 17.5 | 8.1 | 76 | 7.5 | 65 |
| VI | apatite/active material | 16 | 16-SW13-F | 16-SW13-NF | 17.5 | 8.1 | 450 | 7.7 | 26 |
| | | 17 | 17-SW13-F | 17-SW13-NF | 17.5 | 8.0 | 442 | 7.8 | 28 |
| | | 18 | 18-SW13-F | 18-SW13-NF | 17.5 | 8.1 | 487 | 7.8 | 25 |
| VII | apatite/active material | 19 | 19-SW13-F | 19-SW13-NF | 17.7 | 8.2 | 613 | 8.0 | 24 |
| | | 20 | 20-SW13-F | 20-SW13-NF | 17.7 | 8.0 | 658 | 7.9 | 24 |
| | | 21 | 21-SW13-F | 21-SW13-NF | 17.7 | 8.0 | 625 | 8.0 | 25 |
| VIII | activated carbon | 22 | 22-SW13-F | 22-SW13-NF | 17.8 | 8.1 | 157 | 8.3 | 66 |
| | | 23 | 23-SW13-F | 23-SW13-NF | 17.8 | 8.0 | 133 | 8.5 | 81 |
| | | 24 | 24-SW13-F | 24-SW13-NF | 17.8 | 8.0 | 137 | 8.5 | 90 |
| IX | organoclay MRM/active | 25 | 25-SW13-F | 25-SW13-NF | 17.8 | 8.1 | 1742 | 7.5 | 24 |
| | | 26 | 26-SW13-F | 26-SW13-NF | 17.8 | 8.1 | 1852 | 7.4 | 24 |
| | | 27 | 27-SW13-F | 27-SW13-NF | 17.8 | 8.1 | 1592 | 7.5 | 28 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW13-F | 28-SW13-NF | 17.9 | 8.0 | 1190 | 8.0 | 28 |
| | | 29 | 29-SW13-F | 29-SW13-NF | 18.0 | 8.0 | 1195 | 7.8 | 28 |
| | | 30 | 30-SW13-F | 30-SW13-NF | 18.0 | 8.1 | 1265 | 8.0 | 30 |

Table A1. 14. Surface water properties for each sample at time 480 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/29/2014 | | 12/29/2014 | 12/29/2014 | 12/29/2014 | 12/29/2014 | 12/29/2014 | 12/29/2014 | 12/29/2014 |
| Sampling time | 11AM Time 480 hrs | | 480hrs | 480hrs | 480hrs | 480hrs | 480hrs | 480hrs | 480hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW14-F | 1-SW14-NF | 16.5 | 8.2 | 32 | 6.8 | 0 |
| | | 3 | 3-SW14-F | 3-SW14-NF | 16.5 | 8.0 | 34 | 6.8 | 0 |
| II | sediment only | 4 | 4-SW14-F | 4-SW14-NF | 16.5 | 8.0 | 41 | 6.8 | 122 |
| | | 5 | 5-SW14-F | 5-SW14-NF | 16.5 | 8.1 | 41 | 6.9 | 112 |
| | | 6 | 6-SW14-F | 6-SW14-NF | 16.5 | 8.0 | 44 | 7.0 | 104 |
| III | sand/passive material | 7 | 7-SW14-F | 7-SW14-NF | 16.6 | 8.1 | 38 | 7.1 | 38 |
| | | 8 | 8-SW14-F | 8-SW14-NF | 16.6 | 8.2 | 37 | 7.1 | 34 |
| | | 9 | 9-SW14-F | 9-SW14-NF | 16.6 | 8.1 | 31 | 7.1 | 42 |
| IV | sand/passive material | 10 | 10-SW14-F | 10-SW14-NF | 17.0 | 8.2 | 39 | 7.0 | 36 |
| | | 11 | 11-SW14-F | 11-SW14-NF | 17.0 | 8.1 | 38 | 6.9 | 39 |
| | | 12 | 12-SW14-F | 12-SW14-NF | 17.0 | 8.2 | 38 | 6.8 | 34 |
| V | silty clay/passive material | 13 | 13-SW14-F | 13-SW14-NF | 17.0 | 8.0 | 76 | 6.9 | 64 |
| | | 14 | 14-SW14-F | 14-SW14-NF | 17.0 | 8.0 | 76 | 6.8 | 69 |
| | | 15 | 15-SW14-F | 15-SW14-NF | 17.0 | 8.1 | 78 | 7.1 | 87 |
| VI | apatite/active material | 16 | 16-SW14-F | 16-SW14-NF | 17.0 | 8.0 | 439 | 7.6 | 72 |
| | | 17 | 17-SW14-F | 17-SW14-NF | 17.0 | 7.9 | 450 | 7.7 | 70 |
| | | 18 | 18-SW14-F | 18-SW14-NF | 17.0 | 7.9 | 490 | 7.6 | 50 |
| VII | apatite/active material | 19 | 19-SW14-F | 19-SW14-NF | 17.0 | 8.0 | 605 | 7.8 | 70 |
| | | 20 | 20-SW14-F | 20-SW14-NF | 17.1 | 8.0 | 651 | 7.6 | 60 |
| | | 21 | 21-SW14-F | 21-SW14-NF | 17.1 | 8.0 | 612 | 7.8 | 75 |
| VIII | activated carbon | 22 | 22-SW14-F | 22-SW14-NF | 17.1 | 8.0 | 155 | 7.9 | 90 |
| | | 23 | 23-SW14-F | 23-SW14-NF | 17.1 | 7.9 | 135 | 7.9 | 110 |
| | | 24 | 24-SW14-F | 24-SW14-NF | 17.1 | 8.0 | 138 | 8.0 | 109 |
| IX | organoclay MRM/active | 25 | 25-SW14-F | 25-SW14-NF | 17.1 | 8.0 | 1806 | 6.9 | 27 |
| | | 26 | 26-SW14-F | 26-SW14-NF | 17.1 | 7.9 | 1881 | 6.9 | 25 |
| | | 27 | 27-SW14-F | 27-SW14-NF | 17.1 | 7.9 | 1564 | 6.9 | 27 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW14-F | 28-SW14-NF | 17.1 | 7.9 | 1183 | 7.5 | 45 |
| | | 29 | 29-SW14-F | 29-SW14-NF | 17.1 | 7.8 | 1213 | 7.6 | 54 |
| | | 30 | 30-SW14-F | 30-SW14-NF | 17.1 | 8.0 | 1269 | 7.6 | 44 |

Table A.1.15. Surface water properties for each sample at time 504 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 12/30/2014 | | 12/30/2014 | 12/30/2014 | 12/30/2014 | 12/30/2014 | 12/30/2014 | 12/30/2014 | 12/30/2014 |
| Sampling time | 11AM Time 504hrs | | 504 hrs | 504 hrs | 504 hrs | 504 hrs | 504 hrs | 504 hrs | 504 hrs |
| **Treatment** | **Treatment description** | **No** | Filter | No Filter | | | | | |
| I | Spike solution only | 1 | 1-SW15-F | 1-SW15-NF | 16.7 | 8.0 | 36 | 6.6 | 0 |
| | | 3 | 3-SW15-F | 3-SW15-NF | 17.0 | 8.0 | 35 | 6.6 | 0 |
| II | sediment only | 4 | 4-SW15-F | 4-SW15-NF | 17.0 | 8.0 | 42 | 6.6 | 113 |
| | | 5 | 5-SW15-F | 5-SW15-NF | 17.0 | 8.0 | 42 | 6.6 | 112 |
| | | 6 | 6-SW15-F | 6-SW15-NF | 17.0 | 8.0 | 44 | 6.7 | 100 |
| III | sand/passive material | 7 | 7-SW15-F | 7-SW15-NF | 17.0 | 8.1 | 40 | 6.8 | 49 |
| | | 8 | 8-SW15-F | 8-SW15-NF | 17.0 | 8.1 | 39 | 6.8 | 56 |
| | | 9 | 9-SW15-F | 9-SW15-NF | 17.0 | 8.1 | 32 | 6.9 | 55 |
| IV | sand/passive material | 10 | 10-SW15-F | 10-SW15-NF | 17.0 | 8.1 | 41 | 6.8 | 53 |
| | | 11 | 11-SW15-F | 11-SW15-NF | 17.0 | 8.0 | 40 | 7.0 | 59 |
| | | 12 | 12-SW15-F | 12-SW15-NF | 17.0 | 8.0 | 40 | 6.9 | 49 |
| V | silty clay/passive material | 13 | 13-SW15-F | 13-SW15-NF | 17.1 | 8.0 | 76 | 6.8 | 70 |
| | | 14 | 14-SW15-F | 14-SW15-NF | 17.1 | 7.9 | 77 | 7.0 | 65 |
| | | 15 | 15-SW15-F | 15-SW15-NF | 17.1 | 7.9 | 80 | 7.1 | 87 |
| VI | apatite/active material | 16 | 16-SW15-F | 16-SW15-NF | 17.1 | 8.0 | 449 | 7.5 | 84 |
| | | 17 | 17-SW15-F | 17-SW15-NF | 17.1 | 8.0 | 448 | 7.6 | 89 |
| | | 18 | 18-SW15-F | 18-SW15-NF | 17.1 | 8.1 | 481 | 7.6 | 70 |
| VII | apatite/active material | 19 | 19-SW15-F | 19-SW15-NF | 17.2 | 8.0 | 600 | 7.9 | 56 |
| | | 20 | 20-SW15-F | 20-SW15-NF | 17.2 | 8.0 | 640 | 7.9 | 65 |
| | | 21 | 21-SW15-F | 21-SW15-NF | 17.2 | 8.1 | 606 | 8.0 | 76 |
| VIII | activated carbon | 22 | 22-SW15-F | 22-SW15-NF | 17.4 | 8.2 | 153 | 8.2 | 97 |
| | | 23 | 23-SW15-F | 23-SW15-NF | 17.4 | 8.1 | 135 | 8.1 | 111 |
| | | 24 | 24-SW15-F | 24-SW15-NF | 17.4 | 8.1 | 139 | 8.2 | 120 |
| IX | organoclay MRM/active | 25 | 25-SW15-F | 25-SW15-NF | 17.3 | 8.0 | 1784 | 7.2 | 22 |
| | | 26 | 26-SW15-F | 26-SW15-NF | 17.3 | 8.0 | 1864 | 7.2 | 24 |
| | | 27 | 27-SW15-F | 27-SW15-NF | 17.3 | 8.0 | 1611 | 7.3 | 26 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW15-F | 28-SW15-NF | 17.3 | 8.0 | 1195 | 8.0 | 46 |
| | | 29 | 29-SW15-F | 29-SW15-NF | 17.3 | 8.0 | 1222 | 8.1 | 56 |
| | | 30 | 30-SW15-F | 30-SW15-NF | 17.3 | 8.0 | 1276 | 8.0 | 46 |

Table A1.16. Surface water properties for each sample at time 576 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/2/2015 | | 1/2/2015 | 1/2/2015 | 1/2/2015 | 1/2/2015 | 1/2/2015 | 1/2/2015 | 1/2/2015 |
| Sampling time | 11AM Time 576 hrs | | 576 hrs | 576 hrs | 576 hrs | 576 hrs | 576 hrs | 576 hrs | 576 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW16-F | 1-SW16-NF | 17.1 | 8.0 | 39 | 7.0 | 0 |
| | | 3 | 3-SW16-F | 3-SW16-NF | 17.0 | 8.0 | 40 | 6.9 | 0 |
| II | sediment only | 4 | 4-SW16-F | 4-SW16-NF | 17.1 | 8.0 | 45 | 6.8 | 113 |
| | | 5 | 5-SW16-F | 5-SW16-NF | 17.2 | 8.0 | 45 | 6.9 | 112 |
| | | 6 | 6-SW16-F | 6-SW16-NF | 17.2 | 8.0 | 48 | 6.8 | 100 |
| III | sand/passive material | 7 | 7-SW16-F | 7-SW16-NF | 17.3 | 8.1 | 43 | 6.9 | 49 |
| | | 8 | 8-SW16-F | 8-SW16-NF | 17.3 | 8.1 | 42 | 7.0 | 56 |
| | | 9 | 9-SW16-F | 9-SW16-NF | 17.3 | 8.1 | 32 | 6.9 | 55 |
| IV | sand/passive material | 10 | 10-SW16-F | 10-SW16-NF | 17.3 | 8.1 | 44 | 7.0 | 53 |
| | | 11 | 11-SW16-F | 11-SW16-NF | 17.4 | 8.0 | 42 | 7.0 | 59 |
| | | 12 | 12-SW16-F | 12-SW16-NF | 17.4 | 8.0 | 43 | 7.0 | 49 |
| V | silty clay/passive material | 13 | 13-SW16-F | 13-SW16-NF | 17.3 | 8.0 | 78 | 7.0 | 70 |
| | | 14 | 14-SW16-F | 14-SW16-NF | 17.4 | 7.9 | 78 | 7.1 | 65 |
| | | 15 | 15-SW16-F | 15-SW16-NF | 17.4 | 7.9 | 80 | 7.2 | 87 |
| VI | apatite/active material | 16 | 16-SW16-F | 16-SW16-NF | 17.6 | 8.0 | 437 | 7.8 | 84 |
| | | 17 | 17-SW16-F | 17-SW16-NF | 17.6 | 8.0 | 446 | 8.0 | 89 |
| | | 18 | 18-SW16-F | 18-SW16-NF | 17.7 | 8.1 | 478 | 8.1 | 70 |
| VII | apatite/active material | 19 | 19-SW16-F | 19-SW16-NF | 17.7 | 8.0 | 600 | 8.3 | 56 |
| | | 20 | 20-SW16-F | 20-SW16-NF | 17.7 | 8.0 | 624 | 8.2 | 65 |
| | | 21 | 21-SW16-F | 21-SW16-NF | 17.7 | 8.1 | 594 | 8.3 | 76 |
| VIII | activated carbon | 22 | 22-SW16-F | 22-SW16-NF | 17.8 | 8.2 | 169 | 8.6 | 97 |
| | | 23 | 23-SW16-F | 23-SW16-NF | 17.8 | 8.1 | 135 | 8.6 | 111 |
| | | 24 | 24-SW16-F | 24-SW16-NF | 17.8 | 8.1 | 139 | 8.4 | 120 |
| IX | organoclay MRM/active | 25 | 25-SW16-F | 25-SW16-NF | 17.9 | 8.0 | 1726 | 6.8 | 22 |
| | | 26 | 26-SW16-F | 26-SW16-NF | 17.9 | 8.0 | 1864 | 6.8 | 24 |
| | | 27 | 27-SW16-F | 27-SW16-NF | 17.9 | 8.0 | 1590 | 6.7 | 26 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW16-F | 28-SW16-NF | 17.9 | 8.0 | 1211 | 7.9 | 46 |
| | | 29 | 29-SW16-F | 29-SW16-NF | 17.9 | 8.0 | 1238 | 7.9 | 56 |
| | | 30 | 30-SW16-F | 30-SW16-NF | 17.9 | 8.0 | 1280 | 8.0 | 46 |

Table A1.17. Surface water properties for each sample at time 648 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/5/2015 | | 1/5/2015 | 1/5/2015 | 1/5/2015 | 1/5/2015 | 1/5/2015 | 1/5/2015 | 1/5/2015 |
| Sampling time | 11AM Time 648 hrs | | 648 hrs | 648 hrs | 648 hrs | 648 hrs | 648 hrs | 648 hrs | 648 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW17-F | 1-SW17-NF | 16.6 | 7.6 | 43 | 6.5 | 0 |
| | | 3 | 3-SW17-F | 3-SW17-NF | 16.9 | 7.8 | 43 | 6.5 | 0 |
| II | sediment only | 4 | 4-SW17-F | 4-SW17-NF | 16.9 | 7.8 | 49 | 6.7 | 99 |
| | | 5 | 5-SW17-F | 5-SW17-NF | 16.9 | 7.8 | 50 | 6.6 | 89 |
| | | 6 | 6-SW17-F | 6-SW17-NF | 17.1 | 7.9 | 53 | 6.5 | 99 |
| III | sand/passive material | 7 | 7-SW17-F | 7-SW17-NF | 17.0 | 7.8 | 48 | 6.9 | 50 |
| | | 8 | 8-SW17-F | 8-SW17-NF | 17.0 | 7.7 | 45 | 6.9 | 42 |
| | | 9 | 9-SW17-F | 9-SW17-NF | 17.2 | 7.8 | 33 | 7.0 | 54 |
| IV | sand/passive material | 10 | 10-SW17-F | 10-SW17-NF | 17.2 | 7.7 | 48 | 7.1 | 44 |
| | | 11 | 11-SW17-F | 11-SW17-NF | 17.2 | 7.7 | 46 | 7.1 | 56 |
| | | 12 | 12-SW17-F | 12-SW17-NF | 17.2 | 7.7 | 47 | 7.0 | 54 |
| V | silty clay/passive material | 13 | 13-SW17-F | 13-SW17-NF | 17.2 | 7.8 | 82 | 7.1 | 77 |
| | | 14 | 14-SW17-F | 14-SW17-NF | 17.3 | 7.8 | 79 | 7.2 | 76 |
| | | 15 | 15-SW17-F | 15-SW17-NF | 17.3 | 8.0 | 83 | 7.3 | 99 |
| VI | apatite/active material | 16 | 16-SW17-F | 16-SW17-NF | 17.4 | 7.9 | 436 | 7.8 | 89 |
| | | 17 | 17-SW17-F | 17-SW17-NF | 17.4 | 7.9 | 433 | 7.7 | 99 |
| | | 18 | 18-SW17-F | 18-SW17-NF | 17.4 | 7.9 | 477 | 7.9 | 89 |
| VII | apatite/active material | 19 | 19-SW17-F | 19-SW17-NF | 17.5 | 7.8 | 596 | 8.0 | 110 |
| | | 20 | 20-SW17-F | 20-SW17-NF | 17.5 | 7.8 | 632 | 7.9 | 100 |
| | | 21 | 21-SW17-F | 21-SW17-NF | 17.5 | 7.8 | 592 | 8.1 | 120 |
| VIII | activated carbon | 22 | 22-SW17-F | 22-SW17-NF | 17.5 | 7.8 | 155 | 8.4 | 120 |
| | | 23 | 23-SW17-F | 23-SW17-NF | 17.5 | 7.6 | 136 | 8.4 | 99 |
| | | 24 | 24-SW17-F | 24-SW17-NF | 17.5 | 7.8 | 139 | 8.5 | 114 |
| IX | organoclay MRM/active | 25 | 25-SW17-F | 25-SW17-NF | 17.5 | 7.8 | 1731 | 5.5 | 20 |
| | | 26 | 26-SW17-F | 26-SW17-NF | 17.5 | 7.8 | 1871 | 5.3 | 19 |
| | | 27 | 27-SW17-F | 27-SW17-NF | 17.5 | 7.9 | 1622 | 5.7 | 19 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW17-F | 28-SW17-NF | 17.5 | 8.0 | 1198 | 7.9 | 45 |
| | | 29 | 29-SW17-F | 29-SW17-NF | 17.5 | 7.8 | 1191 | 7.9 | 33 |
| | | 30 | 30-SW17-F | 30-SW17-NF | 17.5 | 8.0 | 1252 | 7.9 | 45 |

Table A1.18. Surface water properties for each sample at time 672 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/6/2015 | | 1/6/2015 | 1/6/2015 | 1/6/2015 | 1/6/2015 | 1/6/2015 | 1/6/2015 | 1/6/2015 |
| Sampling time | 11AM Time672hrs | | 672 hrs | 672 hrs | 672 hrs | 672 hrs | 672 hrs | 672 hrs | 672 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW18-F | 1-SW18-NF | 16.4 | 7.6 | 41 | 6.7 | 0 |
| | | 3 | 3-SW18-F | 3-SW18-NF | 16.4 | 7.8 | 44 | 6.6 | 0 |
| II | sediment only | 4 | 4-SW18-F | 4-SW18-NF | 16.5 | 7.8 | 49 | 6.7 | 113 |
| | | 5 | 5-SW18-F | 5-SW18-NF | 16.5 | 7.8 | 50 | 6.6 | 112 |
| | | 6 | 6-SW18-F | 6-SW18-NF | 16.5 | 7.8 | 53 | 6.6 | 100 |
| III | sand/passive material | 7 | 7-SW18-F | 7-SW18-NF | 16.5 | 7.8 | 48 | 6.9 | 49 |
| | | 8 | 8-SW18-F | 8-SW18-NF | 16.5 | 7.8 | 45 | 6.9 | 56 |
| | | 9 | 9-SW18-F | 9-SW18-NF | 16.5 | 7.9 | 45 | 7.1 | 55 |
| IV | sand/passive material | 10 | 10-SW18-F | 10-SW18-NF | 16.6 | 7.8 | 48 | 7.1 | 53 |
| | | 11 | 11-SW18-F | 11-SW18-NF | 16.6 | 7.8 | 46 | 7.0 | 59 |
| | | 12 | 12-SW18-F | 12-SW18-NF | 16.6 | 7.7 | 47 | 7.1 | 49 |
| V | silty clay/passive material | 13 | 13-SW18-F | 13-SW18-NF | 16.7 | 7.8 | 82 | 7.2 | 70 |
| | | 14 | 14-SW18-F | 14-SW18-NF | 16.7 | 7.8 | 79 | 7.3 | 65 |
| | | 15 | 15-SW18-F | 15-SW18-NF | 16.7 | 7.8 | 83 | 7.2 | 87 |
| VI | apatite/active material | 16 | 16-SW18-F | 16-SW18-NF | 16.7 | 7.8 | 436 | 7.8 | 84 |
| | | 17 | 17-SW18-F | 17-SW18-NF | 16.7 | 7.8 | 442 | 7.7 | 89 |
| | | 18 | 18-SW18-F | 18-SW18-NF | 16.7 | 7.8 | 481 | 7.9 | 70 |
| VII | apatite/active material | 19 | 19-SW18-F | 19-SW18-NF | 16.6 | 7.8 | 598 | 8.0 | 56 |
| | | 20 | 20-SW18-F | 20-SW18-NF | 16.6 | 7.7 | 633 | 7.9 | 65 |
| | | 21 | 21-SW18-F | 21-SW18-NF | 16.6 | 7.8 | 592 | 8.1 | 76 |
| VIII | activated carbon | 22 | 22-SW18-F | 22-SW18-NF | 16.7 | 7.7 | 155 | 8.2 | 97 |
| | | 23 | 23-SW18-F | 23-SW18-NF | 16.5 | 7.8 | 136 | 8.4 | 111 |
| | | 24 | 24-SW18-F | 24-SW18-NF | 16.6 | 8.0 | 139 | 8.5 | 120 |
| IX | organoclay MRM/active | 25 | 25-SW18-F | 25-SW18-NF | 16.6 | 7.9 | 1731 | 5.5 | 22 |
| | | 26 | 26-SW18-F | 26-SW18-NF | 16.6 | 7.8 | 1871 | 5.6 | 24 |
| | | 27 | 27-SW18-F | 27-SW18-NF | 16.6 | 7.8 | 1622 | 5.7 | 26 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW18-F | 28-SW18-NF | 16.8 | 7.8 | 1198 | 7.9 | 46 |
| | | 29 | 29-SW18-F | 29-SW18-NF | 16.8 | 7.8 | 1191 | 7.7 | 56 |
| | | 30 | 30-SW18-F | 30-SW18-NF | 16.8 | 7.9 | 1252 | 7.9 | 46 |

Table A1.19. Surface water properties for each sample at time 816 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/12/2015 | | 1/12/2015 | 1/12/2015 | 1/12/2015 | 1/12/2015 | 1/12/2015 | 1/12/2015 | 1/12/2015 |
| Sampling time | 11AM Time816hrs | | 816 hrs | 816 hrs | 816 hrs | 816 hrs | 816 hrs | 816 hrs | 816 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW19-F | 1-SW19-NF | 16.4 | 7.6 | 48 | 7.0 | 1 |
| | | 3 | 3-SW19-F | 3-SW19-NF | 16.4 | 7.8 | 48 | 6.9 | 0 |
| II | sediment only | 4 | 4-SW19-F | 4-SW19-NF | 16.5 | 7.8 | 52 | 6.9 | 197 |
| | | 5 | 5-SW19-F | 5-SW19-NF | 16.5 | 7.8 | 52 | 6.9 | 192 |
| | | 6 | 6-SW19-F | 6-SW19-NF | 16.5 | 7.8 | 56 | 6.9 | 200 |
| III | sand/passive material | 7 | 7-SW19-F | 7-SW19-NF | 16.5 | 7.8 | 52 | 7.0 | 74 |
| | | 8 | 8-SW19-F | 8-SW19-NF | 16.5 | 7.8 | 52 | 6.7 | 67 |
| | | 9 | 9-SW19-F | 9-SW19-NF | 16.5 | 7.9 | 50 | 6.9 | 65 |
| IV | sand/passive material | 10 | 10-SW19-F | 10-SW19-NF | 16.6 | 7.8 | 53 | 6.9 | 49 |
| | | 11 | 11-SW19-F | 11-SW19-NF | 16.6 | 7.8 | 52 | 6.9 | 65 |
| | | 12 | 12-SW19-F | 12-SW19-NF | 16.6 | 7.7 | 52 | 6.8 | 56 |
| V | silty clay/passive material | 13 | 13-SW19-F | 13-SW19-NF | 16.7 | 7.8 | 81 | 6.9 | 188 |
| | | 14 | 14-SW19-F | 14-SW19-NF | 16.7 | 7.8 | 81 | 7.0 | 183 |
| | | 15 | 15-SW19-F | 15-SW19-NF | 16.7 | 7.8 | 86 | 6.9 | 210 |
| VI | apatite/active material | 16 | 16-SW19-F | 16-SW19-NF | 16.7 | 7.8 | 447 | 7.6 | 193 |
| | | 17 | 17-SW19-F | 17-SW19-NF | 16.7 | 7.8 | 460 | 7.8 | 140 |
| | | 18 | 18-SW19-F | 18-SW19-NF | 16.7 | 7.8 | 481 | 7.8 | 172 |
| VII | apatite/active material | 19 | 19-SW19-F | 19-SW19-NF | 16.6 | 7.8 | 611 | 8.1 | 143 |
| | | 20 | 20-SW19-F | 20-SW19-NF | 16.6 | 7.7 | 635 | 8.0 | 134 |
| | | 21 | 21-SW19-F | 21-SW19-NF | 16.6 | 7.8 | 593 | 8.1 | 142 |
| VIII | activated carbon | 22 | 22-SW19-F | 22-SW19-NF | 16.7 | 7.7 | 163 | 8.5 | 182 |
| | | 23 | 23-SW19-F | 23-SW19-NF | 16.5 | 7.8 | 140 | 8.2 | 201 |
| | | 24 | 24-SW19-F | 24-SW19-NF | 16.6 | 8.0 | 144 | 8.4 | 204 |
| IX | organoclay MRM/active | 25 | 25-SW19-F | 25-SW19-NF | 16.6 | 7.9 | 1745 | 4.6 | 45 |
| | | 26 | 26-SW19-F | 26-SW19-NF | 16.6 | 7.8 | 1906 | 4.8 | 48 |
| | | 27 | 27-SW19-F | 27-SW19-NF | 16.6 | 7.8 | 1655 | 5.0 | 56 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW19-F | 28-SW19-NF | 16.8 | 7.8 | 1313 | 7.3 | 106 |
| | | 29 | 29-SW19-F | 29-SW19-NF | 16.8 | 7.8 | 1274 | 7.2 | 104 |
| | | 30 | 30-SW19-F | 30-SW19-NF | 16.8 | 7.9 | 1254 | 7.4 | 120 |

Table A1.20. Surface water properties for each sample at time 840 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/13/2015 | | 1/13/2015 | 1/13/2015 | 1/13/2015 | 1/13/2015 | 1/13/2015 | 1/13/2015 | 1/13/2015 |
| Sampling time | 11AM Time840hrs | | 840 hrs | 840 hrs | 840 hrs | 840 hrs | 840 hrs | 840 hrs | 840 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW20-F | 1-SW20-NF | 16.4 | 7.6 | 48 | 6.9 | 0 |
| | | 3 | 3-SW20-F | 3-SW20-NF | 16.4 | 7.8 | 49 | 6.9 | 0 |
| II | sediment only | 4 | 4-SW20-F | 4-SW20-NF | 16.5 | 7.8 | 53 | 6.9 | 230 |
| | | 5 | 5-SW20-F | 5-SW20-NF | 16.5 | 7.8 | 55 | 7.0 | 250 |
| | | 6 | 6-SW20-F | 6-SW20-NF | 16.5 | 7.8 | 59 | 6.9 | 245 |
| III | sand/passive material | 7 | 7-SW20-F | 7-SW20-NF | 16.5 | 7.8 | 52 | 7.0 | 74 |
| | | 8 | 8-SW20-F | 8-SW20-NF | 16.5 | 7.8 | 50 | 7.0 | 67 |
| | | 9 | 9-SW20-F | 9-SW20-NF | 16.5 | 7.9 | 50 | 7.1 | 65 |
| IV | sand/passive material | 10 | 10-SW20-F | 10-SW20-NF | 16.6 | 7.8 | 55 | 7.1 | 77 |
| | | 11 | 11-SW20-F | 11-SW20-NF | 16.6 | 7.8 | 55 | 7.2 | 65 |
| | | 12 | 12-SW20-F | 12-SW20-NF | 16.6 | 7.7 | 52 | 7.2 | 78 |
| V | silty clay/passive material | 13 | 13-SW20-F | 13-SW20-NF | 16.7 | 7.8 | 82 | 7.2 | 169 |
| | | 14 | 14-SW20-F | 14-SW20-NF | 16.7 | 7.8 | 81 | 7.3 | 168 |
| | | 15 | 15-SW20-F | 15-SW20-NF | 16.7 | 7.8 | 89 | 7.2 | 156 |
| VI | apatite/active material | 16 | 16-SW20-F | 16-SW20-NF | 16.7 | 7.8 | 447 | 7.9 | 157 |
| | | 17 | 17-SW20-F | 17-SW20-NF | 16.7 | 7.8 | 453 | 8.0 | 156 |
| | | 18 | 18-SW20-F | 18-SW20-NF | 16.7 | 7.8 | 467 | 8.1 | 180 |
| VII | apatite/active material | 19 | 19-SW20-F | 19-SW20-NF | 16.6 | 7.8 | 598 | 8.0 | 179 |
| | | 20 | 20-SW20-F | 20-SW20-NF | 16.6 | 7.7 | 630 | 8.1 | 199 |
| | | 21 | 21-SW20-F | 21-SW20-NF | 16.6 | 7.8 | 594 | 8.0 | 210 |
| VIII | activated carbon | 22 | 22-SW20-F | 22-SW20-NF | 16.7 | 7.7 | 137 | 8.2 | 179 |
| | | 23 | 23-SW20-F | 23-SW20-NF | 16.5 | 7.8 | 135 | 8.6 | 199 |
| | | 24 | 24-SW20-F | 24-SW20-NF | 16.6 | 8.0 | 137 | 8.3 | 210 |
| IX | organoclay MRM/active | 25 | 25-SW20-F | 25-SW20-NF | 16.6 | 7.9 | 1789 | 4.9 | 57 |
| | | 26 | 26-SW20-F | 26-SW20-NF | 16.6 | 7.8 | 1921 | 4.6 | 56 |
| | | 27 | 27-SW20-F | 27-SW20-NF | 16.6 | 7.8 | 1654 | 5.1 | 58 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW20-F | 28-SW20-NF | 16.8 | 7.8 | 1249 | 7.9 | 120 |
| | | 29 | 29-SW20-F | 29-SW20-NF | 16.8 | 7.8 | 1269 | 8.1 | 121 |
| | | 30 | 30-SW20-F | 30-SW20-NF | 16.8 | 7.9 | 1274 | 8.1 | 143 |

Table A1.21. Surface water properties for each sample at time 1008 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/m | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/20/2015 | | 1/20/2015 | 1/20/2015 | 1/20/2015 | 1/20/2015 | 1/20/2015 | 1/20/2015 | 1/20/2015 |
| Sampling time | 11AM Time1008hrs | | 1008 hrs | 1008 hrs | 1008 hrs | 1008 hrs | 1008 hrs | 1008 hrs | 1008 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW21-F | 1-SW21-NF | 17.6 | 7.6 | 57 | 6.8 | 1 |
| | | 3 | 3-SW21-F | 3-SW21-NF | 17.6 | 7.8 | 55 | 6.8 | 0 |
| II | sediment only | 4 | 4-SW21-F | 4-SW21-NF | 17.6 | 7.8 | 59 | 6.7 | 245 |
| | | 5 | 5-SW21-F | 5-SW21-NF | 17.6 | 7.8 | 59 | 6.7 | 258 |
| | | 6 | 6-SW21-F | 6-SW21-NF | 17.6 | 7.8 | 62 | 6.7 | 289 |
| III | sand/passive material | 7 | 7-SW21-F | 7-SW21-NF | 17.6 | 7.8 | 60 | 6.8 | 54 |
| | | 8 | 8-SW21-F | 8-SW21-NF | 17.5 | 7.8 | 57 | 6.8 | 49 |
| | | 9 | 9-SW21-F | 9-SW21-NF | 17.4 | 7.9 | 53 | 6.9 | 54 |
| IV | sand/passive material | 10 | 10-SW21-F | 10-SW21-NF | 17.5 | 7.8 | 60 | 6.8 | 65 |
| | | 11 | 11-SW21-F | 11-SW21-NF | 17.4 | 7.8 | 58 | 7.0 | 68 |
| | | 12 | 12-SW21-F | 12-SW21-NF | 17.5 | 7.7 | 56 | 7.0 | 57 |
| V | silty clay/passive material | 13 | 13-SW21-F | 13-SW21-NF | 17.5 | 7.8 | 84 | 7.1 | 180 |
| | | 14 | 14-SW21-F | 14-SW21-NF | 17.4 | 7.8 | 82 | 7.1 | 190 |
| | | 15 | 15-SW21-F | 15-SW21-NF | 17.5 | 7.8 | 86 | 7.1 | 167 |
| VI | apatite/active material | 16 | 16-SW21-F | 16-SW21-NF | 17.5 | 7.8 | 419 | 8.0 | 145 |
| | | 17 | 17-SW21-F | 17-SW21-NF | 17.5 | 7.8 | 444 | 8.2 | 176 |
| | | 18 | 18-SW21-F | 18-SW21-NF | 17.5 | 7.8 | 463 | 8.2 | 142 |
| VII | apatite/active material | 19 | 19-SW21-F | 19-SW21-NF | 17.5 | 7.8 | 564 | 8.1 | 155 |
| | | 20 | 20-SW21-F | 20-SW21-NF | 17.5 | 7.7 | 610 | 8.1 | 133 |
| | | 21 | 21-SW21-F | 21-SW21-NF | 17.5 | 7.8 | 569 | 8.2 | 156 |
| VIII | activated carbon | 22 | 22-SW21-F | 22-SW21-NF | 17.5 | 7.7 | 161 | 8.3 | 260 |
| | | 23 | 23-SW21-F | 23-SW21-NF | 17.5 | 7.8 | 140 | 8.3 | 250 |
| | | 24 | 24-SW21-F | 24-SW21-NF | 17.5 | 8.0 | 142 | 8.3 | 229 |
| IX | organoclay MRM/active | 25 | 25-SW21-F | 25-SW21-NF | 17.6 | 7.9 | 1717 | 4.8 | 89 |
| | | 26 | 26-SW21-F | 26-SW21-NF | 17.6 | 7.8 | 1816 | 4.7 | 98 |
| | | 27 | 27-SW21-F | 27-SW21-NF | 17.6 | 7.8 | 1629 | 4.6 | 89 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW21-F | 28-SW21-NF | 17.7 | 7.8 | 1333 | 7.9 | 167 |
| | | 29 | 29-SW21-F | 29-SW21-NF | 17.7 | 7.8 | 1280 | 7.9 | 156 |
| | | 30 | 30-SW21-F | 30-SW21-NF | 17.7 | 7.8 | 1253 | 8.0 | 189 |

Table A1.22. Surface water properties for each sample at time 1176 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 1/27/2015 | | 1/27/2015 | 1/27/2015 | 1/27/2015 | 1/27/2015 | 1/27/2015 | 1/27/2015 | 1/27/2015 |
| Sampling time | 11AM Time1176 hrs | | 1176 hrs | 1176 hrs | 1176 hrs | 1176 hrs | 1176 hrs | 1176 hrs | 1176 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW22-F | 1-SW22-NF | 16.4 | 7.6 | 64 | 7.0 | 1 |
| | | 3 | 3-SW22-F | 3-SW22-NF | 16.4 | 7.7 | 61 | 7.0 | 0 |
| II | sediment only | 4 | 4-SW22-F | 4-SW22-NF | 16.4 | 7.6 | 65 | 7.0 | 334 |
| | | 5 | 5-SW22-F | 5-SW22-NF | 16.4 | 7.7 | 65 | 7.0 | 360 |
| | | 6 | 6-SW22-F | 6-SW22-NF | 16.4 | 7.7 | 67 | 7.0 | 367 |
| III | sand/passive material | 7 | 7-SW22-F | 7-SW22-NF | 16.4 | 7.8 | 65 | 7.1 | 55 |
| | | 8 | 8-SW22-F | 8-SW22-NF | 16.4 | 7.8 | 62 | 6.9 | 38 |
| | | 9 | 9-SW22-F | 9-SW22-NF | 16.4 | 7.7 | 61 | 6.9 | 40 |
| IV | sand/passive material | 10 | 10-SW22-F | 10-SW22-NF | 16.5 | 7.8 | 65 | 7.1 | 63 |
| | | 11 | 11-SW22-F | 11-SW22-NF | 16.5 | 7.7 | 66 | 7.1 | 56 |
| | | 12 | 12-SW22-F | 12-SW22-NF | 16.5 | 7.7 | 63 | 7.1 | 45 |
| V | silty clay/passive material | 13 | 13-SW22-F | 13-SW22-NF | 16.5 | 7.7 | 86 | 7.3 | 231 |
| | | 14 | 14-SW22-F | 14-SW22-NF | 16.5 | 7.7 | 86 | 7.3 | 189 |
| | | 15 | 15-SW22-F | 15-SW22-NF | 16.5 | 7.8 | 87 | 7.3 | 170 |
| VI | apatite/active material | 16 | 16-SW22-F | 16-SW22-NF | 16.5 | 7.9 | 416 | 7.9 | 172 |
| | | 17 | 17-SW22-F | 17-SW22-NF | 16.5 | 7.8 | 430 | 8.0 | 167 |
| | | 18 | 18-SW22-F | 18-SW22-NF | 16.5 | 7.7 | 448 | 8.0 | 98 |
| VII | apatite/active material | 19 | 19-SW22-F | 19-SW22-NF | 16.5 | 7.8 | 559 | 8.3 | 170 |
| | | 20 | 20-SW22-F | 20-SW22-NF | 16.5 | 7.8 | 584 | 8.4 | 188 |
| | | 21 | 21-SW22-F | 21-SW22-NF | 16.5 | 7.8 | 537 | 8.4 | 210 |
| VIII | activated carbon | 22 | 22-SW22-F | 22-SW22-NF | 16.5 | 7.8 | 157 | 8.6 | 297 |
| | | 23 | 23-SW22-F | 23-SW22-NF | 16.5 | 7.8 | 138 | 8.6 | 272 |
| | | 24 | 24-SW22-F | 24-SW22-NF | 16.5 | 7.8 | 140 | 8.5 | 266 |
| IX | organoclay MRM/active | 25 | 25-SW22-F | 25-SW22-NF | 16.5 | 7.5 | 1575 | 4.5 | 133 |
| | | 26 | 26-SW22-F | 26-SW22-NF | 16.5 | 7.6 | 1835 | 5.0 | 134 |
| | | 27 | 27-SW22-F | 27-SW22-NF | 16.5 | 7.7 | 1573 | 4.7 | 125 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW22-F | 28-SW22-NF | 16.5 | 7.9 | 1298 | 7.8 | 205 |
| | | 29 | 29-SW22-F | 29-SW22-NF | 16.5 | 7.9 | 1284 | 8.0 | 185 |
| | | 30 | 30-SW22-F | 30-SW22-NF | 16.5 | 7.8 | 1226 | 8.0 | 217 |

Table A1.23. Surface water properties for each sample at time 1348 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 2/3/2015 | | 2/3/2015 | 2/3/2015 | 2/3/2015 | 2/3/2015 | 2/3/2015 | 2/3/2015 | 2/3/2015 |
| Sampling time | 11AM Time1344 hrs | | 1344 hrs | 1344 hrs | 1344 hrs | 1344 hrs | 1344 hrs | 1344 hrs | 1344 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW23-F | 1-SW23-NF | 16.5 | 7.6 | 64 | 6.6 | 1 |
| | | 3 | 3-SW23-F | 3-SW23-NF | 16.5 | 7.7 | 66 | 6.6 | 0 |
| II | sediment only | 4 | 4-SW23-F | 4-SW23-NF | 16.5 | 7.6 | 68 | 6.7 | 387 |
| | | 5 | 5-SW23-F | 5-SW23-NF | 16.5 | 7.7 | 68 | 6.7 | 360 |
| | | 6 | 6-SW23-F | 6-SW23-NF | 16.5 | 7.7 | 69 | 6.8 | 372 |
| III | sand/passive material | 7 | 7-SW23-F | 7-SW23-NF | 16.5 | 7.8 | 67 | 7.0 | 55 |
| | | 8 | 8-SW23-F | 8-SW23-NF | 16.5 | 7.8 | 66 | 7.0 | 48 |
| | | 9 | 9-SW23-F | 9-SW23-NF | 16.5 | 7.7 | 54 | 7.0 | 45 |
| IV | sand/passive material | 10 | 10-SW23-F | 10-SW23-NF | 16.5 | 7.8 | 69 | 7.1 | 51 |
| | | 11 | 11-SW23-F | 11-SW23-NF | 16.5 | 7.7 | 69 | 6.9 | 56 |
| | | 12 | 12-SW23-F | 12-SW23-NF | 16.5 | 7.7 | 65 | 7.1 | 58 |
| V | silty clay/passive material | 13 | 13-SW23-F | 13-SW23-NF | 16.5 | 7.7 | 88 | 7.3 | 194 |
| | | 14 | 14-SW23-F | 14-SW23-NF | 16.5 | 7.7 | 88 | 7.4 | 189 |
| | | 15 | 15-SW23-F | 15-SW23-NF | 16.5 | 7.8 | 92 | 7.3 | 192 |
| VI | apatite/active material | 16 | 16-SW23-F | 16-SW23-NF | 16.5 | 7.9 | 407 | 8.1 | 110 |
| | | 17 | 17-SW23-F | 17-SW23-NF | 16.5 | 7.8 | 420 | 8.2 | 100 |
| | | 18 | 18-SW23-F | 18-SW23-NF | 16.5 | 7.7 | 424 | 8.2 | 92 |
| VII | apatite/active material | 19 | 19-SW23-F | 19-SW23-NF | 16.5 | 7.8 | 550 | 8.5 | 158 |
| | | 20 | 20-SW23-F | 20-SW23-NF | 16.5 | 7.8 | 569 | 8.4 | 145 |
| | | 21 | 21-SW23-F | 21-SW23-NF | 16.5 | 7.8 | 517 | 8.4 | 158 |
| VIII | activated carbon | 22 | 22-SW23-F | 22-SW23-NF | 16.5 | 7.8 | 143 | 8.5 | 226 |
| | | 23 | 23-SW23-F | 23-SW23-NF | 16.6 | 7.8 | 138 | 8.5 | 223 |
| | | 24 | 24-SW23-F | 24-SW23-NF | 16.6 | 7.8 | 138 | 8.4 | 236 |
| IX | organoclay MRM/active | 25 | 25-SW23-F | 25-SW23-NF | 16.7 | 7.5 | 1526 | 4.3 | 223 |
| | | 26 | 26-SW23-F | 26-SW23-NF | 16.7 | 7.6 | 1722 | 4.4 | 213 |
| | | 27 | 27-SW23-F | 27-SW23-NF | 16.7 | 7.7 | 1562 | 4.6 | 199 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW23-F | 28-SW23-NF | 16.8 | 7.9 | 1198 | 8.0 | 189 |
| | | 29 | 29-SW23-F | 29-SW23-NF | 16.8 | 7.9 | 1219 | 8.0 | 199 |
| | | 30 | 30-SW23-F | 30-SW23-NF | 16.8 | 7.8 | 1235 | 8.0 | 193 |

Table A1.24. Surface water properties for each sample at time 1512 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 2/10/2015 | | 2/10/2015 | 2/10/2015 | 2/10/2015 | 2/10/2015 | 2/10/2015 | 2/10/2015 | 2/10/2015 |
| Sampling time | 11AM Time1512 hrs | | 1512hrs | 1512hrs | 1512hrs | 1512hrs | 1512hrs | 1512hrs | 1512hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW24-F | 1-SW24-NF | 16.5 | 7.6 | 88 | 6.9 | 1 |
| | | 3 | 3-SW24-F | 3-SW24-NF | 16.5 | 7.7 | 88 | 6.9 | 0 |
| II | sediment only | 4 | 4-SW24-F | 4-SW24-NF | 16.5 | 7.6 | 90 | 6.9 | 113 |
| | | 5 | 5-SW24-F | 5-SW24-NF | 16.5 | 7.7 | 94 | 6.8 | 112 |
| | | 6 | 6-SW24-F | 6-SW24-NF | 16.5 | 7.7 | 94 | 6.9 | 100 |
| III | sand/passive material | 7 | 7-SW24-F | 7-SW24-NF | 16.5 | 7.8 | 93 | 6.9 | 49 |
| | | 8 | 8-SW24-F | 8-SW24-NF | 16.5 | 7.8 | 90 | 7.1 | 56 |
| | | 9 | 9-SW24-F | 9-SW24-NF | 16.5 | 7.7 | 80 | 7.0 | 55 |
| IV | sand/passive material | 10 | 10-SW24-F | 10-SW24-NF | 16.5 | 7.8 | 95 | 6.7 | 53 |
| | | 11 | 11-SW24-F | 11-SW24-NF | 16.5 | 7.7 | 95 | 6.9 | 59 |
| | | 12 | 12-SW24-F | 12-SW24-NF | 16.5 | 7.7 | 92 | 7.0 | 49 |
| V | silty clay/passive material | 13 | 13-SW24-F | 13-SW24-NF | 16.5 | 7.7 | 117 | 7.4 | 70 |
| | | 14 | 14-SW24-F | 14-SW24-NF | 16.5 | 7.7 | 116 | 7.5 | 65 |
| | | 15 | 15-SW24-F | 15-SW24-NF | 16.5 | 7.8 | 119 | 7.5 | 87 |
| VI | apatite/active material | 16 | 16-SW24-F | 16-SW24-NF | 16.5 | 7.9 | 446 | 8.3 | 84 |
| | | 17 | 17-SW24-F | 17-SW24-NF | 16.5 | 7.8 | 468 | 8.1 | 89 |
| | | 18 | 18-SW24-F | 18-SW24-NF | 16.5 | 7.7 | 501 | 8.3 | 70 |
| VII | apatite/active material | 19 | 19-SW24-F | 19-SW24-NF | 16.5 | 7.8 | 635 | 8.0 | 56 |
| | | 20 | 20-SW24-F | 20-SW24-NF | 16.5 | 7.8 | 647 | 8.0 | 65 |
| | | 21 | 21-SW24-F | 21-SW24-NF | 16.5 | 7.8 | 600 | 8.1 | 76 |
| VIII | activated carbon | 22 | 22-SW24-F | 22-SW24-NF | 16.5 | 7.8 | 190 | 8.5 | 97 |
| | | 23 | 23-SW24-F | 23-SW24-NF | 16.6 | 7.8 | 168 | 8.7 | 111 |
| | | 24 | 24-SW24-F | 24-SW24-NF | 16.6 | 7.8 | 167 | 8.6 | 120 |
| IX | organoclay MRM/active | 25 | 25-SW24-F | 25-SW24-NF | 16.7 | 7.5 | 1765 | 4.5 | 22 |
| | | 26 | 26-SW24-F | 26-SW24-NF | 16.7 | 7.6 | 1724 | 5.0 | 24 |
| | | 27 | 27-SW24-F | 27-SW24-NF | 16.7 | 7.7 | 1763 | 4.8 | 26 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW24-F | 28-SW24-NF | 16.8 | 7.9 | 1362 | 8.5 | 46 |
| | | 29 | 29-SW24-F | 29-SW24-NF | 16.8 | 7.9 | 1466 | 8.1 | 56 |
| | | 30 | 30-SW24-F | 30-SW24-NF | 16.8 | 7.8 | 1370 | 8.1 | 46 |

Table A1.25. Surface water properties for each sample at time 1680 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 2/17/2015 | | 2/17/2015 | 2/17/2015 | 2/17/2015 | 2/17/2015 | 2/17/2015 | 2/17/2015 | 2/17/2015 |
| Sampling time | 11AM Time1680 hrs | | 1680 hrs | 1680 hrs | 1680 hrs | 1680 hrs | 1680 hrs | 1680 hrs | 1680 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW25-F | 1-SW25-NF | 16.0 | 7.3 | 74 | 6.3 | 1 |
| | | 3 | 3-SW25-F | 3-SW25-NF | 16.0 | 7.4 | 74 | 6.4 | 0 |
| II | sediment only | 4 | 4-SW25-F | 4-SW25-NF | 16.0 | 7.9 | 74 | 6.3 | 342 |
| | | 5 | 5-SW25-F | 5-SW25-NF | 16.0 | 7.8 | 75 | 6.2 | 302 |
| | | 6 | 6-SW25-F | 6-SW25-NF | 16.0 | 8.0 | 75 | 6.3 | 392 |
| III | sand/passive material | 7 | 7-SW25-F | 7-SW25-NF | 16.0 | 8.0 | 75 | 6.3 | 60 |
| | | 8 | 8-SW25-F | 8-SW25-NF | 16.0 | 7.9 | 73 | 6.3 | 64 |
| | | 9 | 9-SW25-F | 9-SW25-NF | 16.0 | 7.8 | 73 | 6.5 | 45 |
| IV | sand/passive material | 10 | 10-SW25-F | 10-SW25-NF | 16.0 | 7.7 | 77 | 6.6 | 87 |
| | | 11 | 11-SW25-F | 11-SW25-NF | 16.0 | 7.6 | 76 | 6.6 | 90 |
| | | 12 | 12-SW25-F | 12-SW25-NF | 16.0 | 7.6 | 73 | 6.8 | 80 |
| V | silty clay/passive material | 13 | 13-SW25-F | 13-SW25-NF | 16.0 | 8.1 | 90 | 6.8 | 309 |
| | | 14 | 14-SW25-F | 14-SW25-NF | 16.0 | 7.6 | 96 | 7.1 | 310 |
| | | 15 | 15-SW25-F | 15-SW25-NF | 16.0 | 7.7 | 94 | 7.1 | 277 |
| VI | apatite/active material | 16 | 16-SW25-F | 16-SW25-NF | 16.0 | 7.6 | 401 | 7.6 | 193 |
| | | 17 | 17-SW25-F | 17-SW25-NF | 16.0 | 7.2 | 406 | 7.8 | 190 |
| | | 18 | 18-SW25-F | 18-SW25-NF | 16.0 | 7.9 | 412 | 7.8 | 205 |
| VII | apatite/active material | 19 | 19-SW25-F | 19-SW25-NF | 16.0 | 7.5 | 541 | 7.9 | 211 |
| | | 20 | 20-SW25-F | 20-SW25-NF | 16.0 | 7.9 | 549 | 8.0 | 209 |
| | | 21 | 21-SW25-F | 21-SW25-NF | 16.0 | 8.0 | 490 | 8.1 | 209 |
| VIII | activated carbon | 22 | 22-SW25-F | 22-SW25-NF | 16.0 | 7.8 | 137 | 8.1 | 339 |
| | | 23 | 23-SW25-F | 23-SW25-NF | 16.0 | 7.7 | 132 | 8.1 | 325 |
| | | 24 | 24-SW25-F | 24-SW25-NF | 16.0 | 7.6 | 130 | 8.0 | 366 |
| IX | organoclay MRM/active | 25 | 25-SW25-F | 25-SW25-NF | 16.2 | 7.9 | 1414 | 4.1 | 200 |
| | | 26 | 26-SW25-F | 26-SW25-NF | 16.2 | 8.0 | 1625 | 4.0 | 210 |
| | | 27 | 27-SW25-F | 27-SW25-NF | 16.2 | 7.6 | 1523 | 4.3 | 210 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW25-F | 28-SW25-NF | 16.3 | 7.4 | 1187 | 7.9 | 210 |
| | | 29 | 29-SW25-F | 29-SW25-NF | 16.3 | 7.5 | 1275 | 8.1 | 206 |
| | | 30 | 30-SW25-F | 30-SW25-NF | 16.4 | 7.5 | 1204 | 8.1 | 220 |

Table A1.26. Surface water properties for each sample at time 1848 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 2/24/2015 | | 2/24/2015 | 2/24/2015 | 2/24/2015 | 2/24/2015 | 2/24/2015 | 2/24/2015 | 2/24/2015 |
| Sampling time | 11AM Time1848 hrs | | 1848 hrs | 1848 hrs | 1848 hrs | 1848 hrs | 1848 hrs | 1848 hrs | 1848 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW26-F | 1-SW26-NF | 14.8 | 7.7 | 82 | 6.9 | 1 |
| | | 3 | 3-SW26-F | 3-SW26-NF | 14.8 | 7.6 | 76 | 6.5 | 1 |
| II | sediment only | 4 | 4-SW26-F | 4-SW26-NF | 14.8 | 7.7 | 77 | 6.2 | 456 |
| | | 5 | 5-SW26-F | 5-SW26-NF | 14.8 | 7.7 | 78 | 6.1 | 415 |
| | | 6 | 6-SW26-F | 6-SW26-NF | 14.8 | 7.9 | 79 | 6.2 | 565 |
| III | sand/passive material | 7 | 7-SW26-F | 7-SW26-NF | 14.7 | 7.9 | 80 | 6.5 | 94 |
| | | 8 | 8-SW26-F | 8-SW26-NF | 14.7 | 7.8 | 75 | 6.6 | 102 |
| | | 9 | 9-SW26-F | 9-SW26-NF | 14.7 | 7.8 | 68 | 6.7 | 95 |
| IV | sand/passive material | 10 | 10-SW26-F | 10-SW26-NF | 14.6 | 7.8 | 82 | 6.7 | 119 |
| | | 11 | 11-SW26-F | 11-SW26-NF | 14.6 | 7.8 | 79 | 6.7 | 120 |
| | | 12 | 12-SW26-F | 12-SW26-NF | 14.5 | 7.8 | 76 | 6.7 | 100 |
| V | silty clay/passive material | 13 | 13-SW26-F | 13-SW26-NF | 14.6 | 8.2 | 97 | 7.0 | 506 |
| | | 14 | 14-SW26-F | 14-SW26-NF | 14.6 | 8.1 | 93 | 7.1 | 356 |
| | | 15 | 15-SW26-F | 15-SW26-NF | 14.7 | 8.1 | 94 | 7.2 | 500 |
| VI | apatite/active material | 16 | 16-SW26-F | 16-SW26-NF | 14.7 | 7.9 | 396 | 8.2 | 295 |
| | | 17 | 17-SW26-F | 17-SW26-NF | 14.7 | 7.9 | 400 | 8.2 | 251 |
| | | 18 | 18-SW26-F | 18-SW26-NF | 14.7 | 8.1 | 418 | 8.2 | 225 |
| VII | apatite/active material | 19 | 19-SW26-F | 19-SW26-NF | 14.8 | 7.8 | 522 | 8.0 | 217 |
| | | 20 | 20-SW26-F | 20-SW26-NF | 14.8 | 7.8 | 535 | 8.2 | 281 |
| | | 21 | 21-SW26-F | 21-SW26-NF | 14.8 | 7.9 | 463 | 8.3 | 222 |
| VIII | activated carbon | 22 | 22-SW26-F | 22-SW26-NF | 14.9 | 8.0 | 140 | 8.2 | 396 |
| | | 23 | 23-SW26-F | 23-SW26-NF | 14.9 | 8.4 | 131 | 8.3 | 392 |
| | | 24 | 24-SW26-F | 24-SW26-NF | 14.9 | 8.4 | 134 | 8.2 | 542 |
| IX | organoclay MRM/active | 25 | 25-SW26-F | 25-SW26-NF | 14.9 | 7.9 | 1392 | 4.4 | 367 |
| | | 26 | 26-SW26-F | 26-SW26-NF | 14.9 | 7.8 | 1619 | 4.5 | 389 |
| | | 27 | 27-SW26-F | 27-SW26-NF | 14.9 | 7.9 | 1485 | 4.6 | 360 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW26-F | 28-SW26-NF | 14.8 | 8.2 | 1222 | 8.2 | 240 |
| | | 29 | 29-SW26-F | 29-SW26-NF | 14.9 | 8.2 | 1296 | 8.2 | 230 |
| | | 30 | 30-SW26-F | 30-SW26-NF | 14.9 | 7.9 | 1212 | 8.2 | 246 |

Table A1.27. Surface water properties for each sample at time 1896 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 2/26/2015 | | 2/26/2015 | 2/26/2015 | 2/26/2015 | 2/26/2015 | 2/26/2015 | 2/26/2015 | 2/26/2015 |
| Sampling time | 11AM Time1896 hrs | | 1896 hrs | 1896 hrs | 1896 hrs | 1896 hrs | 1896 hrs | 1896 hrs | 1896 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW27-F | 1-SW27-NF | 15.4 | 7.7 | 82 | 6.7 | 1 |
| | | 3 | 3-SW27-F | 3-SW27-NF | 15.4 | 7.7 | 77 | 6.6 | 1 |
| II | sediment only | 4 | 4-SW27-F | 4-SW27-NF | 15.4 | 7.9 | 79 | 6.4 | 441 |
| | | 5 | 5-SW27-F | 5-SW27-NF | 15.4 | 7.9 | 78 | 6.0 | 415 |
| | | 6 | 6-SW27-F | 6-SW27-NF | 15.4 | 8.0 | 79 | 6.0 | 565 |
| III | sand/passive material | 7 | 7-SW27-F | 7-SW27-NF | 15.4 | 8.0 | 81 | 6.6 | 94 |
| | | 8 | 8-SW27-F | 8-SW27-NF | 15.3 | 7.7 | 79 | 6.7 | 102 |
| | | 9 | 9-SW27-F | 9-SW27-NF | 15.4 | 7.7 | 71 | 6.8 | 95 |
| IV | sand/passive material | 10 | 10-SW27-F | 10-SW27-NF | 15.4 | 7.8 | 82 | 6.8 | 119 |
| | | 11 | 11-SW27-F | 11-SW27-NF | 15.4 | 7.8 | 80 | 7.0 | 120 |
| | | 12 | 12-SW27-F | 12-SW27-NF | 15.4 | 7.8 | 78 | 7.0 | 100 |
| V | silty clay/passive material | 13 | 13-SW27-F | 13-SW27-NF | 15.4 | 8.6 | 97 | 6.9 | 506 |
| | | 14 | 14-SW27-F | 14-SW27-NF | 15.4 | 8.7 | 94 | 7.0 | 356 |
| | | 15 | 15-SW27-F | 15-SW27-NF | 15.4 | 7.8 | 96 | 7.1 | 500 |
| VI | apatite/active material | 16 | 16-SW27-F | 16-SW27-NF | 15.5 | 7.6 | 370 | 7.6 | 295 |
| | | 17 | 17-SW27-F | 17-SW27-NF | 15.5 | 7.7 | 395 | 7.6 | 251 |
| | | 18 | 18-SW27-F | 18-SW27-NF | 15.7 | 8.0 | 412 | 7.9 | 225 |
| VII | apatite/active material | 19 | 19-SW27-F | 19-SW27-NF | 15.7 | 7.6 | 527 | 8.0 | 217 |
| | | 20 | 20-SW27-F | 20-SW27-NF | 15.6 | 7.8 | 520 | 8.1 | 281 |
| | | 21 | 21-SW27-F | 21-SW27-NF | 15.6 | 7.8 | 451 | 8.2 | 222 |
| VIII | activated carbon | 22 | 22-SW27-F | 22-SW27-NF | 15.7 | 7.8 | 146 | 8.4 | 396 |
| | | 23 | 23-SW27-F | 23-SW27-NF | 15.6 | 8.0 | 131 | 8.2 | 392 |
| | | 24 | 24-SW27-F | 24-SW27-NF | 15.7 | 7.7 | 136 | 8.1 | 542 |
| IX | organoclay MRM/active | 25 | 25-SW27-F | 25-SW27-NF | 16.0 | 7.8 | 1286 | 4.3 | 367 |
| | | 26 | 26-SW27-F | 26-SW27-NF | 16.0 | 7.6 | 1602 | 4.3 | 389 |
| | | 27 | 27-SW27-F | 27-SW27-NF | 16.0 | 8.1 | 1424 | 4.3 | 360 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW27-F | 28-SW27-NF | 16.0 | 7.8 | 1207 | 8.1 | 240 |
| | | 29 | 29-SW27-F | 29-SW27-NF | 16.0 | 8.0 | 1307 | 8.1 | 230 |
| | | 30 | 30-SW27-F | 30-SW27-NF | 16.1 | 7.7 | 1220 | 8.2 | 246 |

Table A1.28. Surface water properties for each sample at time 2016 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 3/2/2015 | | 3/2/2015 | 3/2/2015 | 3/2/2015 | 3/2/2015 | 3/2/2015 | 3/2/2015 | 3/2/2015 |
| Sampling time | 11AM Time 2016 hrs | | 2016 hrs | 2016 hrs | 2016 hrs | 2016 hrs | 2016 hrs | 2016 hrs | 2016 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW28-F | 1-SW28-NF | 16.1 | 7.8 | 80 | 6.7 | 3 |
| | | 3 | 3-SW28-F | 3-SW28-NF | 16.2 | 7.6 | 80 | 6.4 | 3 |
| II | sediment only | 4 | 4-SW28-F | 4-SW28-NF | 16.7 | 8.0 | 78 | 6.3 | 388 |
| | | 5 | 5-SW28-F | 5-SW28-NF | 16.7 | 7.4 | 77 | 6.3 | 319 |
| | | 6 | 6-SW28-F | 6-SW28-NF | 16.8 | 8.3 | 79 | 6.1 | 345 |
| III | sand/passive material | 7 | 7-SW28-F | 7-SW28-NF | 16.8 | 7.4 | 82 | 6.6 | 33 |
| | | 8 | 8-SW28-F | 8-SW28-NF | 16.8 | 7.4 | 79 | 6.7 | 20 |
| | | 9 | 9-SW28-F | 9-SW28-NF | 16.8 | 7.2 | 71 | 6.8 | 22 |
| IV | sand/passive material | 10 | 10-SW28-F | 10-SW28-NF | 16.8 | 7.5 | 81 | 6.8 | 29 |
| | | 11 | 11-SW28-F | 11-SW28-NF | 16.9 | 7.2 | 83 | 6.9 | 29 |
| | | 12 | 12-SW28-F | 12-SW28-NF | 16.9 | 7.3 | 82 | 7.0 | 25 |
| V | silty clay/passive material | 13 | 13-SW28-F | 13-SW28-NF | 16.9 | 7.4 | 97 | 7.0 | 270 |
| | | 14 | 14-SW28-F | 14-SW28-NF | 17.0 | 7.4 | 95 | 7.0 | 226 |
| | | 15 | 15-SW28-F | 15-SW28-NF | 17.0 | 7.4 | 98 | 7.1 | 252 |
| VI | apatite/active material | 16 | 16-SW28-F | 16-SW28-NF | 13.9 | 7.4 | 365 | 7.8 | 85 |
| | | 17 | 17-SW28-F | 17-SW28-NF | 16.1 | 7.5 | 391 | 7.9 | 70 |
| | | 18 | 18-SW28-F | 18-SW28-NF | 16.0 | 7.7 | 395 | 8.2 | 75 |
| VII | apatite/active material | 19 | 19-SW28-F | 19-SW28-NF | 16.0 | 7.9 | 496 | 8.1 | 56 |
| | | 20 | 20-SW28-F | 20-SW28-NF | 16.0 | 7.7 | 478 | 8.1 | 80 |
| | | 21 | 21-SW28-F | 21-SW28-NF | 16.0 | 7.5 | 447 | 8.1 | 92 |
| VIII | activated carbon | 22 | 22-SW28-F | 22-SW28-NF | 16.0 | 7.7 | 143 | 8.2 | 380 |
| | | 23 | 23-SW28-F | 23-SW28-NF | 16.0 | 7.8 | 132 | 8.1 | 389 |
| | | 24 | 24-SW28-F | 24-SW28-NF | 16.0 | 7.7 | 139 | 8.0 | 382 |
| IX | organoclay MRM/active | 25 | 25-SW28-F | 25-SW28-NF | 16.0 | 7.7 | 1348 | 4.0 | 236 |
| | | 26 | 26-SW28-F | 26-SW28-NF | 16.0 | 7.7 | 1565 | 4.2 | 265 |
| | | 27 | 27-SW28-F | 27-SW28-NF | 16.0 | 7.8 | 1410 | 4.2 | 258 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW28-F | 28-SW28-NF | 16.0 | 7.8 | 1204 | 8.1 | 99 |
| | | 29 | 29-SW28-F | 29-SW28-NF | 16.0 | 7.5 | 1300 | 8.0 | 76 |
| | | 30 | 30-SW28-F | 30-SW28-NF | 16.0 | 7.7 | 1194 | 8.0 | 89 |

Table A1.29. Surface water properties for each sample at time 2040 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 3/2/2015 | | 3/4/2015 | 3/4/2015 | 3/4/2015 | 3/4/2015 | 3/4/2015 | 3/4/2015 | 3/4/2015 |
| Sampling time | 11AM Time 2040 hrs | | 2040 hrs | 2040 hrs | 2040 hrs | 2040 hrs | 2040 hrs | 2040 hrs | 2040 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW29-F | 1-SW29-NF | 17.1 | 7.5 | 98 | 6.9 | 3 |
| | | 3 | 3-SW29-F | 3-SW29-NF | 17.0 | 7.2 | 89 | 6.9 | 3 |
| II | sediment only | 4 | 4-SW29-F | 4-SW29-NF | 16.7 | 7.5 | 81 | 6.8 | 388 |
| | | 5 | 5-SW29-F | 5-SW29-NF | 16.7 | 7.3 | 81 | 6.9 | 319 |
| | | 6 | 6-SW29-F | 6-SW29-NF | 16.8 | 7.4 | 83 | 6.4 | 345 |
| III | sand/passive material | 7 | 7-SW29-F | 7-SW29-NF | 16.8 | 7.7 | 84 | 6.6 | 33 |
| | | 8 | 8-SW29-F | 8-SW29-NF | 16.8 | 7.5 | 81 | 6.7 | 20 |
| | | 9 | 9-SW29-F | 9-SW29-NF | 16.8 | 7.5 | 76 | 6.9 | 22 |
| IV | sand/passive material | 10 | 10-SW29-F | 10-SW29-NF | 16.8 | 7.7 | 85 | 6.8 | 29 |
| | | 11 | 11-SW29-F | 11-SW29-NF | 16.9 | 7.7 | 86 | 6.9 | 29 |
| | | 12 | 12-SW29-F | 12-SW29-NF | 16.9 | 7.5 | 84 | 6.9 | 25 |
| V | silty clay/passive material | 13 | 13-SW29-F | 13-SW29-NF | 16.9 | 7.6 | 101 | 7.0 | 270 |
| | | 14 | 14-SW29-F | 14-SW29-NF | 17.0 | 7.6 | 99 | 7.0 | 226 |
| | | 15 | 15-SW29-F | 15-SW29-NF | 17.0 | 7.8 | 98 | 7.1 | 252 |
| VI | apatite/active material | 16 | 16-SW29-F | 16-SW29-NF | 17.0 | 7.8 | 379 | 7.8 | 85 |
| | | 17 | 17-SW29-F | 17-SW29-NF | 17.0 | 7.9 | 401 | 7.8 | 70 |
| | | 18 | 18-SW29-F | 18-SW29-NF | 17.0 | 7.9 | 410 | 7.9 | 75 |
| VII | apatite/active material | 19 | 19-SW29-F | 19-SW29-NF | 17.0 | 7.7 | 502 | 7.9 | 56 |
| | | 20 | 20-SW29-F | 20-SW29-NF | 17.0 | 7.7 | 489 | 8.0 | 80 |
| | | 21 | 21-SW29-F | 21-SW29-NF | 17.0 | 7.5 | 451 | 8.1 | 92 |
| VIII | activated carbon | 22 | 22-SW29-F | 22-SW29-NF | 17.0 | 7.7 | 146 | 8.0 | 380 |
| | | 23 | 23-SW29-F | 23-SW29-NF | 17.0 | 7.6 | 135 | 7.9 | 389 |
| | | 24 | 24-SW29-F | 24-SW29-NF | 17.0 | 7.6 | 141 | 7.9 | 382 |
| IX | organoclay MRM/active | 25 | 25-SW29-F | 25-SW29-NF | 17.0 | 7.7 | 1301 | 3.9 | 236 |
| | | 26 | 26-SW29-F | 26-SW20--NF | 17.0 | 7.6 | 1564 | 4.0 | 265 |
| | | 27 | 27-SW29-F | 27-SW29-NF | 17.0 | 7.6 | 1429 | 4.2 | 258 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW29-F | 28-SW29-NF | 17.0 | 7.7 | 1137 | 7.3 | 99 |
| | | 29 | 29-SW29-F | 29-SW29-NF | 17.0 | 7.5 | 1305 | 7.9 | 76 |
| | | 30 | 30-SW29-F | 30-SW29-NF | 17.0 | 7.5 | 1197 | 8.0 | 89 |

Table A1.30. Surface water properties for each sample at time 2184 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 3/10/2015 | | 3/10/2015 | 3/10/2015 | 3/10/2015 | 3/10/2015 | 3/10/2015 | 3/10/2015 | 3/10/2015 |
| Sampling time | 11AM Time 2184 hrs | | 2184 hrs | 2184 hrs | 2184 hrs | 2184 hrs | 2184 hrs | 2184 hrs | 2184 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW30-F | 1-SW30-NF | 17.1 | 8.0 | 84 | 6.6 | 1 |
| | | 3 | 3-SW30-F | 3-SW30-NF | 17.0 | 7.8 | 85 | 6.3 | 1 |
| II | sediment only | 4 | 4-SW30-F | 4-SW30-NF | 17.0 | 7.5 | 80 | 6.3 | 441 |
| | | 5 | 5-SW30-F | 5-SW30-NF | 17.0 | 7.3 | 79 | 6.3 | 415 |
| | | 6 | 6-SW30-F | 6-SW30-NF | 17.0 | 7.4 | 80 | 6.3 | 465 |
| III | sand/passive material | 7 | 7-SW30-F | 7-SW30-NF | 17.0 | 7.7 | 84 | 6.7 | 94 |
| | | 8 | 8-SW30-F | 8-SW30-NF | 16.8 | 7.5 | 81 | 6.7 | 102 |
| | | 9 | 9-SW30-F | 9-SW30-NF | 16.8 | 7.5 | 76 | 6.8 | 95 |
| IV | sand/passive material | 10 | 10-SW30-F | 10-SW30-NF | 16.8 | 7.7 | 85 | 6.9 | 119 |
| | | 11 | 11-SW30-F | 11-SW30-NF | 16.9 | 7.7 | 85 | 6.7 | 120 |
| | | 12 | 12-SW30-F | 12-SW30-NF | 16.9 | 7.5 | 83 | 6.9 | 100 |
| V | silty clay/passive material | 13 | 13-SW30-F | 13-SW30-NF | 16.9 | 7.6 | 97 | 6.9 | 359 |
| | | 14 | 14-SW30-F | 14-SW30-NF | 17.0 | 7.6 | 95 | 7.0 | 356 |
| | | 15 | 15-SW30-F | 15-SW30-NF | 17.0 | 7.8 | 95 | 7.1 | 335 |
| VI | apatite/active material | 16 | 16-SW30-F | 16-SW30-NF | 17.0 | 7.8 | 392 | 7.9 | 295 |
| | | 17 | 17-SW30-F | 17-SW30-NF | 17.0 | 7.9 | 386 | 8.0 | 251 |
| | | 18 | 18-SW30-F | 18-SW30-NF | 17.0 | 7.9 | 402 | 8.0 | 225 |
| VII | apatite/active material | 19 | 19-SW30-F | 19-SW30-NF | 17.0 | 7.7 | 461 | 8.0 | 217 |
| | | 20 | 20-SW30-F | 20-SW30-NF | 17.0 | 7.7 | 453 | 8.1 | 281 |
| | | 21 | 21-SW30-F | 21-SW30-NF | 17.0 | 7.5 | 433 | 8.1 | 222 |
| VIII | activated carbon | 22 | 22-SW30-F | 22-SW30-NF | 16.8 | 7.7 | 153 | 8.2 | 396 |
| | | 23 | 23-SW30-F | 23-SW30-NF | 16.8 | 7.6 | 136 | 8.1 | 392 |
| | | 24 | 24-SW30-F | 24-SW30-NF | 16.8 | 7.6 | 140 | 8.0 | 345 |
| IX | organoclay MRM/active | 25 | 25-SW30-F | 25-SW30-NF | 16.8 | 7.7 | 1178 | 4.1 | 98 |
| | | 26 | 26-SW30-F | 26-SW30--NF | 16.9 | 7.6 | 1439 | 4.1 | 120 |
| | | 27 | 27-SW30-F | 27-SW30-NF | 16.9 | 7.6 | 1403 | 4.2 | 110 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW30-F | 28-SW30-NF | 16.9 | 7.7 | 1237 | 7.6 | 210 |
| | | 29 | 29-SW30-F | 29-SW30-NF | 17.0 | 7.5 | 1297 | 7.6 | 230 |
| | | 30 | 30-SW30-F | 30-SW30-NF | 17.0 | 7.5 | 1148 | 8.0 | 246 |

Table A1.31. Surface water properties for each sample at time 2352 h.

| | | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 3/17/2015 | | 3/17/2015 | 3/17/2015 | 3/17/2015 | 3/17/2015 | 3/17/2015 | 3/17/2015 | 3/17/2015 |
| Sampling time | 11AM Time 2352 hrs | | 2352 hrs | 2352 hrs | 2352 hrs | 2352 hrs | 2352 hrs | 2352 hrs | 2352 hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW31-F | 1-SW31-NF | 17.1 | 7.9 | 88 | 6.9 | 3 |
| | | 3 | 3-SW31-F | 3-SW31-NF | 17.0 | 7.7 | 84 | 6.8 | 2 |
| II | sediment only | 4 | 4-SW31-F | 4-SW31-NF | 17.0 | 7.6 | 82 | 6.7 | 341 |
| | | 5 | 5-SW31-F | 5-SW31-NF | 17.0 | 7.6 | 80 | 6.6 | 290 |
| | | 6 | 6-SW31-F | 6-SW31-NF | 17.0 | 8.1 | 82 | 6.6 | 310 |
| III | sand/passive material | 7 | 7-SW31-F | 7-SW31-NF | 17.0 | 7.7 | 86 | 7.0 | 94 |
| | | 8 | 8-SW31-F | 8-SW31-NF | 16.8 | 7.7 | 84 | 7.0 | 102 |
| | | 9 | 9-SW31-F | 9-SW31-NF | 16.8 | 7.8 | 78 | 7.2 | 95 |
| IV | sand/passive material | 10 | 10-SW31-F | 10-SW31-NF | 16.8 | 7.7 | 86 | 7.1 | 119 |
| | | 11 | 11-SW31-F | 11-SW31-NF | 16.9 | 7.8 | 86 | 7.1 | 120 |
| | | 12 | 12-SW31-F | 12-SW31-NF | 16.9 | 7.6 | 86 | 7.2 | 100 |
| V | silty clay/passive material | 13 | 13-SW31-F | 13-SW31-NF | 16.9 | 8.0 | 99 | 7.2 | 359 |
| | | 14 | 14-SW31-F | 14-SW31-NF | 17.0 | 7.9 | 95 | 7.3 | 356 |
| | | 15 | 15-SW31-F | 15-SW31-NF | 17.0 | 8.3 | 98 | 7.2 | 335 |
| VI | apatite/active material | 16 | 16-SW31-F | 16-SW31-NF | 17.0 | 7.8 | 392 | 8.2 | 195 |
| | | 17 | 17-SW31-F | 17-SW31-NF | 17.0 | 8.3 | 386 | 8.2 | 189 |
| | | 18 | 18-SW31-F | 18-SW31-NF | 17.0 | 8.1 | 389 | 8.1 | 198 |
| VII | apatite/active material | 19 | 19-SW31-F | 19-SW31-NF | 17.0 | 7.8 | 478 | 8.1 | 208 |
| | | 20 | 20-SW31-F | 20-SW31-NF | 17.0 | 7.7 | 488 | 8.1 | 213 |
| | | 21 | 21-SW31-F | 21-SW31-NF | 17.0 | 7.6 | 460 | 8.1 | 199 |
| VIII | activated carbon | 22 | 22-SW31-F | 22-SW31-NF | 16.8 | 7.7 | 150 | 8.1 | 396 |
| | | 23 | 23-SW31-F | 23-SW31-NF | 16.8 | 7.7 | 132 | 8.1 | 392 |
| | | 24 | 24-SW31-F | 24-SW31-NF | 16.8 | 8.0 | 142 | 8.0 | 345 |
| IX | organoclay MRM/active | 25 | 25-SW31-F | 25-SW31-NF | 16.8 | 8.0 | 1233 | 4.0 | 98 |
| | | 26 | 26-SW31-F | 26-SW31-NF | 16.9 | 7.8 | 1421 | 4.0 | 89 |
| | | 27 | 27-SW31-F | 27-SW31-NF | 16.9 | 8.0 | 1354 | 4.2 | 98 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW31-F | 28-SW31-NF | 16.9 | 8.3 | 1137 | 7.6 | 189 |
| | | 29 | 29-SW31-F | 29-SW31-NF | 17.0 | 8.0 | 1257 | 8.0 | 210 |
| | | 30 | 30-SW31-F | 30-SW31-NF | 17.0 | 8.0 | 1131 | 8.0 | 215 |

Table A1.32. Surface water properties for each sample at time 2520 h.

| | SW32-F/NF the end/ after spike 0 time pa1) | | Sample ID | Sample ID | TEMP oC | DO mg/L | Cond us/cm | pH | Turb NTU |
|---|---|---|---|---|---|---|---|---|---|
| Sampling date | 3/24/2015 | | 3/24/2015 | 3/24/2015 | 3/24/2015 | 3/24/2015 | 3/24/2015 | 3/24/2015 | 3/24/2015 |
| Sampling time | 11AM Time 2520 (0) hrs | | 2520(0) hrs | 2520(0) hrs | 2520(0) hrs | 2520(0) hrs | 2520(0) hrs | 2520(0) hrs | 2520(0) hrs |
| **Treatment** | **Treatment description** | **No** | **Filter** | **No Filter** | | | | | |
| I | Spike solution only | 1 | 1-SW32(pa1)-F | 1-SW32(pa1)-NF | 20.0 | 7.6 | 92 | 7.1 | 3 |
| | | 3 | 3-SW32(pa1)-F | 3-SW32(pa1)-NF | 20.0 | 7.7 | 90 | 7.1 | 2 |
| II | sediment only | 4 | 4-SW32(pa1)-F | 4-SW32(pa1)-NF | 19.9 | 7.9 | 81 | 6.8 | 341 |
| | | 5 | 5-SW32(pa1)-F | 5-SW32(pa1)-NF | 20.0 | 7.6 | 83 | 6.6 | 290 |
| | | 6 | 6-SW32(pa1)-F | 6-SW32(pa1)-NF | 19.8 | 8.1 | 84 | 6.5 | 310 |
| III | sand/passive material | 7 | 7-SW32(pa1)-F | 7-SW32(pa1)-NF | 19.9 | 7.9 | 89 | 6.6 | 94 |
| | | 8 | 8-SW32(pa1)-F | 8-SW32(pa1)-NF | 20.0 | 7.7 | 86 | 6.9 | 102 |
| | | 9 | 9-SW32(pa1)-F | 9-SW32(pa1)-NF | 19.9 | 7.8 | 87 | 6.8 | 95 |
| IV | sand/passive material | 10 | 10-SW32(pa1)-F | 10-SW32(pa1)-NF | 19.9 | 7.8 | 92 | 7.0 | 119 |
| | | 11 | 11-SW32(pa1)-F | 11-SW32(pa1)-NF | 20.0 | 7.8 | 92 | 7.0 | 120 |
| | | 12 | 12-SW32(pa1)-F | 12-SW32(pa1)-NF | 20.0 | 7.6 | 89 | 6.9 | 100 |
| V | silty clay/passive material | 13 | 13-SW32(pa1)-F | 13-SW32(pa1)-NF | 20.0 | 7.8 | 98 | 7.1 | 359 |
| | | 14 | 14-SW32(pa1)-F | 14-SW32(pa1)-NF | 20.1 | 7.7 | 93 | 7.1 | 356 |
| | | 15 | 15-SW32(pa1)-F | 15-SW32(pa1)-NF | 20.2 | 7.9 | 98 | 7.1 | 335 |
| VI | apatite/active material | 16 | 16-SW32(pa1)-F | 16-SW32(pa1)-NF | 20.2 | 7.8 | 358 | 7.8 | 195 |
| | | 17 | 17-SW32(pa1)-F | 17-SW32(pa1)-NF | 20.1 | 7.9 | 365 | 7.5 | 189 |
| | | 18 | 18-SW32(pa1)-F | 18-SW32(pa1)-NF | 20.0 | 7.9 | 382 | 7.6 | 198 |
| VII | apatite/active material | 19 | 19-SW32(pa1)-F | 19-SW32(pa1)-NF | 20.0 | 7.8 | 465 | 7.9 | 208 |
| | | 20 | 20-SW32(pa1)-F | 20-SW32(pa1)-NF | 20.0 | 7.7 | 484 | 7.8 | 213 |
| | | 21 | 21-SW32(pa1)-F | 21-SW32(pa1)-NF | 20.1 | 7.6 | 442 | 7.9 | 199 |
| VIII | activated carbon | 22 | 22-SW32(pa1)-F | 22-SW32(pa1)-NF | 20.2 | 8.0 | 149 | 8.1 | 396 |
| | | 23 | 23-SW32(pa1)-F | 23-SW32(pa1)-NF | 20.2 | 7.7 | 130 | 8.1 | 392 |
| | | 24 | 24-SW32(pa1)-F | 24-SW32(pa1)-NF | 20.1 | 7.9 | 131 | 8.0 | 345 |
| IX | organoclay MRM/active | 25 | 25-SW32(pa1)-F | 25-SW32(pa1)-NF | 20.0 | 7.8 | 1171 | 4.1 | 98 |
| | | 26 | 26-SW32(pa1)-F | 26-SW32(pa1)-NF | 20.0 | 7.8 | 1340 | 4.1 | 89 |
| | | 27 | 27-SW32(pa1)-F | 27-SW32(pa1)-NF | 20.0 | 8.0 | 1289 | 4.0 | 98 |
| X | NCA60/MRM35/AC5 | 28 | 28-SW32(pa1)-F | 28-SW32(pa1)-NF | 20.1 | 7.9 | 1047 | 7.6 | 189 |
| | | 29 | 29-SW32(pa1)-F | 29-SW32(pa1)-NF | 20.2 | 8.0 | 1250 | 7.5 | 210 |
| | | 30 | 30-SW32(pa1)-F | 30-SW32(pa1)-NF | 20.2 | 8.0 | 1094 | 7.8 | 215 |

Table A1.33. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time zero (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 1.016 | 1.049 | 1.476 | 2.182 | 11.130 | 0.264 | 0.820 | 0.181 | 5.211 | 0.724 |
| | | 3 | 0.405 | 0.818 | 0.296 | 0.963 | 8.164 | 0.165 | 1.001 | 0.017 | 4.089 | 0.170 |
| II | Sediment | 4 | 0.355 | 0.977 | 0.548 | 1.054 | 1.101 | 0.145 | 0.496 | 0.013 | 3.637 | 0.083 |
| | | 5 | 0.175 | 0.854 | 0.094 | 1.265 | 2.114 | 0.136 | 0.453 | 0.001 | 3.223 | 0.005 |
| | | 6 | 0.085 | 0.693 | 0.055 | 0.285 | 0.867 | 0.072 | 0.389 | 0.004 | 2.660 | 0.110 |
| III | Sand - 1 inch | 7 | 0.025 | 0.672 | 0.081 | 0.997 | 9.646 | 0.092 | 0.748 | 0.010 | 2.704 | 0.195 |
| | | 8 | 0.033 | 0.725 | 0.235 | 0.578 | 10.440 | 0.102 | 0.218 | 0.005 | 2.300 | 0.131 |
| | | 9 | 0.011 | 0.641 | 0.054 | 0.689 | 10.580 | 0.068 | 0.632 | 0.033 | 2.167 | 0.206 |
| IV | Sand - 2 inches | 10 | 0.343 | 0.816 | 0.324 | 3.565 | 14.440 | 0.103 | 0.184 | 0.021 | 1.993 | 2.138 |
| | | 11 | 0.180 | 0.753 | 0.172 | 1.254 | 11.130 | 0.143 | 0.633 | 0.004 | 2.128 | 0.434 |
| | | 12 | 0.076 | 0.806 | 0.107 | 0.940 | 7.641 | 0.095 | 0.491 | 0.035 | 1.742 | 0.073 |
| V | Silty clay | 13 | 0.441 | 1.024 | 0.403 | 3.130 | 5.720 | 0.615 | 0.690 | 0.005 | 3.272 | 0.058 |
| | | 14 | 0.349 | 1.231 | 0.393 | 1.900 | 6.544 | 0.712 | 0.252 | 0.023 | 1.925 | 0.073 |
| | | 15 | 0.307 | 1.232 | 0.283 | 2.250 | 7.411 | 0.694 | 0.736 | 0.020 | 1.636 | 0.148 |
| VI | Apatite - 1 inch | 16 | 0.090 | 0.874 | 2.546 | 0.187 | 8.080 | 0.703 | 0.173 | 0.091 | 1.219 | 0.222 |
| | | 17 | 0.090 | 0.693 | 2.896 | 0.130 | 2.764 | 0.703 | 0.452 | 0.149 | 0.998 | 0.192 |
| | | 18 | 0.216 | 1.000 | 2.639 | 0.318 | 7.766 | 0.842 | 0.131 | 0.114 | 0.851 | 0.219 |
| VII | Apatite - 2 inches | 19 | 0.132 | 0.694 | 3.605 | 0.849 | 10.290 | 0.775 | 0.692 | 0.194 | 0.795 | 0.197 |
| | | 20 | 0.022 | 0.822 | 3.929 | 0.233 | 7.154 | 0.690 | 0.562 | 0.206 | 0.768 | 0.248 |
| | | 21 | 0.148 | 0.763 | 4.219 | 0.530 | 7.738 | 0.854 | 0.680 | 0.173 | 0.646 | 0.126 |
| VIII | Activated carbon | 22 | 0.183 | 0.746 | 0.094 | 0.206 | 1.434 | 0.127 | 0.236 | 0.008 | 0.542 | 0.166 |
| | | 23 | 0.176 | 0.476 | 0.139 | 1.941 | 2.597 | 0.104 | 0.344 | 0.001 | 0.529 | 0.188 |
| | | 24 | 0.125 | 0.557 | 0.076 | 1.095 | 2.687 | 0.116 | 0.387 | 0.000 | 0.479 | 0.195 |
| IX | Organoclay MRM | 25 | 0.163 | 1.194 | 0.960 | 0.002 | 8.844 | 0.610 | 0.132 | 0.123 | 0.978 | 0.058 |
| | | 26 | 0.017 | 1.112 | 1.783 | 0.000 | 10.160 | 0.728 | 0.113 | 0.082 | 0.995 | 0.015 |
| | | 27 | 0.043 | 1.042 | 1.155 | 0.847 | 6.526 | 0.602 | 0.107 | 0.073 | 0.723 | 0.159 |
| X | MAAC | 28 | 0.145 | 0.817 | 1.069 | 0.055 | 2.116 | 0.778 | 0.153 | 0.056 | 0.540 | 0.213 |
| | | 29 | 0.093 | 0.767 | 1.064 | 1.930 | 5.278 | 0.726 | 0.498 | 0.077 | 0.470 | 0.166 |
| | | 30 | 0.032 | 0.898 | 1.501 | 4.660 | 7.078 | 0.881 | 0.323 | 0.102 | 0.501 | 0.211 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 0.203 | 0.004 | 0.126 | 0.511 | 9.705 | 3.862 | 0.655 | 0.335 | 0.220 | 0.057 |
| | | 3 | 0.000 | 0.018 | 0.113 | 0.415 | 8.478 | 2.502 | 0.187 | 0.038 | 0.301 | 0.089 |
| II | Sediment | 4 | 0.604 | 0.696 | 0.398 | 1.234 | 9.652 | 1.822 | 0.640 | 0.006 | 0.184 | 1.364 |
| | | 5 | 0.186 | 0.149 | 0.047 | 0.361 | 74.010 | 1.263 | 0.005 | 0.005 | 0.188 | 0.199 |
| | | 6 | 0.629 | 0.550 | 0.383 | 0.915 | 8.486 | 0.830 | 0.188 | 0.010 | 0.219 | 0.799 |
| III | Sand - 1 inch | 7 | 0.017 | 0.022 | 0.114 | 0.218 | 10.450 | 0.404 | 0.417 | 0.054 | 0.163 | 0.041 |
| | | 8 | 0.145 | 0.013 | 0.000 | 0.090 | 8.531 | 0.183 | 0.173 | 0.015 | 0.179 | 0.133 |
| | | 9 | 0.088 | 0.021 | 0.015 | 0.066 | 18.280 | 0.026 | 0.034 | 0.026 | 0.193 | 0.120 |
| IV | Sand - 2 inches | 10 | 0.119 | 0.017 | 0.000 | 0.000 | 9.323 | 0.025 | 0.399 | 0.007 | 0.207 | 0.006 |
| | | 11 | 0.124 | 0.029 | 0.013 | 0.099 | 13.130 | 0.026 | 0.154 | 0.028 | 0.175 | 0.066 |
| | | 12 | 0.024 | 0.013 | 0.036 | 0.000 | 8.824 | 0.085 | -0.010 | 0.062 | 0.217 | 0.102 |
| V | Silty clay | 13 | 0.823 | 0.693 | 0.312 | 24.520 | 15.930 | 0.632 | 0.045 | 0.061 | 0.152 | 4.851 |
| | | 14 | 0.480 | 0.522 | 0.347 | 14.040 | 10.140 | 0.468 | 0.198 | 0.054 | 0.111 | 0.753 |
| | | 15 | 0.423 | 0.506 | 0.570 | 15.430 | 12.190 | 0.381 | 0.053 | 0.045 | 0.098 | 0.757 |
| VI | Apatite - 1 inch | 16 | 0.700 | 0.109 | 2.890 | 0.184 | 11.810 | 0.771 | 0.718 | 0.226 | 0.114 | 0.157 |
| | | 17 | 0.598 | 0.098 | 3.245 | 1.282 | 6.773 | 1.081 | 0.781 | 0.243 | 0.762 | 0.448 |
| | | 18 | 0.590 | 0.107 | 2.998 | 0.797 | 10.410 | 0.973 | 0.028 | 0.246 | 0.395 | 1.057 |
| VII | Apatite - 2 inches | 19 | 0.218 | 0.097 | 3.673 | 0.202 | 8.553 | 0.509 | 0.147 | 0.223 | 0.263 | 0.006 |
| | | 20 | 0.258 | 0.109 | 3.844 | 0.167 | 9.541 | 0.592 | 0.346 | 0.277 | 0.191 | 0.095 |
| | | 21 | 0.329 | 0.123 | 4.108 | 0.103 | 10.690 | 0.879 | 0.262 | 0.295 | 0.164 | 0.213 |
| VIII | Activated carbon | 22 | 0.392 | 0.163 | 0.082 | 0.094 | 6.593 | 0.207 | 0.661 | 0.049 | 0.150 | 0.154 |
| | | 23 | 0.161 | 0.155 | 0.083 | 0.032 | 9.207 | 0.341 | 0.846 | 0.052 | 0.099 | 0.162 |
| | | 24 | 0.141 | 0.130 | 0.000 | 0.460 | 7.299 | 0.280 | 0.132 | 0.018 | 0.080 | 0.081 |
| IX | Organoclay MRM | 25 | 0.197 | 0.416 | 0.926 | 0.141 | 8.029 | 0.216 | 0.231 | 0.149 | 0.234 | 0.225 |
| | | 26 | 0.194 | 0.361 | 0.922 | 0.029 | 9.644 | 0.208 | 0.223 | 0.091 | 0.157 | 0.023 |
| | | 27 | 0.188 | 0.462 | 1.463 | 0.349 | 30.710 | 0.086 | 0.974 | 0.094 | 0.186 | 0.119 |
| X | MAAC | 28 | 0.145 | 0.111 | 1.377 | 6.290 | 37.590 | 0.348 | 0.797 | 0.118 | 0.062 | 1.295 |
| | | 29 | 0.124 | 0.090 | 1.153 | 0.059 | 5.704 | 0.211 | 0.538 | 0.225 | 0.039 | 0.021 |
| | | 30 | 0.116 | 0.190 | 1.400 | 0.157 | 8.858 | 0.289 | 0.028 | 0.137 | 0.007 | 0.069 |

Table A1.34. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 24 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 1.105 | 6.155 | 7.053 | 1.999 | 10.750 | 2.476 | 8.407 | 6.889 | 1.535 | 1.792 |
| | | 3 | 1.317 | 6.514 | 7.295 | 2.116 | 10.410 | 2.752 | 7.795 | 6.941 | 1.318 | 1.791 |
| II | Sediment | 4 | 0.109 | 0.967 | 0.568 | 1.416 | 1.878 | 1.528 | 5.293 | 0.437 | 0.944 | 0.196 |
| | | 5 | 0.100 | 0.369 | 0.429 | 0.435 | 1.258 | 1.553 | 6.130 | 0.196 | 1.006 | 0.122 |
| III | Sand - 1 inch | 7 | 0.037 | 4.495 | 5.173 | 0.300 | 4.448 | 1.930 | 6.664 | 4.892 | 0.700 | 0.172 |
| | | 8 | 0.000 | 4.309 | 8.379 | 0.976 | 12.510 | 1.721 | 6.208 | 4.542 | 0.675 | 0.200 |
| IV | Sand - 2 inches | 10 | 0.000 | 4.904 | 5.938 | 2.472 | 7.540 | 2.090 | 6.522 | 5.335 | 0.554 | 0.018 |
| | | 11 | 0.000 | 4.890 | 5.555 | 0.357 | 4.562 | 1.749 | 7.549 | 5.186 | 0.591 | 0.039 |
| V | Silty clay | 13 | 0.667 | 2.854 | 4.226 | 20.680 | 54.980 | 2.607 | 6.618 | 1.456 | 0.717 | 0.141 |
| | | 14 | 0.432 | 2.711 | 4.075 | 10.530 | 2.646 | 2.247 | 6.489 | 1.315 | 0.391 | 0.085 |
| VI | Apatite - 1 inch | 16 | 1.613 | 2.374 | 7.907 | 3.519 | 2.379 | 2.063 | 2.743 | 1.088 | 0.254 | 0.261 |
| | | 17 | 0.216 | 2.766 | 5.528 | 0.974 | 1.818 | 1.790 | 3.344 | 1.132 | 0.345 | 0.280 |
| VII | Apatite - 2 inches | 19 | 0.232 | 2.267 | 6.731 | 0.545 | 17.840 | 1.878 | 3.376 | 1.375 | 0.311 | 0.266 |
| | | 20 | 0.212 | 1.889 | 6.600 | 0.589 | 2.844 | 1.463 | 3.023 | 1.142 | 0.316 | 0.284 |
| VIII | Activated carbon | 22 | 0.374 | 0.628 | 0.901 | 1.171 | 0.574 | 1.741 | 5.270 | 0.160 | 0.297 | 0.237 |
| | | 23 | 0.312 | 0.589 | 0.877 | 0.397 | 0.505 | 1.676 | 4.323 | 0.206 | 0.320 | 0.235 |
| IX | Organoclay MRM | 25 | 0.170 | 4.894 | 6.606 | 1.030 | 5.866 | 2.545 | 5.850 | 3.592 | 0.405 | 0.369 |
| | | 26 | 0.110 | 4.942 | 5.845 | 2.511 | 4.713 | 2.196 | 6.192 | 3.559 | 0.253 | 0.128 |
| X | MAAC | 28 | 0.057 | 3.399 | 5.044 | 0.351 | 3.990 | 2.196 | 4.269 | 2.355 | 0.189 | 0.263 |
| | | 29 | 0.093 | 4.752 | 6.522 | 0.270 | 3.596 | 2.441 | 5.236 | 3.829 | 0.155 | 0.230 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 1.500 | 6.294 | 7.154 | 6.112 | 13.430 | 2.373 | 9.256 | 7.025 | 2.098 | 1.649 |
| | | 3 | 1.877 | 6.786 | 7.888 | 2.584 | 19.760 | 2.906 | 9.015 | 7.124 | 1.703 | 2.051 |
| II | Sediment | 4 | 1.587 | 5.203 | 5.948 | 2.217 | 9.252 | 1.194 | 2.323 | 5.172 | 1.115 | 1.626 |
| | | 5 | 1.783 | 4.840 | 5.603 | 11.450 | 16.920 | 0.979 | 1.846 | 4.708 | 0.976 | 2.993 |
| III | Sand - 1 inch | 7 | 1.160 | 5.089 | 5.723 | 1.265 | 6.470 | 2.091 | 6.126 | 5.358 | 0.846 | 0.939 |
| | | 8 | 1.175 | 5.220 | 6.059 | 1.448 | 7.134 | 1.960 | 6.400 | 5.341 | 0.680 | 0.778 |
| IV | Sand - 2 inches | 10 | 1.038 | 5.520 | 6.568 | 1.286 | 8.637 | 2.332 | 7.491 | 5.931 | 0.858 | 0.841 |
| | | 11 | 1.204 | 5.621 | 6.669 | 7.451 | 9.588 | 2.102 | 7.401 | 5.768 | 0.631 | 0.999 |
| V | Silty clay | 13 | 2.379 | 4.943 | 5.978 | 33.220 | 13.880 | 2.388 | 4.189 | 4.053 | 1.407 | 5.310 |
| | | 14 | 3.097 | 4.503 | 5.940 | 27.730 | 13.450 | 2.687 | 4.429 | 3.282 | 1.210 | 4.732 |
| VI | Apatite - 1 inch | 16 | 3.579 | 2.966 | 8.043 | 1.655 | 25.280 | 3.458 | 4.804 | 2.421 | 0.634 | 1.103 |
| | | 17 | 2.630 | 2.555 | 6.984 | 1.521 | 8.011 | 3.010 | 4.718 | 1.959 | 0.504 | 0.811 |
| VII | Apatite - 2 inches | 19 | 2.691 | 2.760 | 8.217 | 2.502 | 9.106 | 2.858 | 4.118 | 2.336 | 0.373 | 0.573 |
| | | 20 | 2.812 | 2.311 | 8.137 | 1.341 | 9.032 | 2.749 | 2.857 | 1.998 | 0.335 | 2.186 |
| VIII | Activated carbon | 22 | 2.200 | 3.863 | 4.077 | 7.204 | 8.256 | 1.119 | 2.830 | 2.972 | 0.242 | 1.868 |
| | | 23 | 2.294 | 4.087 | 4.527 | 2.468 | 9.233 | 1.011 | 2.225 | 3.170 | 0.188 | 2.484 |
| IX | Organoclay MRM | 25 | 1.186 | 5.191 | 6.563 | 2.072 | 8.528 | 2.695 | 6.682 | 3.947 | 0.560 | 1.447 |
| | | 26 | 0.650 | 4.944 | 6.476 | 1.557 | 7.285 | 2.294 | 5.772 | 3.703 | 0.387 | 0.931 |
| X | MAAC | 28 | 1.674 | 3.931 | 6.255 | 2.235 | 8.071 | 2.765 | 4.804 | 3.140 | 0.178 | 1.997 |
| | | 29 | 1.392 | 5.419 | 7.815 | 1.905 | 8.101 | 3.141 | 6.630 | 4.897 | 0.230 | 1.689 |

Table A1.35. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 48 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | | | | | Filtered samples | | | | | |
| I | Spike solution | 1 | 1.793 | 11.820 | 13.700 | 2.388 | 13.210 | 4.679 | 15.750 | 14.470 | 3.570 | 2.825 |
| | | 3 | 2.268 | 11.930 | 14.460 | 2.017 | 23.890 | 5.505 | 14.750 | 14.330 | 2.095 | 2.940 |
| II | Sediment | 4 | 0.013 | 1.014 | 0.436 | 0.856 | 0.550 | 2.310 | 8.562 | 0.394 | 1.395 | 0.124 |
| | | 5 | 0.161 | 1.017 | 0.544 | 0.433 | 1.555 | 2.267 | 9.337 | 0.551 | 1.367 | 0.086 |
| III | Sand - 1 inch | 7 | 0.000 | 8.529 | 10.010 | 0.000 | 5.551 | 3.749 | 12.640 | 10.240 | 0.743 | 0.023 |
| | | 8 | 0.000 | 7.649 | 9.220 | 0.000 | 4.235 | 3.368 | 10.610 | 9.072 | 0.700 | 0.156 |
| IV | Sand - 2 inches | 10 | 0.001 | 8.522 | 10.380 | 0.409 | 4.698 | 3.969 | 12.700 | 10.430 | 0.569 | 0.079 |
| | | 11 | 0.034 | 8.752 | 10.470 | 0.000 | 4.827 | 3.838 | 13.470 | 10.630 | 0.582 | 0.069 |
| V | Silty clay | 13 | 0.508 | 4.880 | 6.394 | 11.810 | 2.186 | 2.884 | 11.710 | 3.051 | 0.671 | 0.146 |
| | | 14 | 0.457 | 4.331 | 5.989 | 10.310 | 2.054 | 2.692 | 11.090 | 2.445 | 0.507 | 0.053 |
| VI | Apatite - 1 inch | 16 | 0.285 | 3.020 | 6.977 | 0.029 | 1.788 | 2.301 | 3.479 | 1.485 | 0.415 | 0.253 |
| | | 17 | 0.325 | 2.947 | 7.000 | 0.021 | 1.996 | 2.203 | 3.954 | 1.576 | 0.315 | 0.231 |
| VII | Apatite - 2 inches | 19 | 0.297 | 3.303 | 9.081 | 0.023 | 13.920 | 2.327 | 4.385 | 2.160 | 0.275 | 0.253 |
| | | 20 | 0.257 | 3.202 | 8.475 | 0.178 | 2.964 | 1.545 | 4.222 | 1.805 | 0.324 | 0.176 |
| VIII | Activated carbon | 22 | 0.336 | 1.422 | 1.337 | 0.726 | 1.360 | 3.019 | 5.798 | 0.721 | 0.241 | 0.206 |
| | | 23 | 0.240 | 1.420 | 1.173 | 1.100 | 1.518 | 2.832 | 6.067 | 0.738 | 0.264 | 0.146 |
| IX | Organoclay MRM | 25 | 0.132 | 8.985 | 11.260 | 0.125 | 5.196 | 3.669 | 9.878 | 6.800 | 0.346 | 0.323 |
| | | 26 | 0.022 | 8.121 | 10.650 | 0.199 | 5.039 | 3.544 | 8.935 | 6.646 | 0.317 | 0.337 |
| X | MAAC | 28 | 0.146 | 4.733 | 7.578 | 0.138 | 2.105 | 3.011 | 5.342 | 3.683 | 0.231 | 0.068 |
| | | 29 | 0.039 | 8.770 | 11.510 | 0.256 | 3.447 | 3.751 | 10.220 | 7.224 | 0.193 | 0.117 |
| | | | | | | | Unfiltered samples | | | | | |
| I | Spike solution | 1 | 2.070 | 13.720 | 15.130 | 4.510 | 11.870 | 4.602 | 15.750 | 15.170 | 0.980 | 3.241 |
| | | 3 | 3.307 | 14.210 | 16.050 | 3.609 | 15.390 | 5.798 | 17.180 | 15.330 | 0.797 | 4.270 |
| II | Sediment | 4 | 2.258 | 9.481 | 10.070 | 2.845 | 12.270 | 1.286 | 8.900 | 9.843 | 1.654 | 4.064 |
| | | 5 | 2.207 | 8.079 | 8.904 | 2.644 | 10.730 | 0.829 | 10.725 | 8.537 | 1.568 | 3.558 |
| III | Sand - 1 inch | 7 | 2.020 | 10.090 | 11.830 | 1.562 | 9.425 | 4.145 | 12.220 | 11.340 | 0.793 | 2.247 |
| | | 8 | 2.034 | 9.631 | 11.600 | 3.845 | 8.443 | 3.863 | 12.570 | 10.990 | 0.661 | 2.302 |
| IV | Sand - 2 inches | 10 | 1.892 | 10.330 | 12.200 | 1.399 | 7.764 | 4.441 | 12.740 | 11.630 | 0.708 | 1.892 |
| | | 11 | 2.114 | 10.790 | 12.880 | 5.481 | 9.711 | 4.445 | 13.450 | 12.500 | 0.680 | 2.466 |
| V | Silty clay | 13 | 2.934 | 7.496 | 9.859 | 34.900 | 17.180 | 2.914 | 3.999 | 6.875 | 1.422 | 7.639 |
| | | 14 | 3.191 | 6.859 | 9.476 | 35.140 | 17.220 | 3.153 | 5.029 | 5.705 | 1.345 | 8.010 |
| VI | Apatite - 1 inch | 16 | 5.401 | 4.692 | 11.160 | 1.971 | 14.850 | 5.026 | 4.074 | 4.029 | 0.524 | 2.272 |
| | | 17 | 4.231 | 4.169 | 10.410 | 1.773 | 12.660 | 4.776 | 3.518 | 3.279 | 0.313 | 1.996 |
| VII | Apatite - 2 inches | 19 | 3.631 | 4.351 | 11.290 | 1.345 | 10.440 | 3.935 | 4.291 | 3.692 | 0.319 | 1.468 |
| | | 20 | 3.320 | 3.992 | 10.600 | 1.655 | 14.740 | 3.364 | 3.647 | 3.327 | 0.234 | 1.836 |
| VIII | Activated carbon | 22 | 3.300 | 6.413 | 7.088 | 3.528 | 12.250 | 1.868 | 2.563 | 4.926 | 0.254 | 4.470 |
| | | 23 | 2.727 | 6.567 | 7.189 | 2.662 | 10.000 | 1.472 | 3.054 | 4.932 | 0.260 | 3.695 |
| IX | Organoclay MRM | 25 | 1.153 | 9.174 | 11.570 | 1.790 | 8.415 | 4.066 | 8.218 | 7.165 | 0.455 | 1.639 |
| | | 26 | 0.864 | 7.944 | 10.540 | 1.599 | 7.901 | 3.896 | 6.734 | 6.741 | 0.388 | 1.356 |
| X | MAAC | 28 | 1.366 | 5.304 | 8.451 | 1.933 | 7.520 | 3.503 | 5.756 | 4.521 | 0.259 | 2.210 |
| | | 29 | 1.713 | 9.444 | 12.660 | 1.684 | 8.188 | 4.795 | 10.760 | 8.922 | 0.297 | 2.184 |

Table A1.36. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 72 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | **Filtered samples** | | | | | | | | | |
| I | Spike solution | 1 | 2.233 | 18.630 | 20.630 | 4.904 | 15.640 | 6.324 | 22.230 | 22.270 | 3.566 | 4.321 |
| | | 3 | 3.969 | 19.700 | 29.130 | 19.160 | 27.200 | 8.434 | 24.820 | 22.650 | 2.701 | 8.133 |
| II | Sediment | 4 | 0.027 | 1.394 | 0.641 | 0.453 | 0.730 | 3.191 | 14.120 | 0.799 | 2.251 | 0.068 |
| | | 5 | 0.072 | 1.405 | 0.822 | 0.383 | 0.719 | 3.288 | 15.040 | 0.911 | 2.001 | 0.109 |
| III | Sand - 1 inch | 7 | 0.000 | 13.180 | 14.660 | 0.173 | 7.429 | 5.887 | 18.780 | 14.640 | 1.495 | 0.309 |
| | | 8 | 0.000 | 12.720 | 14.630 | 0.242 | 6.475 | 5.271 | 19.150 | 14.380 | 1.556 | 0.001 |
| IV | Sand - 2 inches | 10 | 0.000 | 13.820 | 16.350 | 1.170 | 6.439 | 6.222 | 20.800 | 16.260 | 1.308 | 0.959 |
| | | 11 | 0.002 | 14.550 | 16.660 | 0.173 | 6.727 | 6.026 | 20.550 | 16.350 | 1.380 | 0.066 |
| V | Silty clay | 13 | 0.652 | 7.487 | 10.430 | 23.790 | 29.820 | 4.453 | 18.040 | 5.465 | 2.329 | 0.742 |
| | | 14 | 0.569 | 6.961 | 8.917 | 11.560 | 5.507 | 3.909 | 18.350 | 4.774 | 1.796 | 0.326 |
| VI | Apatite - 1 inch | 16 | 0.342 | 4.777 | 8.758 | 0.522 | 3.051 | 2.821 | 5.747 | 2.067 | 1.095 | 0.119 |
| | | 17 | 0.306 | 4.217 | 9.242 | 0.196 | 2.115 | 2.839 | 6.402 | 2.044 | 1.005 | 0.174 |
| VII | Apatite - 2 inches | 19 | 0.382 | 4.863 | 10.540 | 0.354 | 2.157 | 3.018 | 6.039 | 2.784 | 0.862 | 0.148 |
| | | 20 | 0.249 | 4.380 | 9.453 | 2.407 | 3.382 | 1.840 | 4.806 | 2.271 | 0.674 | 0.181 |
| VIII | Activated carbon | 22 | 0.625 | 2.490 | 2.365 | 2.186 | 3.258 | 4.461 | 8.294 | 1.391 | 0.593 | 0.443 |
| | | 23 | 0.275 | 2.436 | 2.323 | 4.135 | 4.285 | 4.204 | 7.701 | 1.621 | 0.511 | 0.072 |
| IX | Organoclay MRM | 25 | 0.006 | 12.020 | 15.030 | 0.581 | 8.443 | 5.116 | 12.110 | 9.252 | 0.481 | 0.667 |
| | | 26 | 0.046 | 11.480 | 15.000 | 0.344 | 5.583 | 4.924 | 11.390 | 9.500 | 0.465 | 0.511 |
| X | MAAC | 28 | 0.063 | 5.758 | 9.055 | 0.301 | 21.440 | 3.468 | 7.454 | 4.386 | 0.313 | 0.054 |
| | | 29 | 0.064 | 12.510 | 16.170 | 0.098 | 4.645 | 5.864 | 14.650 | 10.440 | 0.231 | 0.019 |
| | | | **Unfiltered samples** | | | | | | | | | |
| I | Spike solution | 1 | 3.170 | 20.370 | 22.470 | 4.195 | 16.150 | 7.085 | 25.100 | 22.650 | 4.657 | 4.831 |
| | | 3 | 5.450 | 21.930 | 23.740 | 5.822 | 17.680 | 8.995 | 25.600 | 23.100 | 3.462 | 7.237 |
| II | Sediment | 4 | 3.118 | 10.750 | 11.580 | 4.138 | 11.700 | 2.217 | 16.115 | 11.190 | 2.397 | 3.925 |
| | | 5 | 3.188 | 9.595 | 10.930 | 3.417 | 11.670 | 1.797 | 16.541 | 10.030 | 2.225 | 4.218 |
| III | Sand - 1 inch | 7 | 4.444 | 16.360 | 18.050 | 3.796 | 11.520 | 7.147 | 17.660 | 16.150 | 1.898 | 3.985 |
| | | 8 | 3.360 | 16.460 | 18.290 | 4.260 | 10.370 | 6.323 | 18.930 | 16.630 | 1.518 | 3.532 |
| IV | Sand - 2 inches | 10 | 3.216 | 16.780 | 19.310 | 2.608 | 9.820 | 7.532 | 19.850 | 17.580 | 1.471 | 3.077 |
| | | 11 | 3.094 | 18.200 | 20.150 | 4.453 | 12.250 | 6.743 | 19.860 | 18.480 | 1.499 | 3.680 |
| V | Silty clay | 13 | 3.374 | 10.200 | 13.200 | 25.740 | 13.790 | 5.070 | 13.180 | 7.835 | 4.434 | 6.037 |
| | | 14 | 3.287 | 8.933 | 11.540 | 21.420 | 10.980 | 4.827 | 13.370 | 6.673 | 4.863 | 5.151 |
| VI | Apatite - 1 inch | 16 | 6.599 | 6.113 | 12.940 | 3.124 | 15.110 | 6.082 | 7.133 | 4.416 | 2.079 | 3.305 |
| | | 17 | 4.588 | 5.587 | 11.910 | 5.318 | 9.505 | 5.378 | 6.593 | 4.440 | 1.203 | 2.353 |
| VII | Apatite - 2 inches | 19 | 4.368 | 6.342 | 13.200 | 2.506 | 9.765 | 5.333 | 7.116 | 4.385 | 1.181 | 2.250 |
| | | 20 | 3.066 | 4.712 | 11.320 | 1.524 | 9.284 | 3.632 | 4.301 | 3.410 | 1.009 | 1.584 |
| VIII | Activated carbon | 22 | 4.501 | 8.062 | 9.067 | 4.239 | 10.140 | 4.020 | 5.937 | 6.065 | 0.732 | 4.770 |
| | | 23 | 3.465 | 7.722 | 8.953 | 3.274 | 9.166 | 3.692 | 6.103 | 5.837 | 0.686 | 3.814 |
| IX | Organoclay MRM | 25 | 1.607 | 13.560 | 16.670 | 2.459 | 8.643 | 6.042 | 13.070 | 9.523 | 0.867 | 2.067 |
| | | 26 | 0.737 | 12.550 | 16.390 | 1.574 | 8.526 | 5.058 | 10.010 | 9.451 | 0.766 | 1.299 |
| X | MAAC | 28 | 2.210 | 7.404 | 12.070 | 3.680 | 10.040 | 4.387 | 8.434 | 5.270 | 0.504 | 2.164 |
| | | 29 | 3.532 | 15.900 | 19.850 | 5.676 | 11.090 | 7.442 | 17.100 | 12.740 | 0.463 | 3.161 |

Table A1.37. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 144 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 7.005 | 39.350 | 40.830 | 8.538 | 28.660 | 17.990 | 43.880 | 45.050 | 3.124 | 11.260 |
| | | 3 | 8.924 | 40.670 | 42.740 | 13.200 | 32.090 | 20.660 | 48.430 | 45.480 | 2.518 | 13.900 |
| II | Sediment | 4 | 0.619 | 2.664 | 2.014 | 1.720 | 1.893 | 4.256 | 8.629 | 2.181 | 1.126 | 0.003 |
| | | 5 | 0.596 | 2.490 | 1.809 | 1.617 | 2.046 | 5.271 | 12.660 | 2.071 | 0.980 | 0.033 |
| III | Sand - 1 inch | 7 | 0.145 | 27.750 | 29.510 | 1.594 | 15.730 | 13.350 | 32.710 | 30.720 | 0.891 | 0.569 |
| | | 8 | 0.107 | 26.130 | 26.630 | 2.455 | 14.710 | 11.770 | 32.150 | 29.820 | 0.898 | 1.339 |
| IV | Sand - 2 inches | 10 | 0.039 | 27.460 | 28.830 | 1.061 | 15.870 | 14.170 | 36.050 | 31.920 | 0.908 | 0.474 |
| | | 11 | 0.062 | 28.100 | 28.800 | 2.541 | 15.130 | 12.790 | 32.140 | 31.550 | 0.654 | 1.267 |
| V | Silty clay | 13 | 1.106 | 9.375 | 12.430 | 14.030 | 4.273 | 7.844 | 20.740 | 5.487 | 1.076 | 1.368 |
| | | 14 | 0.928 | 9.794 | 12.580 | 12.250 | 4.407 | 7.179 | 23.630 | 6.453 | 1.099 | 1.226 |
| VI | Apatite - 1 inch | 16 | 0.491 | 6.252 | 10.070 | 2.390 | 3.040 | 4.588 | 6.505 | 2.639 | 0.617 | 0.161 |
| | | 17 | 0.461 | 7.016 | 11.930 | 1.534 | 5.491 | 4.750 | 7.922 | 3.101 | 0.431 | 0.136 |
| VII | Apatite - 2 inches | 19 | 0.616 | 6.869 | 12.420 | 1.075 | 3.245 | 4.237 | 5.520 | 3.541 | 0.369 | 0.173 |
| | | 20 | 0.386 | 5.468 | 10.750 | 6.263 | 3.620 | 3.045 | 5.394 | 3.240 | 0.275 | 0.122 |
| VIII | Activated carbon | 22 | 0.433 | 6.578 | 7.715 | 0.917 | 2.602 | 8.833 | 7.868 | 6.139 | 0.233 | 0.679 |
| | | 23 | 0.329 | 4.765 | 5.456 | 0.631 | 1.677 | 8.118 | 7.084 | 4.276 | 0.190 | 0.274 |
| IX | Organoclay MRM | 25 | 0.089 | 22.020 | 26.530 | 1.106 | 8.521 | 9.742 | 13.260 | 17.050 | 0.429 | 0.737 |
| | | 26 | -0.020 | 19.290 | 23.750 | 0.964 | 7.880 | 8.381 | 10.650 | 15.480 | 0.365 | 0.629 |
| X | MAAC | 28 | 0.152 | 6.324 | 10.960 | 0.560 | 2.306 | 5.428 | 7.158 | 4.373 | 0.219 | 0.036 |
| | | 29 | 0.243 | 19.630 | 25.700 | 0.614 | 10.030 | 9.367 | 18.220 | 14.420 | 0.197 | 0.010 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 9.915 | 44.460 | 45.950 | 12.680 | 31.430 | 18.750 | 44.020 | 45.530 | 2.068 | 17.050 |
| | | 3 | 11.580 | 47.180 | 50.120 | 16.670 | 35.140 | 22.030 | 47.750 | 48.120 | 1.911 | 20.140 |
| II | Sediment | 4 | 6.455 | 18.800 | 19.240 | 7.716 | 16.560 | 7.437 | 25.600 | 18.990 | 1.607 | 9.982 |
| | | 5 | 7.909 | 17.020 | 17.840 | 9.374 | 16.030 | 8.809 | 28.530 | 16.740 | 1.334 | 11.530 |
| III | Sand - 1 inch | 7 | 6.666 | 34.210 | 36.260 | 8.623 | 21.810 | 15.210 | 36.560 | 34.770 | 1.204 | 9.602 |
| | | 8 | 6.406 | 30.570 | 32.530 | 8.082 | 18.680 | 13.560 | 34.030 | 31.830 | 0.979 | 7.735 |
| IV | Sand - 2 inches | 10 | 7.071 | 34.170 | 35.820 | 8.054 | 21.030 | 15.890 | 35.520 | 35.740 | 0.897 | 7.985 |
| | | 11 | 3.978 | 32.320 | 34.040 | 6.257 | 20.840 | 13.550 | 33.960 | 33.190 | 0.665 | 6.535 |
| V | Silty clay | 13 | 6.505 | 15.010 | 19.080 | 35.530 | 19.410 | 9.239 | 27.890 | 10.930 | 2.278 | 12.110 |
| | | 14 | 5.694 | 14.280 | 17.660 | 24.780 | 14.440 | 9.147 | 26.780 | 10.300 | 2.250 | 8.978 |
| VI | Apatite - 1 inch | 16 | 9.021 | 9.226 | 15.510 | 5.888 | 15.690 | 8.832 | 7.799 | 5.467 | 1.049 | 5.107 |
| | | 17 | 5.664 | 9.677 | 16.070 | 4.055 | 12.780 | 8.407 | 8.690 | 5.913 | 0.628 | 4.152 |
| VII | Apatite - 2 inches | 19 | 8.846 | 9.774 | 22.030 | 4.963 | 14.000 | 8.188 | 7.040 | 5.980 | 0.513 | 3.821 |
| | | 20 | 6.697 | 7.613 | 14.590 | 5.510 | 17.310 | 6.257 | 6.096 | 4.739 | 0.486 | 3.729 |
| VIII | Activated carbon | 22 | 6.133 | 11.670 | 12.570 | 7.410 | 12.820 | 9.546 | 11.120 | 7.278 | 0.365 | 8.959 |
| | | 23 | 6.550 | 12.180 | 13.250 | 7.839 | 14.760 | 9.472 | 10.600 | 7.522 | 0.351 | 9.632 |
| IX | Organoclay MRM | 25 | 2.222 | 24.670 | 28.980 | 3.722 | 14.110 | 10.160 | 18.270 | 17.880 | 0.568 | 4.280 |
| | | 26 | 1.286 | 21.280 | 25.830 | 3.002 | 12.790 | 9.024 | 13.090 | 16.190 | 0.549 | 2.715 |
| X | MAAC | 28 | 5.630 | 9.826 | 15.230 | 5.967 | 12.740 | 7.538 | 7.315 | 6.156 | 0.421 | 5.528 |
| | | 29 | 6.469 | 23.830 | 29.910 | 6.511 | 16.870 | 11.880 | 19.190 | 18.390 | 0.357 | 7.240 |

Table A1.38. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 168 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 8.556 | 48.860 | 51.910 | 11.990 | 35.510 | 21.400 | 53.450 | 54.470 | 7.502 | 15.560 |
| | | 3 | 10.670 | 49.350 | 53.530 | 16.710 | 37.500 | 23.730 | 54.010 | 54.790 | 6.335 | 17.880 |
| II | Sediment | 4 | 2.041 | 4.160 | 3.737 | 1.966 | 4.055 | 8.654 | 13.740 | 3.361 | 1.294 | 1.289 |
| | | 5 | 0.860 | 1.865 | 1.715 | 0.687 | 1.353 | 9.422 | 18.360 | 1.976 | 1.861 | 0.075 |
| III | Sand - 1 inch | 7 | 0.158 | 31.830 | 33.590 | 2.448 | 17.730 | 14.770 | 40.230 | 33.120 | 2.396 | 0.199 |
| | | 8 | 0.077 | 30.560 | 32.380 | 2.864 | 18.030 | 13.760 | 37.780 | 34.600 | 1.961 | 1.907 |
| IV | Sand - 2 inches | 10 | 0.025 | 32.780 | 35.730 | 1.265 | 17.590 | 17.820 | 42.290 | 38.530 | 2.410 | 0.753 |
| | | 11 | 0.178 | 31.350 | 33.390 | 2.963 | 18.300 | 14.800 | 38.390 | 35.710 | 2.066 | 2.062 |
| V | Silty clay | 13 | 1.220 | 9.268 | 12.770 | 13.790 | 4.443 | 7.926 | 25.470 | 6.120 | 3.505 | 1.358 |
| | | 14 | 1.042 | 9.317 | 12.830 | 12.900 | 4.774 | 8.098 | 26.260 | 6.303 | 2.531 | 1.158 |
| VI | Apatite - 1 inch | 16 | 0.444 | 5.872 | 10.510 | 0.961 | 2.087 | 5.116 | 6.213 | 2.665 | 1.518 | 0.128 |
| | | 17 | 0.397 | 8.367 | 12.420 | 1.212 | 2.767 | 5.950 | 7.304 | 3.855 | 1.048 | 0.045 |
| VII | Apatite - 2 inches | 19 | 0.702 | 7.716 | 12.720 | 1.184 | 2.939 | 5.230 | 6.759 | 3.959 | 1.179 | 0.073 |
| | | 20 | 0.356 | 6.226 | 10.820 | 0.995 | 3.060 | 3.206 | 4.560 | 3.034 | 0.800 | 0.081 |
| VIII | Activated carbon | 22 | 0.966 | 5.031 | 4.896 | 1.253 | 2.600 | 10.950 | 7.642 | 3.029 | 0.639 | 1.462 |
| | | 23 | 0.793 | 4.719 | 4.647 | 0.981 | 2.299 | 10.830 | 7.889 | 2.868 | 0.529 | 1.036 |
| IX | Organoclay MRM | 25 | 0.000 | 20.350 | 25.190 | 0.976 | 9.070 | 10.490 | 16.040 | 16.670 | 0.818 | 0.806 |
| | | 26 | 0.070 | 18.990 | 24.360 | 1.118 | 9.328 | 9.817 | 14.210 | 16.650 | 0.590 | 0.777 |
| X | MAAC | 28 | 0.099 | 7.815 | 12.810 | 0.977 | 2.995 | 6.620 | 8.228 | 5.697 | 0.412 | 0.101 |
| | | 29 | 0.228 | 20.600 | 26.890 | 0.813 | 7.371 | 11.430 | 21.960 | 15.970 | 0.446 | 0.058 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 11.960 | 49.910 | 52.620 | 16.400 | 36.900 | 22.510 | 50.690 | 54.630 | 2.348 | 17.060 |
| | | 3 | 14.610 | 50.880 | 53.780 | 20.480 | 40.170 | 26.280 | 52.930 | 55.670 | 2.929 | 19.680 |
| II | Sediment | 4 | 6.446 | 17.640 | 18.780 | 7.593 | 18.100 | 6.740 | 28.040 | 18.590 | 4.456 | 7.679 |
| | | 5 | 8.523 | 16.010 | 16.920 | 9.282 | 16.340 | 7.742 | 31.020 | 16.170 | 4.120 | 8.863 |
| III | Sand - 1 inch | 7 | 8.470 | 38.060 | 41.320 | 10.260 | 25.190 | 18.310 | 41.250 | 40.480 | 3.896 | 8.839 |
| | | 8 | 9.954 | 33.820 | 36.740 | 10.640 | 22.990 | 18.180 | 41.100 | 36.010 | 3.225 | 8.022 |
| IV | Sand - 2 inches | 10 | 8.904 | 36.780 | 39.870 | 9.362 | 23.120 | 20.570 | 44.380 | 41.400 | 3.030 | 7.336 |
| | | 11 | 6.586 | 35.280 | 38.290 | 8.916 | 31.310 | 17.330 | 37.610 | 38.750 | 2.514 | 7.387 |
| V | Silty clay | 13 | 6.942 | 14.500 | 18.380 | 30.410 | 16.920 | 10.570 | 29.500 | 11.130 | 6.390 | 9.938 |
| | | 14 | 6.108 | 14.090 | 18.270 | 27.800 | 16.850 | 9.838 | 30.640 | 10.620 | 5.750 | 9.481 |
| VI | Apatite - 1 inch | 16 | 12.100 | 9.736 | 16.700 | 8.450 | 19.330 | 11.180 | 8.405 | 6.847 | 2.463 | 6.218 |
| | | 17 | 8.666 | 10.870 | 17.790 | 6.817 | 14.770 | 11.010 | 9.472 | 7.074 | 1.388 | 5.331 |
| VII | Apatite - 2 inches | 19 | 8.217 | 9.954 | 17.210 | 5.884 | 13.140 | 9.128 | 8.392 | 6.278 | 1.324 | 4.106 |
| | | 20 | 8.150 | 7.542 | 14.360 | 5.333 | 13.110 | 7.185 | 5.963 | 5.027 | 1.034 | 3.952 |
| VIII | Activated carbon | 22 | 8.990 | 13.120 | 14.800 | 10.650 | 16.500 | 10.990 | 9.666 | 8.406 | 0.836 | 10.590 |
| | | 23 | 9.331 | 13.340 | 15.330 | 10.170 | 18.090 | 10.410 | 9.887 | 9.389 | 0.854 | 10.050 |
| IX | Organoclay MRM | 25 | 2.854 | 24.340 | 30.410 | 4.894 | 13.450 | 11.620 | 16.870 | 18.840 | 0.979 | 3.382 |
| | | 26 | 1.504 | 22.180 | 28.080 | 3.388 | 11.650 | 10.340 | 14.180 | 17.370 | 0.886 | 2.074 |
| X | MAAC | 28 | 6.186 | 11.110 | 16.980 | 12.280 | 13.420 | 9.187 | 9.107 | 7.668 | 0.499 | 4.592 |
| | | 29 | 5.646 | 25.380 | 31.800 | 5.666 | 14.970 | 14.110 | 21.880 | 20.230 | 0.621 | 5.485 |

Table A1.39. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 240 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 9.876 | 94.750 | 99.780 | 17.640 | 68.230 | 44.230 | 89.190 | 95.670 | 4.192 | 17.500 |
| | | 3 | 9.496 | 96.930 | 102.500 | 24.390 | 70.350 | 46.650 | 98.290 | 102.000 | 2.709 | 22.170 |
| II | Sediment | 4 | 4.957 | 5.758 | 5.044 | 2.807 | 3.969 | 17.130 | 44.030 | 4.490 | 1.370 | 1.898 |
| | | 5 | 6.591 | 5.732 | 5.186 | 3.477 | 4.059 | 19.730 | 53.470 | 4.269 | 1.161 | 2.344 |
| III | Sand - 1 inch | 7 | 0.545 | 52.270 | 55.470 | 2.362 | 27.730 | 23.340 | 65.160 | 54.160 | 0.681 | 1.444 |
| | | 8 | 0.206 | 53.130 | 55.260 | 2.754 | 28.940 | 25.060 | 66.960 | 53.440 | 0.685 | 1.267 |
| IV | Sand - 2 inches | 10 | 0.098 | 63.910 | 66.220 | 2.020 | 33.750 | 29.540 | 74.860 | 68.960 | 0.806 | 0.841 |
| | | 11 | 0.125 | 58.870 | 60.980 | 2.357 | 32.920 | 25.000 | 69.670 | 62.910 | 0.581 | 1.366 |
| V | Silty clay | 13 | 3.771 | 18.120 | 21.450 | 16.840 | 9.720 | 14.310 | 50.930 | 10.960 | 1.231 | 4.085 |
| | | 14 | 2.242 | 16.810 | 19.780 | 13.840 | 6.827 | 12.550 | 49.650 | 10.420 | 1.002 | 2.600 |
| VI | Apatite - 1 inch | 16 | 1.558 | 15.240 | 22.710 | 1.121 | 2.930 | 15.900 | 12.480 | 8.466 | 0.477 | 0.564 |
| | | 17 | 0.944 | 9.182 | 14.470 | 1.733 | 2.942 | 6.889 | 8.167 | 3.473 | 0.291 | 0.113 |
| VII | Apatite - 2 inches | 19 | 1.515 | 16.490 | 24.130 | 1.903 | 4.516 | 9.864 | 11.310 | 7.322 | 0.230 | 0.003 |
| | | 20 | 0.788 | 6.916 | 12.520 | 4.011 | 3.126 | 4.596 | 5.785 | 3.653 | 0.226 | 0.081 |
| VIII | Activated carbon | 22 | 1.737 | 7.440 | 7.832 | 1.694 | 3.268 | 20.770 | 11.850 | 4.121 | 0.308 | 1.748 |
| | | 23 | 1.486 | 6.377 | 6.388 | 4.003 | 3.550 | 18.490 | 9.693 | 3.471 | 0.246 | 1.638 |
| IX | Organoclay MRM | 25 | 0.191 | 36.320 | 51.830 | 1.371 | 15.910 | 13.840 | 16.700 | 31.860 | 0.277 | 1.031 |
| | | 26 | 0.314 | 38.860 | 51.300 | 1.231 | 18.580 | 11.690 | 9.949 | 33.310 | 0.251 | 1.226 |
| X | MAAC | 28 | 0.813 | 18.180 | 29.290 | 0.842 | 5.473 | 13.230 | 19.700 | 13.770 | 0.186 | 0.140 |
| | | 29 | 0.679 | 17.620 | 27.510 | 2.422 | 5.677 | 10.780 | 15.890 | 12.500 | 0.161 | 0.108 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 18.380 | 92.680 | 98.740 | 27.570 | 70.050 | 47.460 | 94.380 | 101.000 | 1.847 | 28.050 |
| | | 3 | 12.660 | 96.610 | 102.800 | 28.770 | 74.000 | 46.770 | 96.280 | 103.000 | 1.262 | 26.780 |
| II | Sediment | 4 | 17.550 | 22.830 | 24.350 | 16.140 | 24.810 | 17.600 | 53.010 | 22.520 | 1.133 | 15.390 |
| | | 5 | 19.310 | 21.420 | 23.730 | 16.010 | 25.000 | 20.950 | 44.850 | 21.100 | 0.920 | 14.950 |
| III | Sand - 1 inch | 7 | 16.930 | 56.990 | 60.590 | 15.700 | 40.220 | 30.730 | 67.000 | 59.970 | 0.507 | 12.990 |
| | | 8 | 17.080 | 58.210 | 61.610 | 18.710 | 42.590 | 30.950 | 67.730 | 61.820 | 0.610 | 14.360 |
| IV | Sand - 2 inches | 10 | 17.120 | 65.800 | 69.140 | 15.610 | 45.880 | 36.520 | 74.810 | 74.460 | 0.532 | 12.980 |
| | | 11 | 15.950 | 61.190 | 65.430 | 16.400 | 41.740 | 30.770 | 72.980 | 69.360 | 0.383 | 13.200 |
| V | Silty clay | 13 | 10.940 | 21.240 | 25.920 | 31.870 | 23.630 | 17.430 | 51.590 | 16.040 | 1.800 | 14.060 |
| | | 14 | 8.166 | 19.710 | 23.570 | 26.170 | 18.990 | 15.350 | 50.730 | 15.340 | 1.930 | 12.330 |
| VI | Apatite - 1 inch | 16 | 14.680 | 14.000 | 21.210 | 10.710 | 19.480 | 15.450 | 10.680 | 8.351 | 0.699 | 8.520 |
| | | 17 | 14.920 | 13.190 | 20.020 | 10.280 | 19.650 | 14.870 | 10.370 | 7.918 | 0.463 | 8.807 |
| VII | Apatite - 2 inches | 19 | 13.000 | 20.240 | 28.310 | 9.247 | 17.680 | 15.560 | 14.490 | 11.420 | 0.387 | 7.125 |
| | | 20 | 13.020 | 9.892 | 16.570 | 8.968 | 17.610 | 10.610 | 6.793 | 6.705 | 0.449 | 6.765 |
| VIII | Activated carbon | 22 | 13.450 | 18.400 | 21.790 | 16.010 | 24.730 | 21.630 | 15.360 | 11.830 | 0.376 | 14.980 |
| | | 23 | 10.930 | 16.370 | 19.850 | 13.550 | 22.960 | 18.870 | 11.730 | 9.751 | 0.502 | 13.290 |
| IX | Organoclay MRM | 25 | 1.061 | 38.800 | 53.730 | 2.589 | 17.100 | 13.440 | 17.710 | 31.180 | 0.326 | 1.927 |
| | | 26 | 0.974 | 37.320 | 49.440 | 2.416 | 19.050 | 11.440 | 11.180 | 32.210 | 0.274 | 2.099 |
| X | MAAC | 28 | 11.270 | 23.210 | 34.000 | 13.770 | 18.020 | 17.720 | 19.340 | 18.410 | 0.218 | 9.086 |
| | | 29 | 9.923 | 21.920 | 30.260 | 9.686 | 15.640 | 15.550 | 17.330 | 15.910 | 0.199 | 8.068 |

Table A1.40. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 504 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 9.509 | 134.800 | 141.100 | 29.990 | 112.300 | 58.840 | 117.500 | 144.700 | 0.974 | 28.050 |
| | | 3 | 9.692 | 136.900 | 143.400 | 32.040 | 116.500 | 64.160 | 127.300 | 144.300 | 1.291 | 24.840 |
| II | Sediment | 4 | 7.382 | 12.000 | 11.390 | 5.077 | 11.310 | 22.580 | 60.220 | 10.950 | 0.832 | 2.682 |
| | | 5 | 11.240 | 18.420 | 18.390 | 7.905 | 18.200 | 29.450 | 71.480 | 17.180 | 0.867 | 5.404 |
| III | Sand - 1 inch | 7 | 0.436 | 67.100 | 67.610 | 2.823 | 41.610 | 28.630 | 79.380 | 69.930 | 0.672 | 1.132 |
| | | 8 | 0.254 | 76.610 | 77.830 | 3.215 | 49.490 | 27.170 | 87.160 | 80.760 | 0.705 | 1.165 |
| IV | Sand - 2 inches | 10 | 0.186 | 91.700 | 93.430 | 3.507 | 62.050 | 34.670 | 100.900 | 101.400 | 0.851 | 1.339 |
| | | 11 | 0.113 | 83.240 | 85.750 | 2.942 | 54.840 | 29.540 | 91.050 | 89.460 | 0.676 | 1.008 |
| V | Silty clay | 13 | 5.789 | 29.890 | 31.870 | 20.150 | 16.000 | 19.010 | 61.080 | 17.910 | 1.305 | 5.502 |
| | | 14 | 4.348 | 27.930 | 29.810 | 17.330 | 13.520 | 17.180 | 62.180 | 16.800 | 1.271 | 3.676 |
| VI | Apatite - 1 inch | 16 | 1.823 | 14.610 | 21.740 | 1.743 | 5.215 | 9.727 | 10.480 | 4.820 | 0.575 | 0.105 |
| | | 17 | 1.741 | 15.020 | 21.930 | 1.887 | 4.516 | 9.130 | 9.531 | 5.420 | 0.392 | 0.029 |
| VII | Apatite - 2 inches | 19 | 2.780 | 11.040 | 20.290 | 2.500 | 7.273 | 11.240 | 10.800 | 8.082 | 0.292 | 0.116 |
| | | 20 | 1.632 | 11.550 | 18.300 | 2.065 | 5.659 | 5.802 | 6.019 | 5.402 | 0.227 | 0.001 |
| VIII | Activated carbon | 22 | 4.409 | 13.940 | 15.200 | 5.131 | 9.624 | 29.790 | 18.970 | 8.657 | 0.521 | 3.896 |
| | | 23 | 3.646 | 10.310 | 11.610 | 4.008 | 7.255 | 27.320 | 13.830 | 5.326 | 0.417 | 3.324 |
| IX | Organoclay MRM | 25 | 0.262 | 65.550 | 78.570 | 2.627 | 34.980 | 10.780 | 14.180 | 57.240 | 0.274 | 1.726 |
| | | 26 | 1.251 | 64.950 | 75.500 | 2.802 | 52.600 | 6.754 | 9.455 | 65.130 | 0.174 | 5.220 |
| X | MAAC | 28 | 1.179 | 24.290 | 42.840 | 1.530 | 17.300 | 16.520 | 18.580 | 17.720 | 0.168 | 0.456 |
| | | 29 | 1.060 | 21.890 | 35.180 | 1.116 | 8.490 | 13.460 | 16.520 | 16.480 | 0.128 | 0.600 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 22.480 | 148.300 | 155.100 | 44.860 | 123.200 | 66.190 | 125.600 | 151.600 | 1.492 | 39.840 |
| | | 3 | 15.560 | 140.800 | 148.800 | 40.750 | 118.100 | 65.260 | 126.000 | 150.000 | 1.864 | 35.830 |
| II | Sediment | 4 | 22.850 | 30.410 | 32.170 | 19.200 | 34.560 | 28.760 | 62.300 | 28.790 | 1.359 | 17.070 |
| | | 5 | 23.120 | 30.360 | 30.880 | 19.080 | 32.700 | 34.160 | 69.820 | 29.220 | 1.035 | 16.720 |
| III | Sand - 1 inch | 7 | 27.730 | 82.260 | 85.590 | 28.880 | 65.900 | 41.980 | 85.940 | 83.220 | 0.662 | 21.200 |
| | | 8 | 26.750 | 90.300 | 93.630 | 29.060 | 72.080 | 40.260 | 93.180 | 92.370 | 0.779 | 21.700 |
| IV | Sand - 2 inches | 10 | 27.830 | 98.610 | 101.700 | 27.500 | 78.400 | 47.880 | 100.500 | 107.300 | 0.613 | 20.890 |
| | | 11 | 27.010 | 97.800 | 100.900 | 27.160 | 78.520 | 42.050 | 99.440 | 103.900 | 0.547 | 21.370 |
| V | Silty clay | 13 | 17.380 | 36.170 | 39.540 | 36.570 | 32.840 | 24.580 | 60.570 | 25.110 | 1.927 | 19.290 |
| | | 14 | 12.710 | 31.510 | 34.650 | 29.530 | 28.100 | 21.030 | 58.230 | 21.920 | 1.639 | 15.750 |
| VI | Apatite - 1 inch | 16 | 20.870 | 21.690 | 30.780 | 16.470 | 28.490 | 20.640 | 16.840 | 12.330 | 0.760 | 12.790 |
| | | 17 | 18.220 | 20.230 | 28.440 | 15.810 | 26.370 | 19.500 | 15.030 | 11.120 | 0.484 | 12.130 |
| VII | Apatite - 2 inches | 19 | 24.320 | 26.500 | 35.820 | 17.350 | 40.460 | 22.260 | 17.220 | 15.770 | 0.571 | 14.530 |
| | | 20 | 22.910 | 17.900 | 30.510 | 17.300 | 32.090 | 17.080 | 12.700 | 11.560 | 0.536 | 13.140 |
| VIII | Activated carbon | 22 | 18.450 | 24.000 | 29.550 | 22.140 | 33.040 | 34.490 | 18.170 | 14.610 | 0.619 | 17.670 |
| | | 23 | 20.410 | 23.480 | 28.970 | 26.540 | 36.050 | 31.910 | 13.080 | 12.900 | 0.644 | 20.400 |
| IX | Organoclay MRM | 25 | 2.285 | 65.860 | 82.480 | 6.261 | 38.970 | 11.540 | 12.930 | 55.500 | 0.382 | 4.401 |
| | | 26 | 1.740 | 65.210 | 83.590 | 4.966 | 59.360 | 6.857 | 10.410 | 61.310 | 0.370 | 5.758 |
| X | MAAC | 28 | 18.710 | 34.650 | 50.330 | 20.600 | 30.730 | 24.960 | 22.080 | 24.660 | 0.279 | 15.420 |
| | | 29 | 13.810 | 27.850 | 39.970 | 131.900 | 89.990 | 19.720 | 19.520 | 20.310 | 0.267 | 15.930 |

Table A1.41. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 672 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | **Filtered samples** | | | | | | | | | |
| I | Spike solution | 1 | 8.110 | 173.100 | 191.500 | 39.730 | 143.200 | 76.100 | 141.800 | 174.600 | 1.794 | 34.820 |
| | | 3 | 7.959 | 178.500 | 198.700 | 40.190 | 150.000 | 76.640 | 150.900 | 183.900 | 1.880 | 33.250 |
| II | Sediment | 4 | 12.090 | 19.590 | 19.550 | 7.016 | 16.450 | 29.820 | 73.760 | 15.860 | 1.313 | 3.464 |
| | | 5 | 16.600 | 26.660 | 26.930 | 9.749 | 22.340 | 36.790 | 91.360 | 21.950 | 1.452 | 5.207 |
| III | Sand - 1 inch | 7 | 2.429 | 83.870 | 86.740 | 4.223 | 52.240 | 37.150 | 107.500 | 78.740 | 1.083 | 1.171 |
| | | 8 | 2.286 | 104.600 | 110.100 | 6.451 | 68.950 | 31.350 | 115.000 | 102.300 | 0.802 | 1.572 |
| IV | Sand - 2 inches | 10 | 0.509 | 120.700 | 126.900 | 5.534 | 79.740 | 34.910 | 119.200 | 122.000 | 1.238 | 0.874 |
| | | 11 | 0.561 | 107.600 | 112.700 | 4.170 | 67.940 | 29.730 | 109.800 | 107.200 | 0.952 | 0.456 |
| V | Silty clay | 13 | 9.037 | 45.510 | 45.550 | 19.740 | 22.480 | 22.640 | 72.660 | 24.300 | 1.714 | 6.583 |
| | | 14 | 6.249 | 38.530 | 39.030 | 16.140 | 18.070 | 20.980 | 70.500 | 20.920 | 1.620 | 4.394 |
| VI | Apatite - 1 inch | 16 | 2.453 | 17.970 | 25.610 | 1.878 | 4.645 | 11.700 | 10.200 | 5.863 | 0.785 | 0.024 |
| | | 17 | 2.358 | 17.500 | 24.930 | 2.046 | 4.736 | 10.130 | 10.720 | 5.505 | 0.519 | 0.008 |
| VII | Apatite - 2 inch | 19 | 3.595 | 22.400 | 33.200 | 2.081 | 6.018 | 11.690 | 10.050 | 7.867 | 0.361 | 0.005 |
| | | 20 | 1.786 | 11.930 | 19.510 | 1.643 | 4.524 | 6.304 | 6.653 | 5.105 | 0.281 | 0.133 |
| VIII | Activated carbo | 22 | 4.489 | 13.520 | 15.780 | 4.337 | 7.832 | 38.320 | 26.000 | 7.393 | 0.530 | 2.738 |
| | | 23 | 4.592 | 12.850 | 16.280 | 5.284 | 8.615 | 34.580 | 17.630 | 6.382 | 0.482 | 4.216 |
| IX | Organoclay MR | 25 | 14.550 | 103.800 | 124.300 | 15.530 | 91.530 | 16.680 | 19.360 | 93.980 | 0.300 | 20.690 |
| | | 26 | 14.640 | 103.200 | 119.800 | 8.967 | 136.600 | 14.920 | 13.380 | 91.570 | 0.236 | 25.710 |
| X | MAAC | 28 | 1.110 | 27.220 | 52.290 | 1.333 | 8.389 | 19.960 | 25.320 | 19.000 | 0.265 | 0.370 |
| | | 29 | 1.249 | 23.530 | 41.790 | 1.012 | 8.461 | 16.300 | 19.620 | 17.860 | 0.233 | 0.159 |
| | | | **Unfiltered samples** | | | | | | | | | |
| I | Spike solution | 1 | 24.290 | 168.200 | 185.000 | 53.900 | 145.200 | 84.000 | 143.900 | 175.700 | 1.816 | 46.930 |
| | | 3 | 14.820 | 174.400 | 194.100 | 46.630 | 147.500 | 80.130 | 150.000 | 180.200 | 1.962 | 41.000 |
| II | Sediment | 4 | 29.500 | 31.970 | 34.680 | 20.470 | 33.220 | 38.930 | 72.380 | 30.430 | 1.182 | 18.030 |
| | | 5 | 29.960 | 34.430 | 37.120 | 21.010 | 34.760 | 43.650 | 88.140 | 32.850 | 1.069 | 16.690 |
| III | Sand - 1 inch | 7 | 38.390 | 102.600 | 109.900 | 36.680 | 79.490 | 55.730 | 106.300 | 98.330 | 1.213 | 26.330 |
| | | 8 | 33.730 | 120.800 | 129.000 | 35.370 | 92.050 | 48.110 | 115.400 | 116.800 | 1.174 | 24.880 |
| IV | Sand - 2 inches | 10 | 40.830 | 129.900 | 139.600 | 37.960 | 99.540 | 55.610 | 124.800 | 129.700 | 1.039 | 26.280 |
| | | 11 | 36.590 | 118.300 | 127.200 | 37.060 | 91.700 | 49.170 | 113.800 | 118.300 | 0.927 | 26.540 |
| V | Silty clay | 13 | 25.280 | 53.050 | 54.480 | 45.340 | 46.120 | 31.700 | 69.570 | 32.960 | 2.005 | 24.350 |
| | | 14 | 21.620 | 45.070 | 48.020 | 36.430 | 40.710 | 29.820 | 69.030 | 28.520 | 2.273 | 19.410 |
| VI | Apatite - 1 inch | 16 | 33.820 | 26.190 | 36.820 | 25.070 | 37.740 | 28.340 | 17.680 | 14.950 | 0.955 | 19.580 |
| | | 17 | 36.230 | 25.620 | 37.350 | 26.850 | 40.790 | 29.930 | 16.230 | 16.090 | 0.641 | 23.460 |
| VII | Apatite - 2 inch | 19 | 32.110 | 30.400 | 42.390 | 21.010 | 34.500 | 26.260 | 19.180 | 17.580 | 0.680 | 18.580 |
| | | 20 | 26.560 | 17.230 | 27.010 | 17.830 | 26.060 | 18.370 | 9.349 | 10.450 | 0.399 | 14.500 |
| VIII | Activated carbo | 22 | 28.990 | 35.580 | 44.130 | 33.770 | 43.690 | 44.360 | 21.420 | 20.400 | 0.511 | 26.190 |
| | | 23 | 25.500 | 27.410 | 37.010 | 29.440 | 36.820 | 40.560 | 16.960 | 13.260 | 0.558 | 22.700 |
| IX | Organoclay MR | 25 | 17.500 | 110.200 | 131.000 | 19.250 | 102.500 | 18.300 | 20.860 | 97.490 | 0.285 | 22.090 |
| | | 26 | 17.060 | 106.400 | 122.500 | 10.460 | 141.500 | 15.500 | 13.090 | 90.500 | 0.263 | 26.250 |
| X | MAAC | 28 | 29.370 | 44.220 | 67.180 | 30.670 | 38.390 | 33.400 | 27.140 | 28.530 | 0.240 | 23.010 |
| | | 29 | 17.780 | 33.580 | 50.740 | 15.540 | 24.000 | 23.670 | 21.410 | 23.210 | 0.239 | 13.110 |

Table A1.42. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 840 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 25.050 | 208.700 | 222.000 | 42.670 | 155.700 | 87.460 | 158.200 | 202.900 | 1.684 | 39.520 |
| | | 3 | 24.896 | 215.600 | 233.300 | 41.290 | 161.000 | 84.920 | 177.500 | 210.500 | 2.515 | 37.380 |
| II | Sediment | 4 | 13.700 | 11.850 | 10.700 | 3.255 | 9.382 | 28.740 | 77.960 | 9.266 | 1.050 | 1.686 |
| | | 5 | 14.800 | 19.700 | 18.490 | 4.576 | 14.950 | 33.590 | 76.740 | 16.320 | 1.377 | 2.184 |
| III | Sand - 1 inch | 7 | 2.915 | 94.060 | 93.660 | 3.782 | 51.900 | 38.090 | 116.700 | 86.940 | 0.673 | 2.554 |
| | | 8 | 1.445 | 127.700 | 130.000 | 4.994 | 77.980 | 31.360 | 130.700 | 122.600 | 0.679 | 2.710 |
| IV | Sand - 2 inche | 10 | 0.355 | 142.500 | 145.700 | 5.458 | 89.670 | 32.650 | 134.600 | 144.900 | 0.475 | 2.781 |
| | | 11 | 0.492 | 127.700 | 129.500 | 3.863 | 74.370 | 29.120 | 123.500 | 122.400 | 0.517 | 1.594 |
| V | Silty clay | 13 | 6.920 | 46.350 | 42.110 | 16.390 | 22.020 | 18.320 | 71.700 | 22.690 | 1.281 | 4.155 |
| | | 14 | 6.157 | 45.010 | 42.630 | 15.640 | 22.970 | 18.200 | 65.960 | 23.480 | 1.346 | 3.888 |
| VI | Apatite - 1 inc | 16 | 2.797 | 17.050 | 24.430 | 1.321 | 4.631 | 11.060 | 9.069 | 4.955 | 0.732 | 0.150 |
| | | 17 | 2.582 | 13.610 | 21.680 | 1.375 | 3.868 | 8.787 | 8.577 | 4.347 | 0.404 | 0.068 |
| VII | Apatite - 2 inc | 19 | 3.460 | 20.880 | 29.530 | 1.410 | 5.311 | 10.950 | 10.470 | 7.214 | 0.504 | 0.243 |
| | | 20 | 1.729 | 12.100 | 18.330 | 1.120 | 4.311 | 5.457 | 6.495 | 4.638 | 0.447 | 0.255 |
| VIII | Activated carb | 22 | 4.241 | 11.330 | 12.820 | 3.201 | 5.351 | 44.280 | 19.950 | 5.545 | 0.910 | 1.977 |
| | | 23 | 4.486 | 9.391 | 11.230 | 3.396 | 6.189 | 39.180 | 18.510 | 3.849 | 0.854 | 2.490 |
| IX | Organoclay M | 25 | 16.660 | 121.500 | 137.400 | 11.680 | 146.900 | 17.820 | 12.870 | 118.100 | 0.338 | 26.440 |
| | | 26 | 15.780 | 133.000 | 134.900 | 6.550 | 161.500 | 13.690 | 13.180 | 104.200 | 0.291 | 27.980 |
| X | MAAC | 28 | 1.359 | 24.070 | 53.470 | 0.752 | 6.798 | 18.720 | 19.510 | 11.700 | 0.279 | 0.201 |
| | | 29 | 1.563 | 21.890 | 44.510 | 0.733 | 6.594 | 14.960 | 15.680 | 14.520 | 0.230 | 0.145 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 36.650 | 212.200 | 230.600 | 70.820 | 180.800 | 102.600 | 169.700 | 203.200 | 0.962 | 57.960 |
| | | 3 | 23.430 | 216.900 | 234.700 | 62.390 | 173.500 | 94.280 | 172.600 | 208.500 | 1.789 | 48.130 |
| II | Sediment | 4 | 33.980 | 50.840 | 53.840 | 33.780 | 51.440 | 33.560 | 93.840 | 44.460 | 0.866 | 29.050 |
| | | 5 | 38.180 | 51.890 | 53.220 | 34.140 | 50.340 | 43.890 | 98.620 | 44.280 | 0.805 | 26.830 |
| III | Sand - 1 inch | 7 | 43.330 | 111.900 | 114.900 | 42.250 | 86.930 | 60.060 | 117.300 | 104.500 | 0.451 | 31.250 |
| | | 8 | 47.300 | 149.200 | 156.500 | 46.650 | 110.800 | 57.430 | 133.600 | 138.500 | 0.492 | 34.650 |
| IV | Sand - 2 inche | 10 | 49.710 | 154.700 | 162.100 | 47.090 | 116.000 | 58.840 | 137.400 | 149.600 | 0.364 | 34.960 |
| | | 11 | 38.910 | 134.500 | 140.800 | 41.510 | 109.600 | 49.940 | 123.700 | 131.600 | 0.343 | 29.260 |
| V | Silty clay | 13 | 16.100 | 48.200 | 46.900 | 31.140 | 35.160 | 22.760 | 76.300 | 25.660 | 1.819 | 14.490 |
| | | 14 | 13.960 | 47.370 | 46.560 | 25.140 | 33.090 | 20.620 | 75.840 | 25.920 | 1.873 | 12.840 |
| VI | Apatite - 1 inc | 16 | 45.920 | 30.080 | 42.540 | 32.940 | 47.660 | 33.830 | 18.160 | 17.720 | 0.695 | 29.550 |
| | | 17 | 38.550 | 24.710 | 35.580 | 28.040 | 40.140 | 29.040 | 14.740 | 14.150 | 0.414 | 25.890 |
| VII | Apatite - 2 inc | 19 | 29.580 | 28.430 | 39.970 | 20.550 | 35.070 | 24.400 | 15.280 | 16.720 | 0.437 | 20.430 |
| | | 20 | 36.360 | 18.530 | 27.800 | 24.440 | 36.280 | 23.220 | 10.780 | 12.120 | 0.372 | 22.670 |
| VIII | Activated carb | 22 | 28.090 | 34.040 | 42.830 | 35.880 | 48.220 | 46.970 | 19.320 | 19.460 | 0.461 | 30.170 |
| | | 23 | 29.800 | 29.070 | 38.520 | 33.820 | 44.380 | 43.890 | 24.320 | 14.270 | 0.647 | 28.690 |
| IX | Organoclay M | 25 | 17.090 | 123.700 | 139.700 | 12.280 | 152.500 | 18.200 | 16.190 | 113.500 | 0.231 | 26.930 |
| | | 26 | 16.370 | 135.800 | 140.600 | 8.161 | 166.300 | 15.230 | 12.380 | 122.000 | 0.220 | 29.220 |
| X | MAAC | 28 | 32.750 | 42.160 | 65.780 | 29.040 | 38.710 | 31.470 | 20.870 | 24.120 | 0.202 | 29.240 |
| | | 29 | 31.090 | 35.010 | 52.300 | 25.210 | 32.770 | 25.220 | 15.950 | 22.220 | 0.164 | 24.850 |

TableA1.43. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at time 1008 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | | | | | Filtered samples | | | | | |
| I | Spike solution | 1 | 33.892 | 224.300 | 251.000 | 46.780 | 197.600 | 106.400 | 180.400 | 233.300 | 2.764 | 38.460 |
| | | 3 | 33.369 | 222.200 | 252.800 | 41.260 | 196.100 | 95.050 | 190.500 | 230.200 | 2.375 | 38.500 |
| II | Sediment | 4 | 10.840 | 13.870 | 14.200 | 2.396 | 12.260 | 24.400 | 59.380 | 13.430 | 1.539 | 0.149 |
| | | 5 | 9.638 | 15.600 | 15.280 | 2.461 | 14.220 | 30.090 | 56.130 | 14.640 | 1.499 | 0.109 |
| III | Sand - 1 inch | 7 | 2.030 | 107.500 | 109.300 | 4.079 | 67.970 | 40.890 | 132.900 | 104.500 | 0.998 | 1.408 |
| | | 8 | 0.983 | 152.200 | 158.800 | 6.782 | 103.800 | 35.910 | 145.100 | 148.600 | 0.675 | 1.751 |
| IV | Sand - 2 inches | 10 | 0.301 | 163.600 | 169.500 | 5.993 | 110.900 | 35.120 | 156.300 | 169.000 | 1.049 | 2.011 |
| | | 11 | 0.464 | 142.800 | 148.200 | 4.688 | 94.090 | 32.760 | 139.400 | 145.300 | 0.642 | 1.202 |
| V | Silty clay | 13 | 8.022 | 42.940 | 39.700 | 17.270 | 21.210 | 19.110 | 67.770 | 18.550 | 1.107 | 4.649 |
| | | 14 | 5.646 | 44.360 | 42.030 | 14.760 | 23.760 | 18.810 | 66.830 | 21.370 | 1.001 | 3.596 |
| VI | Apatite - 1 inch | 16 | 3.006 | 19.590 | 29.490 | 1.798 | 4.772 | 13.330 | 12.910 | 5.759 | 0.745 | 0.080 |
| | | 17 | 2.273 | 17.310 | 26.370 | 1.425 | 4.448 | 11.520 | 10.480 | 5.145 | 0.429 | 0.257 |
| VII | Apatite - 2 inches | 19 | 3.953 | 28.580 | 41.130 | 2.087 | 6.889 | 14.980 | 14.260 | 8.944 | 0.514 | 0.033 |
| | | 20 | 1.874 | 12.910 | 20.480 | 1.603 | 4.523 | 7.284 | 8.190 | 5.009 | 0.365 | 0.154 |
| VIII | Activated carbon | 22 | 1.400 | 7.957 | 9.390 | 2.164 | 2.212 | 50.480 | 23.610 | 4.642 | 0.332 | 0.049 |
| | | 23 | 1.190 | 6.476 | 7.933 | 0.482 | 1.050 | 46.860 | 25.390 | 3.777 | 0.351 | 0.115 |
| IX | Organoclay MRM | 25 | 17.940 | 158.300 | 176.700 | 16.580 | 189.100 | 22.370 | 20.690 | 143.600 | 0.411 | 31.350 |
| | | 26 | 18.020 | 146.700 | 163.600 | 14.280 | 200.300 | 20.080 | 20.750 | 125.900 | 0.303 | 35.440 |
| X | MAAC | 28 | 0.380 | 34.080 | 62.370 | 0.684 | 12.990 | 20.600 | 31.190 | 7.561 | 0.303 | 0.385 |
| | | 29 | 0.632 | 29.680 | 53.410 | 0.811 | 11.800 | 18.670 | 23.440 | 20.360 | 0.270 | 0.067 |
| | | | | | | | Unfiltered samples | | | | | |
| I | Spike solution | 1 | 33.870 | 244.200 | 259.300 | 71.910 | 199.400 | 119.000 | 194.200 | 238.300 | 2.774 | 64.790 |
| | | 3 | 34.200 | 241.100 | 261.200 | 56.050 | 195.000 | 98.240 | 197.500 | 241.400 | 2.390 | 46.900 |
| II | Sediment | 4 | 26.850 | 44.930 | 46.110 | 25.850 | 43.820 | 31.300 | 97.510 | 41.320 | 2.349 | 23.750 |
| | | 5 | 29.050 | 50.180 | 51.320 | 31.330 | 47.550 | 39.860 | 92.250 | 46.160 | 1.521 | 26.730 |
| III | Sand - 1 inch | 7 | 36.770 | 130.700 | 134.300 | 42.500 | 98.140 | 64.040 | 137.600 | 127.000 | 1.078 | 31.650 |
| | | 8 | 41.490 | 171.100 | 177.800 | 47.190 | 129.600 | 63.910 | 157.300 | 166.100 | 0.829 | 36.380 |
| IV | Sand - 2 inches | 10 | 54.800 | 181.700 | 189.200 | 55.570 | 140.400 | 70.720 | 163.900 | 183.800 | 1.325 | 41.620 |
| | | 11 | 43.230 | 160.200 | 166.900 | 49.620 | 124.400 | 61.320 | 144.300 | 156.800 | 0.838 | 35.080 |
| V | Silty clay | 13 | 25.930 | 58.450 | 57.050 | 60.390 | 55.240 | 29.270 | 73.710 | 36.370 | 1.715 | 30.160 |
| | | 14 | 23.090 | 56.550 | 54.130 | 45.840 | 47.110 | 29.370 | 70.040 | 32.920 | 1.947 | 24.290 |
| VI | Apatite - 1 inch | 16 | 47.260 | 35.870 | 47.830 | 36.770 | 47.270 | 39.550 | 21.960 | 20.200 | 0.688 | 31.180 |
| | | 17 | 50.520 | 33.650 | 45.750 | 38.650 | 50.350 | 40.760 | 19.830 | 19.660 | 0.507 | 34.090 |
| VII | Apatite - 2 inches | 19 | 40.020 | 42.690 | 55.440 | 30.070 | 47.610 | 36.300 | 24.750 | 23.960 | 0.546 | 27.550 |
| | | 20 | 41.860 | 23.540 | 33.400 | 28.960 | 41.010 | 28.860 | 14.090 | 14.410 | 0.493 | 24.780 |
| VIII | Activated carbon | 22 | 29.640 | 48.370 | 58.930 | 47.040 | 61.230 | 54.970 | 29.800 | 27.820 | 0.432 | 37.330 |
| | | 23 | 29.030 | 42.050 | 52.040 | 42.290 | 58.090 | 51.510 | 28.360 | 21.970 | 0.351 | 33.770 |
| IX | Organoclay MRM | 25 | 21.110 | 167.600 | 183.800 | 18.360 | 192.500 | 23.550 | 25.130 | 148.000 | 0.370 | 35.190 |
| | | 26 | 25.880 | 155.500 | 169.200 | 18.340 | 202.700 | 23.990 | 29.800 | 128.300 | 0.379 | 40.740 |
| X | MAAC | 28 | 49.100 | 63.930 | 85.800 | 45.740 | 56.600 | 44.500 | 31.290 | 36.340 | 0.336 | 41.670 |
| | | 29 | 37.140 | 52.270 | 69.660 | 30.850 | 47.380 | 35.580 | 29.840 | 35.280 | 0.313 | 32.130 |

Table A1.44. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at 1896 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 9.950 | 207.100 | 383.500 | 150.800 | 375.400 | 210.300 | 266.100 | 427.400 | 28.300 | 53.010 |
| | | 3 | 12.940 | 201.100 | 382.500 | 165.400 | 386.000 | 136.500 | 303.800 | 431.100 | 29.230 | 49.440 |
| II | Sediment | 4 | 21.650 | 39.050 | 33.050 | 7.067 | 6.078 | 43.570 | 107.800 | 45.240 | 0.000 | 0.000 |
| | | 5 | 19.400 | 37.660 | 31.270 | 5.564 | 4.536 | 44.120 | 112.400 | 42.380 | 0.000 | 0.000 |
| III | Sand - 1 inch | 7 | 0.731 | 117.400 | 200.400 | 14.240 | 153.100 | 68.880 | 243.700 | 241.700 | 0.000 | 0.000 |
| | | 8 | 0.117 | 134.300 | 238.200 | 22.140 | 201.900 | 65.690 | 263.700 | 289.900 | 0.000 | 0.000 |
| IV | Sand - 2 inches | 10 | 0.035 | 145.700 | 248.400 | 17.460 | 214.400 | 62.420 | 265.300 | 323.100 | 0.000 | 0.000 |
| | | 11 | 0.000 | 126.600 | 192.900 | 12.280 | 167.300 | 60.380 | 235.600 | 298.900 | 0.000 | 0.000 |
| V | Silty clay | 13 | 2.854 | 44.480 | 31.840 | 10.560 | 0.000 | 28.120 | 131.300 | 20.870 | 0.000 | 0.000 |
| | | 14 | 3.115 | 55.750 | 40.300 | 9.733 | 0.000 | 37.440 | 155.100 | 26.860 | 0.000 | 0.000 |
| VI | Apatite - 1 inch | 16 | 5.305 | 23.150 | 32.750 | 0.000 | 0.000 | 25.940 | 24.100 | 8.590 | 0.000 | 0.000 |
| | | 17 | 4.290 | 29.810 | 40.070 | 0.371 | 0.000 | 29.430 | 23.760 | 9.749 | 0.000 | 0.000 |
| VII | Apatite - 2 inches | 19 | 5.085 | 34.660 | 44.140 | 0.413 | 0.000 | 23.410 | 27.010 | 14.840 | 0.000 | 0.000 |
| | | 20 | 2.897 | 21.940 | 29.120 | 0.000 | 0.000 | 16.830 | 15.510 | 9.424 | 0.000 | 0.000 |
| VIII | Activated carbon | 22 | 1.346 | 11.310 | 10.160 | 0.000 | 0.000 | 121.000 | 92.460 | 9.845 | 0.000 | 0.000 |
| | | 23 | 1.212 | 9.879 | 9.520 | 0.000 | 0.000 | 113.800 | 91.670 | 9.430 | 0.000 | 0.000 |
| IX | Organoclay MRM | 25 | 43.060 | 155.400 | 297.600 | 60.150 | 398.200 | 58.390 | 62.560 | 348.500 | 0.000 | 70.770 |
| | | 26 | 44.700 | 176.900 | 323.400 | 41.110 | 446.200 | 49.840 | 53.530 | 361.000 | 0.000 | 70.800 |
| X | MAAC | 28 | 0.000 | 71.020 | 89.100 | 0.000 | 0.000 | 33.580 | 72.030 | 13.300 | 0.000 | 0.000 |
| | | 29 | 0.000 | 44.800 | 69.770 | 0.000 | 0.000 | 28.840 | 44.470 | 13.770 | 0.000 | 0.000 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 89.930 | 186.900 | 371.200 | 258.900 | 409.100 | 272.200 | 308.300 | 408.000 | 5.573 | 119.600 |
| | | 3 | 62.910 | 178.200 | 366.200 | 227.900 | 409.700 | 177.800 | 307.500 | 400.300 | 49.040 | 99.000 |
| II | Sediment | 4 | 90.310 | 96.750 | 92.900 | 61.330 | 115.400 | 70.360 | 114.800 | 97.910 | 9.596 | 38.830 |
| | | 5 | 101.700 | 103.100 | 96.190 | 73.890 | 131.400 | 72.670 | 105.500 | 94.720 | 6.767 | 43.730 |
| III | Sand - 1 inch | 7 | 78.360 | 193.500 | 240.800 | 117.000 | 237.900 | 121.500 | 231.200 | 271.600 | 4.147 | 53.570 |
| | | 8 | 84.020 | 143.500 | 282.800 | 140.400 | 293.600 | 131.000 | 266.800 | 321.800 | 8.465 | 68.320 |
| IV | Sand - 2 inches | 10 | 74.520 | 145.200 | 280.400 | 123.800 | 265.300 | 118.600 | 245.800 | 328.600 | 5.341 | 57.940 |
| | | 11 | 86.550 | 139.600 | 274.500 | 129.700 | 274.400 | 130.200 | 288.500 | 323.100 | 6.426 | 70.520 |
| V | Silty clay | 13 | 98.220 | 101.000 | 96.570 | 166.700 | 144.900 | 80.650 | 149.000 | 66.110 | 17.070 | 83.050 |
| | | 14 | 76.290 | 102.000 | 94.340 | 124.600 | 120.200 | 73.850 | 146.000 | 60.540 | 14.460 | 51.420 |
| VI | Apatite - 1 inch | 16 | 9.508 | 28.950 | 40.070 | 5.641 | 6.243 | 33.060 | 33.770 | 9.068 | 3.701 | 2.774 |
| | | 17 | 39.140 | 43.310 | 57.770 | 39.930 | 34.890 | 54.180 | 35.650 | 21.150 | 4.580 | 25.560 |
| VII | Apatite - 2 inches | 19 | 45.520 | 52.640 | 67.230 | 42.800 | 44.950 | 50.740 | 37.290 | 27.100 | 4.495 | 26.440 |
| | | 20 | 66.770 | 40.720 | 50.320 | 60.530 | 69.700 | 55.420 | 35.330 | 25.730 | 6.381 | 43.260 |
| VIII | Activated carbon | 22 | 98.930 | 85.650 | 102.500 | 130.500 | 145.300 | 127.900 | 87.080 | 52.310 | 8.113 | 71.850 |
| | | 23 | 109.100 | 81.590 | 100.600 | 133.700 | 143.500 | 132.500 | 88.880 | 50.380 | 8.632 | 80.880 |
| IX | Organoclay MRM | 25 | 57.670 | 184.500 | 362.900 | 79.520 | 454.900 | 67.550 | 64.370 | 327.200 | 11.220 | 75.110 |
| | | 26 | 57.180 | 180.100 | 348.500 | 54.980 | 464.200 | 54.150 | 51.420 | 326.400 | 9.568 | 64.680 |
| X | MAAC | 28 | 27.700 | 91.530 | 117.400 | 37.390 | 36.500 | 51.270 | 81.790 | 35.730 | 4.074 | 19.940 |
| | | 29 | 9.729 | 54.850 | 80.120 | 11.910 | 12.140 | 35.090 | 48.510 | 18.540 | 2.264 | 5.805 |

Table A1.45. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at 2016 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 15.170 | 196.600 | 372.800 | 124.400 | 385.500 | 225.800 | 296.200 | 430.100 | 0.146 | 23.070 |
| | | 3 | 23.790 | 196.100 | 372.500 | 181.300 | 390.200 | 171.800 | 348.900 | 432.100 | 20.870 | 50.470 |
| II | Sediment | 4 | 21.650 | 32.010 | 28.600 | 5.185 | 0.000 | 50.830 | 123.100 | 34.450 | 1.060 | 0.000 |
| | | 5 | 18.190 | 33.860 | 29.270 | 7.592 | 0.000 | 53.650 | 129.400 | 37.490 | 0.302 | 0.000 |
| III | Sand - 1 inch | 7 | 1.078 | 112.000 | 187.100 | 15.270 | 149.300 | 85.450 | 251.200 | 246.700 | 0.263 | 0.905 |
| | | 8 | 0.978 | 135.300 | 231.800 | 22.840 | 204.000 | 83.400 | 272.000 | 295.700 | 0.134 | 2.475 |
| IV | Sand - 2 inches | 10 | 0.822 | 146.800 | 255.000 | 28.830 | 230.100 | 77.510 | 285.300 | 334.600 | 0.130 | 4.284 |
| | | 11 | 0.755 | 124.800 | 204.500 | 18.980 | 171.500 | 80.680 | 258.600 | 273.800 | 0.105 | 2.028 |
| V | Silty clay | 13 | 4.045 | 54.000 | 39.560 | 17.040 | 0.000 | 37.200 | 143.700 | 24.800 | 0.778 | 0.221 |
| | | 14 | 4.816 | 63.570 | 47.090 | 16.400 | 0.000 | 46.600 | 168.200 | 32.950 | 1.027 | 0.691 |
| VI | Apatite - 1 inch | 16 | 6.801 | 27.270 | 38.570 | 2.515 | 0.000 | 30.670 | 28.780 | 9.222 | 0.469 | 0.000 |
| | | 17 | 5.441 | 29.170 | 41.100 | 1.865 | 0.000 | 33.040 | 28.440 | 9.587 | 0.371 | 0.000 |
| VII | Apatite - 2 inches | 19 | 6.154 | 50.180 | 62.700 | 2.454 | 0.000 | 43.090 | 36.880 | 19.300 | 0.317 | 0.000 |
| | | 20 | 3.501 | 29.900 | 39.430 | 1.424 | 0.000 | 26.510 | 24.420 | 12.640 | 0.376 | 0.000 |
| VIII | Activated carbon | 22 | 1.674 | 12.820 | 10.870 | -0.412 | 0.000 | 125.400 | 92.440 | 11.300 | 1.358 | 0.000 |
| | | 23 | 1.722 | 10.740 | 9.774 | -0.471 | 0.000 | 123.500 | 87.570 | 9.165 | 0.690 | 0.000 |
| IX | Organoclay MRM | 25 | 55.890 | 175.700 | 344.000 | 79.020 | 444.800 | 64.940 | 66.360 | 360.100 | 0.770 | 88.100 |
| | | 26 | 57.830 | 189.900 | 351.800 | 74.690 | 485.500 | 59.870 | 64.340 | 363.600 | 0.578 | 91.010 |
| X | MAAC | 28 | 0.060 | 74.510 | 97.300 | 0.033 | 0.000 | 35.660 | 71.460 | 17.800 | 0.754 | 0.000 |
| | | 29 | 0.201 | 45.730 | 75.640 | 2.113 | 0.000 | 33.350 | 48.020 | 24.380 | 0.564 | 1.762 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 35.640 | 190.900 | 364.000 | 178.600 | 415.900 | 248.300 | 328.800 | 445.800 | 0.930 | 81.480 |
| | | 3 | 39.710 | 193.800 | 374.300 | 192.700 | 399.900 | 183.000 | 346.200 | 435.900 | 27.200 | 75.230 |
| II | Sediment | 4 | 76.670 | 83.610 | 77.930 | 66.820 | 74.310 | 61.350 | 109.100 | 92.160 | 4.670 | 52.100 |
| | | 5 | 68.940 | 72.220 | 65.560 | 59.670 | 60.430 | 61.010 | 117.600 | 80.670 | 5.269 | 45.960 |
| III | Sand - 1 inch | 7 | 19.360 | 128.900 | 208.600 | 57.240 | 191.000 | 101.100 | 253.300 | 276.100 | 1.663 | 27.670 |
| | | 8 | 20.910 | 144.800 | 247.300 | 63.140 | 229.500 | 104.000 | 278.300 | 320.500 | 1.528 | 32.000 |
| IV | Sand - 2 inches | 10 | 27.240 | 150.300 | 258.600 | 73.050 | 258.300 | 103.400 | 296.000 | 366.700 | 1.574 | 39.210 |
| | | 11 | 4.974 | 122.100 | 206.900 | 31.560 | 175.300 | 83.130 | 260.900 | 290.000 | 0.957 | 11.460 |
| V | Silty clay | 13 | 65.970 | 73.340 | 64.320 | 95.830 | 70.020 | 65.170 | 126.900 | 48.520 | 15.060 | 63.470 |
| | | 14 | 65.530 | 90.440 | 78.980 | 106.300 | 79.670 | 77.680 | 153.300 | 62.390 | 13.910 | 68.370 |
| VI | Apatite - 1 inch | 16 | 46.910 | 39.480 | 49.030 | 46.080 | 10.550 | 60.150 | 38.310 | 22.970 | 5.672 | 37.030 |
| | | 17 | 41.310 | 38.120 | 49.880 | 45.860 | 4.987 | 57.740 | 32.890 | 22.100 | 4.233 | 35.010 |
| VII | Apatite - 2 inches | 19 | 32.950 | 54.370 | 61.400 | 38.410 | 4.623 | 59.350 | 40.490 | 32.600 | 3.103 | 26.130 |
| | | 20 | 34.450 | 34.510 | 45.110 | 38.410 | 3.073 | 43.190 | 27.790 | 22.910 | 3.273 | 27.320 |
| VIII | Activated carbon | 22 | 98.600 | 77.030 | 93.140 | 139.200 | 114.800 | 137.600 | 86.690 | 60.400 | 9.550 | 101.500 |
| | | 23 | 108.200 | 74.580 | 88.870 | 136.100 | 112.200 | 137.400 | 78.300 | 52.120 | 10.310 | 100.100 |
| IX | Organoclay MRM | 25 | 59.650 | 162.300 | 312.900 | 79.510 | 450.700 | 68.980 | 63.690 | 364.100 | 7.890 | 98.160 |
| | | 26 | 64.520 | 171.000 | 307.400 | 73.820 | 479.700 | 68.800 | 59.500 | 371.400 | 9.159 | 104.500 |
| X | MAAC | 28 | 36.140 | 82.870 | 101.900 | 49.860 | 12.010 | 57.310 | 74.410 | 48.090 | 6.718 | 36.790 |
| | | 29 | 16.960 | 46.720 | 67.690 | 23.310 | 0.000 | 41.510 | 46.460 | 33.500 | 2.412 | 18.870 |

Table A1.46. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at 2040 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 13.79 | 193.50 | 373.90 | 119.50 | 404.50 | 222.60 | 299.90 | 431.10 | 9.50 | 42.53 |
| | | 3 | 24.52 | 194.90 | 372.30 | 168.10 | 382.60 | 177.50 | 341.80 | 426.40 | 9.70 | 46.60 |
| II | Sediment | 4 | 20.98 | 31.12 | 28.10 | 4.94 | 0.00 | 54.17 | 126.30 | 32.42 | 0.00 | 0.00 |
| | | 5 | 16.49 | 33.67 | 30.60 | 5.98 | 0.00 | 55.73 | 127.20 | 33.14 | 0.00 | 0.00 |
| III | Sand - 1 inch | 7 | 1.02 | 115.10 | 204.20 | 15.65 | 146.40 | 86.44 | 254.50 | 242.70 | 0.00 | 0.00 |
| | | 8 | 0.55 | 132.20 | 241.50 | 24.68 | 198.70 | 83.03 | 258.10 | 285.10 | 0.00 | 2.15 |
| IV | Sand - 2 inches | 10 | 0.70 | 144.30 | 255.00 | 23.34 | 212.90 | 79.82 | 271.80 | 311.50 | 0.00 | 0.00 |
| | | 11 | 0.50 | 125.10 | 222.00 | 18.94 | 172.40 | 84.65 | 259.30 | 271.00 | 0.00 | 0.00 |
| V | Silty clay | 13 | 5.52 | 57.52 | 43.38 | 20.45 | 0.00 | 40.58 | 143.80 | 25.73 | 0.00 | 1.00 |
| | | 14 | 5.70 | 67.66 | 52.55 | 18.66 | 0.00 | 47.23 | 159.50 | 31.11 | 0.00 | 0.67 |
| VI | Apatite - 1 inch | 16 | 7.81 | 28.62 | 41.73 | 3.11 | 0.00 | 32.24 | 28.33 | 9.60 | 0.00 | 0.00 |
| | | 17 | 5.98 | 29.14 | 40.64 | 3.07 | 0.00 | 31.73 | 23.97 | 9.87 | 0.00 | 0.00 |
| VII | Apatite - 2 inches | 19 | 6.81 | 53.47 | 66.97 | 3.28 | 0.00 | 43.94 | 34.58 | 18.41 | 0.00 | 0.00 |
| | | 20 | 4.21 | 32.98 | 43.02 | 2.40 | 0.00 | 27.99 | 22.23 | 12.32 | 0.00 | 0.00 |
| VIII | Activated carbon | 22 | 1.83 | 16.24 | 14.37 | 0.36 | 0.00 | 133.40 | 97.49 | 14.74 | 0.00 | 0.00 |
| | | 23 | 1.85 | 12.96 | 11.91 | 0.21 | 0.00 | 130.60 | 89.37 | 11.72 | 0.00 | 0.00 |
| IX | Organoclay MRM | 25 | 55.45 | 180.30 | 357.20 | 91.04 | 452.50 | 62.07 | 63.57 | 355.00 | 0.00 | 87.47 |
| | | 26 | 66.81 | 196.40 | 390.50 | 95.68 | 497.60 | 64.31 | 64.33 | 368.80 | 0.00 | 99.97 |
| X | MAAC | 28 | 0.00 | 74.63 | 102.90 | 0.27 | 0.00 | 29.32 | 57.39 | 11.42 | 0.00 | 0.00 |
| | | 29 | 0.01 | 40.97 | 73.29 | 0.00 | 0.00 | 27.30 | 38.82 | 6.93 | 0.00 | 0.00 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 9.37 | 195.40 | 389.10 | 95.26 | 392.00 | 233.10 | 294.10 | 410.70 | 13.41 | 27.63 |
| | | 3 | 43.10 | 202.10 | 409.70 | 220.80 | 432.50 | 210.90 | 362.60 | 452.80 | 16.52 | 65.20 |
| II | Sediment | 4 | 18.37 | 30.81 | 26.51 | 10.33 | 0.00 | 53.57 | 131.60 | 33.56 | 0.55 | 2.09 |
| | | 5 | 15.82 | 28.88 | 24.86 | 10.62 | 0.00 | 65.42 | 153.00 | 30.47 | 0.23 | 1.99 |
| III | Sand - 1 inch | 7 | 1.25 | 115.30 | 209.90 | 23.53 | 148.40 | 96.56 | 259.10 | 238.10 | 0.31 | 4.97 |
| | | 8 | 0.43 | 127.80 | 244.00 | 21.74 | 192.10 | 87.49 | 254.60 | 275.20 | 0.16 | 8.32 |
| IV | Sand - 2 inches | 10 | 1.12 | 153.60 | 278.80 | 34.91 | 246.70 | 94.60 | 293.50 | 322.70 | 0.12 | 7.67 |
| | | 11 | 0.73 | 132.20 | 232.70 | 25.30 | 189.60 | 96.84 | 261.40 | 272.90 | 0.13 | 8.08 |
| V | Silty clay | 13 | 6.67 | 50.69 | 36.83 | 17.32 | 0.00 | 37.45 | 138.30 | 22.13 | 0.65 | 2.82 |
| | | 14 | 6.88 | 69.38 | 51.61 | 17.93 | 1.80 | 52.49 | 165.20 | 31.70 | 0.81 | 3.78 |
| VI | Apatite - 1 inch | 16 | 8.61 | 29.96 | 42.60 | 2.89 | 0.00 | 35.65 | 29.65 | 9.69 | 0.28 | 0.39 |
| | | 17 | 6.90 | 28.49 | 41.20 | 3.18 | 0.00 | 33.23 | 25.38 | 8.75 | 0.22 | 0.35 |
| VII | Apatite - 2 inches | 19 | 6.90 | 60.75 | 76.04 | 3.10 | 0.00 | 53.35 | 40.34 | 19.19 | 0.19 | 0.38 |
| | | 20 | 4.29 | 70.82 | 80.77 | 3.55 | 0.00 | 56.76 | 53.99 | 28.11 | 0.36 | 0.39 |
| VIII | Activated carbon | 22 | 2.18 | 16.84 | 15.41 | 1.11 | 0.00 | 151.80 | 104.50 | 15.34 | 0.91 | 0.66 |
| | | 23 | 2.44 | 12.42 | 11.74 | 0.74 | 0.00 | 140.10 | 96.67 | 10.82 | 0.48 | 0.67 |
| IX | Organoclay MRM | 25 | 69.65 | 189.50 | 378.10 | 108.70 | 457.10 | 73.21 | 70.21 | 349.60 | 0.42 | 93.92 |
| | | 26 | 76.51 | 195.50 | 396.00 | 100.60 | 514.00 | 68.31 | 65.29 | 375.80 | 0.32 | 96.46 |
| X | MAAC | 28 | 0.03 | 71.89 | 96.42 | 0.65 | 0.00 | 32.38 | 65.45 | 18.54 | 0.27 | 0.95 |
| | | 29 | 0.13 | 38.35 | 70.94 | 0.67 | 0.00 | 26.01 | 39.63 | 8.76 | 0.36 | 0.87 |

Table A1.47. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at 2184 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 9.37 | 195.40 | 389.10 | 95.26 | 392.00 | 233.10 | 294.10 | 410.70 | 15.41 | 27.63 |
| | | 3 | 43.10 | 202.10 | 409.70 | 220.80 | 432.50 | 210.90 | 362.60 | 452.80 | 16.52 | 65.20 |
| II | Sediment | 4 | 18.37 | 30.81 | 26.51 | 10.33 | 0.00 | 53.57 | 131.60 | 33.56 | 0.55 | 2.09 |
| | | 5 | 15.82 | 28.88 | 24.86 | 10.62 | 0.00 | 65.42 | 153.00 | 30.47 | 0.23 | 1.99 |
| III | Sand - 1 inch | 7 | 1.25 | 115.30 | 209.90 | 23.53 | 148.40 | 96.56 | 259.10 | 238.10 | 0.31 | 4.97 |
| | | 8 | 0.43 | 127.80 | 244.00 | 21.74 | 192.10 | 87.49 | 254.60 | 275.20 | 0.16 | 8.32 |
| IV | Sand - 2 inches | 10 | 1.12 | 153.60 | 278.80 | 34.91 | 246.70 | 94.60 | 293.50 | 322.70 | 0.12 | 7.67 |
| | | 11 | 0.73 | 132.20 | 232.70 | 25.30 | 189.60 | 96.84 | 261.40 | 272.90 | 0.13 | 8.08 |
| V | Silty clay | 13 | 6.67 | 50.69 | 36.83 | 17.32 | 0.00 | 37.45 | 138.30 | 22.13 | 0.65 | 2.82 |
| | | 14 | 6.88 | 69.38 | 51.61 | 17.93 | 1.80 | 52.49 | 165.20 | 31.70 | 0.81 | 3.78 |
| VI | Apatite - 1 inch | 16 | 8.61 | 29.96 | 42.60 | 2.89 | 0.00 | 35.65 | 29.65 | 9.69 | 0.28 | 0.39 |
| | | 17 | 6.90 | 28.49 | 41.20 | 3.18 | 0.00 | 33.23 | 25.38 | 8.75 | 0.22 | 0.35 |
| VII | Apatite - 2 inches | 19 | 6.90 | 60.75 | 76.04 | 3.10 | 0.00 | 53.35 | 40.34 | 19.19 | 0.19 | 0.38 |
| | | 20 | 4.29 | 70.82 | 80.77 | 3.55 | 0.00 | 56.76 | 53.99 | 28.11 | 0.36 | 0.39 |
| VIII | Activated carbon | 22 | 2.18 | 16.84 | 15.41 | 1.11 | 0.00 | 151.80 | 104.50 | 15.34 | 0.91 | 0.66 |
| | | 23 | 2.44 | 12.42 | 11.74 | 0.74 | 0.00 | 140.10 | 96.67 | 10.82 | 0.48 | 0.67 |
| IX | Organoclay MRM | 25 | 69.65 | 189.50 | 378.10 | 108.70 | 457.10 | 73.21 | 70.21 | 349.60 | 0.42 | 93.92 |
| | | 26 | 76.51 | 195.50 | 396.00 | 100.60 | 514.00 | 68.31 | 65.29 | 375.80 | 0.32 | 96.46 |
| X | MAAC | 28 | 0.03 | 71.89 | 96.42 | 0.65 | 0.00 | 32.38 | 65.45 | 18.54 | 0.27 | 0.95 |
| | | 29 | 0.13 | 38.35 | 70.94 | 0.67 | 0.00 | 26.01 | 39.63 | 8.76 | 0.36 | 0.87 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 20.17 | 220.50 | 438.80 | 142.00 | 428.90 | 237.60 | 304.50 | 425.60 | 20.87 | 44.92 |
| | | 3 | 54.70 | 214.90 | 439.10 | 252.90 | 447.10 | 229.10 | 389.10 | 443.30 | 22.24 | 83.31 |
| II | Sediment | 4 | 140.30 | 119.30 | 114.90 | 131.00 | 119.30 | 89.59 | 126.50 | 111.90 | 9.30 | 94.49 |
| | | 5 | 118.80 | 113.10 | 109.70 | 129.00 | 110.40 | 87.21 | 130.10 | 107.60 | 9.24 | 86.89 |
| III | Sand - 1 inch | 7 | 24.86 | 140.90 | 244.60 | 65.17 | 190.90 | 116.30 | 266.00 | 270.00 | 0.93 | 31.68 |
| | | 8 | 13.93 | 142.60 | 257.80 | 52.27 | 214.00 | 97.78 | 250.80 | 283.40 | 0.71 | 21.37 |
| IV | Sand - 2 inches | 10 | 23.25 | 172.80 | 318.80 | 83.27 | 278.10 | 115.30 | 303.50 | 351.80 | 0.75 | 36.19 |
| | | 11 | 8.00 | 134.60 | 236.90 | 40.82 | 196.20 | 103.40 | 265.60 | 275.90 | 0.64 | 16.26 |
| V | Silty clay | 13 | 112.70 | 101.40 | 94.41 | 185.20 | 119.20 | 81.98 | 130.90 | 63.88 | 14.30 | 97.09 |
| | | 14 | 85.80 | 100.60 | 91.12 | 126.80 | 79.39 | 81.88 | 161.60 | 54.47 | 7.60 | 59.01 |
| VI | Apatite - 1 inch | 16 | 32.60 | 38.69 | 51.89 | 32.54 | 0.00 | 50.77 | 37.68 | 16.75 | 1.53 | 21.86 |
| | | 17 | 42.96 | 40.96 | 54.67 | 43.20 | 4.61 | 56.73 | 33.28 | 18.01 | 2.17 | 30.06 |
| VII | Apatite - 2 inches | 19 | 36.57 | 70.02 | 81.29 | 41.61 | 8.06 | 71.27 | 50.80 | 32.81 | 2.11 | 28.19 |
| | | 20 | 22.94 | 76.90 | 84.80 | 31.34 | 4.24 | 68.35 | 59.35 | 38.48 | 0.96 | 12.14 |
| VIII | Activated carbon | 22 | 96.15 | 73.05 | 88.94 | 126.70 | 80.41 | 157.40 | 106.20 | 39.11 | 6.43 | 57.65 |
| | | 23 | 120.10 | 80.18 | 100.40 | 151.90 | 104.50 | 156.60 | 95.25 | 41.64 | 8.80 | 78.09 |
| IX | Organoclay MRM | 25 | 91.42 | 196.50 | 372.20 | 113.10 | 468.00 | 87.51 | 69.30 | 361.30 | 13.33 | 113.00 |
| | | 26 | 83.41 | 202.70 | 383.20 | 98.04 | 517.10 | 78.37 | 65.37 | 370.40 | 8.54 | 107.30 |
| X | MAAC | 28 | 24.43 | 80.55 | 100.10 | 35.22 | 0.00 | 47.51 | 68.19 | 36.34 | 2.56 | 23.76 |
| | | 29 | 26.09 | 46.65 | 73.66 | 34.87 | 0.00 | 39.19 | 40.64 | 25.76 | 2.14 | 23.65 |

Table A1.48. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at 2352 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 6.379 | 214.500 | 431.800 | 85.810 | 434.700 | 231.300 | 305.000 | 428.000 | 0.000 | 13.150 |
| | | 3 | 33.240 | 219.700 | 443.700 | 228.600 | 509.400 | 244.800 | 403.400 | 489.900 | 0.000 | 58.290 |
| II | Sediment | 4 | 18.980 | 35.560 | 29.610 | 6.722 | 0.102 | 61.920 | 154.300 | 38.500 | 0.000 | 0.000 |
| | | 5 | 15.150 | 40.780 | 33.880 | 32.040 | 0.000 | 74.600 | 175.100 | 44.040 | 0.000 | 0.000 |
| III | Sand - 1 inch | 7 | 1.156 | 128.200 | 216.800 | 12.920 | 155.400 | 100.600 | 275.000 | 248.500 | 0.000 | 0.000 |
| | | 8 | 0.386 | 131.400 | 222.600 | 13.070 | 165.200 | 84.220 | 263.100 | 255.800 | 0.000 | 0.205 |
| IV | Sand - 2 inches | 10 | 1.201 | 167.900 | 281.400 | 26.420 | 244.700 | 99.510 | 299.800 | 336.300 | 0.000 | 3.119 |
| | | 11 | 1.049 | 152.100 | 255.400 | 22.050 | 206.900 | 102.200 | 273.400 | 290.100 | 0.000 | 2.109 |
| V | Silty clay | 13 | 5.018 | 54.870 | 40.160 | 17.490 | 9.356 | 38.960 | 150.500 | 23.320 | 0.000 | 1.357 |
| | | 14 | 8.145 | 70.910 | 53.840 | 18.150 | 4.863 | 52.060 | 176.600 | 32.750 | 0.000 | 0.426 |
| VI | Apatite - 1 inch | 16 | 9.031 | 26.380 | 37.250 | 1.064 | 0.000 | 32.080 | 28.910 | 8.471 | 0.000 | 0.000 |
| | | 17 | 6.515 | 30.560 | 40.390 | 0.869 | 0.000 | 34.980 | 26.870 | 9.745 | 0.000 | 0.000 |
| VII | Apatite - 2 inches | 19 | 6.911 | 44.750 | 56.490 | 1.665 | 0.000 | 40.770 | 31.140 | 15.650 | 0.000 | 0.000 |
| | | 20 | 4.496 | 22.060 | 30.930 | 0.449 | 0.000 | 20.250 | 16.410 | 7.806 | 0.000 | 0.000 |
| VIII | Activated carbon | 22 | 2.125 | 16.870 | 15.010 | 0.000 | 0.000 | 158.200 | 112.300 | 15.110 | 0.000 | 0.000 |
| | | 23 | 2.462 | 14.580 | 13.940 | 0.000 | 0.000 | 145.100 | 102.000 | 12.740 | 0.000 | 0.000 |
| IX | Organoclay MRM | 25 | 62.640 | 202.100 | 387.200 | 93.100 | 532.100 | 62.370 | 62.010 | 377.200 | 0.000 | 91.860 |
| | | 26 | 83.180 | 230.300 | 469.300 | 118.500 | 607.200 | 81.940 | 79.600 | 424.700 | 0.000 | 109.400 |
| X | MAAC | 28 | 0.072 | 74.830 | 100.400 | 0.000 | 0.000 | 31.760 | 68.440 | 32.760 | 0.000 | 0.000 |
| | | 29 | 0.205 | 34.590 | 65.210 | 0.000 | 0.000 | 26.990 | 39.370 | 18.360 | 0.000 | 0.000 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 16.160 | 216.100 | 417.000 | 129.200 | 450.700 | 238.000 | 321.000 | 452.000 | 1.950 | 40.800 |
| | | 3 | 34.720 | 223.200 | 451.600 | 224.800 | 475.700 | 244.500 | 400.100 | 486.700 | 2.073 | 54.870 |
| II | Sediment | 4 | 107.400 | 97.000 | 87.130 | 106.100 | 98.940 | 84.620 | 143.800 | 105.700 | 8.649 | 71.370 |
| | | 5 | 100.700 | 91.850 | 83.210 | 103.600 | 88.330 | 88.710 | 157.600 | 99.960 | 8.792 | 64.860 |
| III | Sand - 1 inch | 7 | 27.470 | 146.800 | 239.900 | 74.840 | 203.500 | 130.500 | 299.600 | 290.200 | 1.935 | 32.920 |
| | | 8 | 76.100 | 160.500 | 278.400 | 142.700 | 274.300 | 146.800 | 295.600 | 326.600 | 4.284 | 76.860 |
| IV | Sand - 2 inches | 10 | 22.950 | 178.200 | 301.000 | 74.530 | 299.600 | 124.300 | 314.400 | 380.300 | 1.460 | 29.460 |
| | | 11 | 32.140 | 159.900 | 275.600 | 82.930 | 250.700 | 133.500 | 293.300 | 334.000 | 1.872 | 38.570 |
| V | Silty clay | 13 | 137.400 | 115.400 | 109.500 | 241.100 | 176.000 | 95.350 | 129.800 | 95.360 | 17.550 | 139.400 |
| | | 14 | 129.800 | 123.200 | 115.500 | 216.500 | 158.800 | 106.400 | 167.200 | 99.510 | 17.130 | 118.000 |
| VI | Apatite - 1 inch | 16 | 102.700 | 55.140 | 69.370 | 101.700 | 58.520 | 88.990 | 53.180 | 34.240 | 9.333 | 77.350 |
| | | 17 | 121.600 | 65.790 | 78.180 | 119.800 | 77.600 | 106.200 | 54.760 | 40.310 | 9.095 | 88.960 |
| VII | Apatite - 2 inches | 19 | 82.280 | 61.410 | 75.140 | 85.980 | 45.290 | 84.100 | 50.870 | 40.050 | 6.253 | 64.310 |
| | | 20 | 129.600 | 48.240 | 56.260 | 124.400 | 80.810 | 84.070 | 41.280 | 36.390 | 10.640 | 91.410 |
| VIII | Activated carbon | 22 | 150.600 | 111.200 | 130.600 | 205.600 | 155.000 | 160.300 | 96.120 | 76.880 | 10.040 | 131.500 |
| | | 23 | 178.600 | 102.900 | 126.500 | 215.700 | 165.200 | 171.400 | 95.610 | 68.800 | 11.970 | 131.300 |
| IX | Organoclay MRM | 25 | 115.700 | 208.500 | 382.200 | 108.700 | 520.500 | 94.260 | 61.010 | 376.500 | 25.650 | 119.400 |
| | | 26 | 131.900 | 225.200 | 428.200 | 135.400 | 596.600 | 108.900 | 73.080 | 425.800 | 20.870 | 135.200 |
| X | MAAC | 28 | 163.000 | 134.900 | 144.400 | 198.000 | 123.000 | 124.700 | 93.760 | 135.300 | 23.840 | 141.100 |
| | | 29 | 102.500 | 75.600 | 95.070 | 135.600 | 66.330 | 84.260 | 47.700 | 74.300 | 8.519 | 96.570 |

Table A1.49. Metal concentrations (µg $L^{-1}$) in surface water (filtered and unfiltered samples) at 2520 h (raw data).

| Treatment | Treatment description | Sample ID | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| | | | Filtered samples | | | | | | | | | |
| I | Spike solution | 1 | 5.45 | 251.70 | 507.40 | 101.40 | 501.80 | 259.30 | 347.00 | 531.80 | 0.36 | 10.40 |
| | | 3 | 17.88 | 246.10 | 491.50 | 115.60 | 474.70 | 246.20 | 446.00 | 520.70 | 0.46 | 14.68 |
| II | Sediment | 4 | 26.61 | 61.75 | 54.16 | 19.53 | 42.05 | 81.76 | 201.30 | 66.05 | 0.00 | 1.01 |
| | | 5 | 26.68 | 56.52 | 52.96 | 17.51 | 59.99 | 100.50 | 231.00 | 55.60 | 0.58 | 2.49 |
| III | Sand - 1 inch | 7 | 0.94 | 151.30 | 245.80 | 11.47 | 168.40 | 121.20 | 325.20 | 301.70 | 0.04 | 1.48 |
| | | 8 | 0.39 | 165.00 | 264.90 | 15.04 | 203.50 | 103.30 | 303.20 | 339.90 | 0.00 | 2.49 |
| IV | Sand - 2 inches | 10 | 1.01 | 196.00 | 342.90 | 22.97 | 284.10 | 117.40 | 364.10 | 427.80 | 0.12 | 4.15 |
| | | 11 | 0.71 | 161.10 | 270.70 | 19.54 | 215.10 | 111.60 | 318.20 | 358.30 | 0.11 | 4.26 |
| V | Silty clay | 13 | 8.69 | 69.00 | 53.75 | 21.05 | 19.16 | 49.49 | 178.90 | 32.12 | 0.36 | 1.83 |
| | | 14 | 12.30 | 72.72 | 57.98 | 20.20 | 25.71 | 56.34 | 198.80 | 35.85 | 0.54 | 2.22 |
| VI | Apatite - 1 inch | 16 | 10.31 | 25.50 | 43.10 | 3.84 | 0.00 | 34.29 | 21.71 | 7.13 | 0.24 | 0.00 |
| | | 17 | 8.36 | 33.79 | 52.16 | 4.15 | 0.00 | 40.56 | 29.35 | 10.70 | 0.27 | 0.00 |
| VII | Apatite - 2 inches | 19 | 7.42 | 50.18 | 69.92 | 4.21 | 0.00 | 49.60 | 36.36 | 15.53 | 0.23 | 0.00 |
| | | 20 | 4.96 | 21.69 | 40.66 | 3.95 | 0.00 | 19.73 | 14.66 | 8.62 | 0.23 | 0.00 |
| VIII | Activated carbon | 22 | 3.22 | 18.97 | 17.04 | 1.19 | 0.00 | 175.30 | 134.20 | 14.39 | 0.15 | 0.00 |
| | | 23 | 3.80 | 14.62 | 13.89 | 1.00 | 0.00 | 170.10 | 130.00 | 10.20 | 0.12 | 0.00 |
| IX | Organoclay MRM | 25 | 89.24 | 215.60 | 417.80 | 105.60 | 581.30 | 71.19 | 70.92 | 398.70 | 0.21 | 115.30 |
| | | 26 | 108.30 | 238.30 | 475.60 | 131.30 | 608.20 | 80.40 | 85.11 | 452.70 | 0.20 | 120.40 |
| X | MAAC | 28 | 0.00 | 78.09 | 121.40 | 3.13 | -9.81 | 43.74 | 82.13 | 61.61 | 0.13 | 0.00 |
| | | 29 | 0.30 | 35.59 | 95.51 | 3.98 | -8.65 | 38.26 | 52.77 | 35.23 | 0.14 | 0.00 |
| | | | Unfiltered samples | | | | | | | | | |
| I | Spike solution | 1 | 61.33 | 237.80 | 507.50 | 231.90 | 510.50 | 299.30 | 374.40 | 498.80 | 7.63 | 126.00 |
| | | 3 | 43.66 | 236.30 | 500.00 | 208.30 | 511.80 | 266.70 | 417.50 | 490.20 | 3.17 | 75.01 |
| II | Sediment | 4 | 118.80 | 97.46 | 89.44 | 103.10 | 88.62 | 106.10 | 176.40 | 105.10 | 11.92 | 71.93 |
| | | 5 | 90.12 | 90.72 | 83.50 | 79.82 | 67.17 | 111.00 | 203.10 | 93.87 | 10.51 | 52.57 |
| III | Sand - 1 inch | 7 | 44.97 | 143.70 | 253.60 | 82.98 | 199.20 | 148.60 | 314.00 | 313.20 | 2.80 | 55.97 |
| | | 8 | 50.90 | 152.50 | 281.30 | 90.50 | 232.20 | 143.60 | 298.70 | 324.30 | 3.32 | 58.63 |
| IV | Sand - 2 inches | 10 | 13.97 | 174.10 | 322.90 | 49.98 | 267.30 | 125.20 | 321.20 | 371.10 | 1.28 | 22.92 |
| | | 11 | 21.60 | 160.40 | 285.90 | 57.40 | 230.00 | 131.40 | 312.00 | 338.00 | 1.77 | 30.74 |
| V | Silty clay | 13 | 108.60 | 96.35 | 88.72 | 138.60 | 84.22 | 95.48 | 163.80 | 61.53 | 14.01 | 86.50 |
| | | 14 | 118.50 | 110.00 | 106.30 | 168.70 | 113.20 | 103.30 | 180.80 | 77.01 | 11.47 | 95.76 |
| VI | Apatite - 1 inch | 16 | 56.54 | 39.15 | 50.07 | 49.21 | 4.34 | 61.79 | 35.40 | 21.28 | 3.19 | 35.40 |
| | | 17 | 63.31 | 48.81 | 61.67 | 60.21 | 14.51 | 73.05 | 37.59 | 25.24 | 1.99 | 40.48 |
| VII | Apatite - 2 inches | 19 | 53.47 | 60.29 | 74.69 | 55.14 | 15.50 | 76.19 | 51.43 | 34.90 | 3.66 | 38.06 |
| | | 20 | 68.22 | 34.88 | 43.19 | 64.72 | 17.50 | 49.25 | 28.13 | 20.19 | 5.72 | 41.10 |
| VIII | Activated carbon | 22 | 153.50 | 104.90 | 125.90 | 196.70 | 136.70 | 205.90 | 122.90 | 67.11 | 13.98 | 123.00 |
| | | 23 | 174.20 | 105.40 | 127.50 | 211.10 | 153.40 | 204.10 | 120.20 | 67.43 | 15.17 | 136.50 |
| IX | Organoclay MRM | 25 | 96.74 | 206.60 | 422.90 | 111.40 | 576.00 | 90.16 | 69.43 | 380.00 | 10.32 | 125.70 |
| | | 26 | 115.30 | 221.20 | 428.00 | 133.60 | 600.60 | 99.46 | 83.74 | 427.10 | 9.96 | 132.80 |
| X | MAAC | 28 | 33.64 | 87.69 | 110.50 | 46.24 | 8.83 | 63.22 | 85.70 | 63.91 | 2.22 | 26.57 |
| | | 29 | 11.61 | 38.64 | 71.82 | 15.04 | 0.00 | 42.80 | 51.97 | 34.74 | 1.23 | 7.45 |

Table A1.50. Whole body metal concentrations in *Lumbriculus variegates* measured before placement in experimental mesocosms (i.e., "background concentrations).

| Treatment | Description | Replicate | Cr (mg/kg) | Co (mg/kg) | Ni (mg/kg) | Cu (mg/kg) | Zn (mg/kg) | As (mg/kg) | Se (mg/kg) | Cd (mg/kg) | Pb (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Background | | | | | | | | | | |
| A | Background | 1 | 0.88 | 0.70 | 0.63 | 10.22 | 186.48 | 3.49 | 1.73 | 0.36 | 0.84 |
| B | Background | 2 | 0.94 | 0.73 | 0.87 | 11.20 | 199.27 | 3.73 | 2.03 | 0.40 | 0.67 |
| B1 | Background | 3 | 0.79 | 0.79 | 0.69 | 14.89 | 203.82 | 4.77 | 1.55 | 0.36 | 0.87 |
| B2 | Background | 4 | 2.34 | 0.65 | 1.35 | 9.39 | 176.58 | 3.80 | 1.46 | 0.30 | 0.90 |
| B3 | Background | 5 | 0.96 | 0.73 | 0.70 | 11.06 | 197.97 | 4.09 | 1.63 | 0.39 | 1.03 |
| C | Background | 6 | 1.22 | 0.72 | 0.85 | 11.24 | 194.11 | 4.03 | 2.19 | 0.35 | 0.84 |
| D | Background | 7 | 0.77 | 0.70 | 0.61 | 9.35 | 181.30 | 4.31 | 1.70 | 0.31 | 0.67 |

Table A1.51. Whole body metal concentrations *in Lumbriculus variegates* measured after ten days of exposure in experimental mesocosms with low level metal influx and treated sediments**.

| Treatment | Description | Replicate | Cr (mg/kg) | Co (mg/kg) | Ni (mg/kg) | Cu (mg/kg) | Zn (mg/kg) | As (mg/kg) | Se (mg/kg) | Cd (mg/kg) | Pb (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ten day test | | | | | | |
| II | Sediment only | 4 | 23.69 | 29.39 | 20.21 | 69.57 | 613.88 | 10.54 | 36.46 | 321.26 | 84.88 |
| | | 5 | 23.65 | 28.92 | 16.42 | 119.31 | 751.65 | 11.59 | 46.88 | 413.69 | 166.05 |
| | | 6 | 23.51 | 38.84 | 25.85 | 80.39 | 769.79 | 12.79 | 16.32 | 459.00 | 201.47 |
| V | Silty clay/passive material | 13 | 5.33 | 10.15 | 8.84 | 71.20 | 191.94 | 8.79 | 8.64 | 111.81 | 11.67 |
| | | 14 | 3.30 | 8.20 | 7.62 | 62.12 | 206.39 | 6.43 | 6.40 | 111.96 | 7.18 |
| | | 15 | 3.44 | 7.71 | 7.48 | 57.39 | 210.79 | 7.49 | 6.72 | 109.18 | 7.01 |
| VI | Apatite/active material | 16 | 3.87 | 2.62 | 4.60 | 40.87 | 215.24 | 6.77 | 3.69 | 8.28 | 2.95 |
| | | 17 | 5.46 | 3.15 | 5.94 | 37.91 | 212.07 | 7.58 | 3.93 | 9.38 | 4.11 |
| | | 18 | 6.79 | 3.33 | 5.64 | 40.76 | 190.12 | 8.57 | 4.02 | 8.15 | 4.77 |
| VIII | Activated carbon | 22 | 3.87 | 5.60 | 7.62 | 30.72 | 200.44 | 7.33 | 4.58 | 60.76 | 6.86 |
| | | 23 | 4.48 | 4.45 | 5.67 | 29.12 | 197.55 | 7.63 | 4.40 | 45.83 | 6.98 |
| | | 24 | 4.60 | 5.68 | 7.64 | 32.94 | 186.25 | 6.47 | 4.10 | 40.81 | 6.56 |
| IX | Organoclay MRM/active | 25 | 1.20 | 2.52 | 2.90 | 38.31 | 199.39 | 4.76 | 6.05 | 37.85 | 29.76 |
| | | 26 | 1.39 | 2.38 | 2.60 | 35.97 | 203.23 | 4.98 | 5.88 | 41.68 | 33.12 |
| | | 27 | 1.23 | 2.34 | 2.45 | 30.94 | 222.07 | 5.04 | 3.70 | 42.20 | 28.03 |
| X | NCA60/MRM35/AC5 | 28 | 1.08 | 1.70 | 3.38 | 16.97 | 202.56 | 5.38 | 6.77 | 3.15 | 1.72 |
| | | 29 | 1.15 | 1.53 | 2.86 | 19.79 | 213.75 | 5.39 | 6.61 | 2.56 | 1.22 |
| | | 30 | 1.24 | 2.22 | 4.33 | 23.67 | 215.66 | 5.62 | 7.59 | 8.03 | 1.17 |

* * Data are unavailable for mesocoms with zero survival (spike solution and sand caps).

Table A1.52. Mortality of Asian clams after 10 day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals (raw data). Mesocosm treatments included spike solution only, uncapped sediment, sediment with passive caps (sand), and sediment with active caps [clay; apatite; activated carbon (AC); organoclay (MRM); and a mixture of activated carbon, apatite, and MRM].

| Treatment | Sample Id | Mortality after 10 days | Mortality in % |
|---|---|---|---|
| Spike solution | **1** | 10 | 100 |
| | **3** | 10 | 100 |
| **Sediment** | **4** | **1** | 10 |
| | **5** | **1** | 10 |
| | **6** | **1** | 10 |
| Sand | **7** | 6 | 60 |
| | **8** | 5 | 50 |
| | **9** | 6 | 60 |
| | **10** | 6 | 60 |
| | **11** | 5 | 50 |
| | **12** | 5 | 50 |
| Clay | **13** | 0 | 0 |
| | **14** | 0 | 0 |
| | **15** | 0 | 0 |
| Apatite | **16** | 0 | 0 |
| | **17** | 0 | 0 |
| | **18** | 0 | 0 |
| | **19** | 0 | 0 |
| | **20** | 0 | 0 |
| Activated carbon | **22** | 0 | 0 |
| | **23** | 0 | 0 |
| | **24** | 0 | 0 |
| Organoclay MRM | **25** | 4 | 40 |
| | **26** | 2 | 20 |
| | **27** | 3 | 30 |
| MAAC | **28** | 0 | 0 |
| | **29** | 0 | 0 |
| | **30** | 0 | 0 |

Table A1. 53. Metal concentrations in Asian clams (soft tissues) after 10 day toxicity tests conducted in mesocosms receiving water spiked with dissolved metals (raw data). Mesocosm treatments included spike solution only, uncapped sediment, sediment with passive caps (sand), and sediment with active caps [clay; apatite; activated carbon (AC); organoclay (MRM); and a mixture of activated carbon, apatite, and MRM]. BR represents background concentrations; i.e., concentrations measured in Asian clams before testing.

| Treatments | Sample ID | Cr (mg/kg) | Co (mg/kg) | Ni (mg/kg) | Cu (mg/kg) | Zn (mg/kg) | As (mg/kg) | Se (mg/kg) | Cd (mg/kg) | Pb (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sediment | 4 Dup | 16.930 | 16.465 | 22.733 | 18.214 | 136.166 | 5.651 | 4.436 | 60.677 | 4.857 |
| | 4 | 14.663 | 15.648 | 20.494 | 15.958 | 127.137 | 4.979 | 3.996 | 57.614 | 4.596 |
| | 5 | 15.000 | 14.458 | 18.905 | 18.000 | 125.000 | 4.899 | 4.310 | 51.907 | 4.599 |
| | 6 | 16.000 | 15.488 | 19.787 | 17.256 | 133.209 | 4.951 | 4.400 | 60.000 | 4.268 |
| Silty caly | 13 | 5.243 | 11.789 | 12.147 | 26.692 | 125.000 | 6.608 | 3.768 | 29.567 | 7.923 |
| | 14 | 4.757 | 13 .345 | 19.567 | 18.454 | 136.594 | 4.982 | 3.258 | 30.895 | 6.438 |
| | 15 | 5.194 | 14.626 | 15.569 | 21.572 | 131.902 | 5.568 | 3.078 | 29.868 | 7.228 |
| Apatie | 16 | 6.900 | 4.317 | 5.500 | 34.783 | 99.000 | 4.300 | 3.568 | 20.000 | 3.200 |
| | 18 | 7.090 | 3.236 | 5.330 | 29.283 | 98.528 | 4.297 | 2.485 | 19.333 | 3.128 |
| | 19 | 9.781 | 3.633 | 5.914 | 36.930 | 103.465 | 4.660 | 3.211 | 22.000 | 3.300 |
| | 19 Dup | 8.780 | 3.369 | 5.603 | 34.099 | 104.573 | 4.426 | 2.825 | 24.772 | 4.870 |
| AC | 22 | 4.940 | 4.395 | 8.570 | 20.031 | 97.706 | 3.637 | 3.282 | 47.865 | 3.900 |
| | 23 | 4.427 | 4.480 | 6.615 | 25.816 | 103.214 | 4.118 | 3.174 | 33.418 | 3.684 |
| | 24 | 4.367 | 4.677 | 7.339 | 23.154 | 102.345 | 3.770 | 2.723 | 40.800 | 4.500 |
| MRM | 25 | 16.967 | 2.041 | 10.100 | 54.547 | 113.620 | 4.854 | 5.494 | 25.236 | 9.923 |
| | 26 | 15.701 | 1.602 | 6.186 | 54.899 | 116.032 | 5.302 | 4.332 | 23.765 | 11.141 |
| | 27 | 15.000 | 1.552 | 6.825 | 57.048 | 129.471 | 5.336 | 6.344 | 25.869 | 11.635 |
| MAAC | 28 | 5.270 | 5.107 | 2.506 | 16.466 | 102.368 | 5.228 | 2.128 | 14.337 | 8.751 |
| | 29 | 7.060 | 3.396 | 2.553 | 19.738 | 107.870 | 4.875 | 1.996 | 11.576 | 7.852 |
| | 30 | 7.747 | 3.273 | 2.181 | 16.409 | 113.010 | 5.405 | 1.967 | 12.992 | 10.094 |
| BR | S1 | 1.020 | 0.325 | 0.334 | 8.257 | 119.485 | 2.766 | 1.364 | 0.868 | 0.314 |
| | S2 | 0.952 | 0.371 | 0.448 | 9.971 | 131.799 | 3.258 | 1.846 | 1.055 | 0.371 |
| | S3 | 1.039 | 0.493 | 1.067 | 9.450 | 129.231 | 3.430 | 2.421 | 1.379 | 0.376 |

Table A1.54. Effect of cap materials on metal concentrations in surface water (µg/l) measured by water DGT probes (raw data).

| Treatments | Replicates | | | | | Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | As | Cd | Co | Cr | Cu | Ni | Pb | Se | Zn |
| | | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| Spike | 1 | 9.7 | 1353.0 | 772.7 | 25.0 | 322.1 | 951.5 | 217.1 | 5.3 | 1386.0 |
| | 3 | 10.7 | 1063.0 | 567.8 | 28.1 | 350.7 | 1153.0 | 170.7 | 6.4 | 1061.0 |
| | 4 | 2.0 | 120.6 | 119.7 | 3.5 | 32.5 | 108.8 | 10.1 | 0.6 | 1433.0 |
| Sediment | 5 | 2.5 | 102.1 | 103.5 | 3.1 | 29.2 | 96.8 | 7.9 | 0.5 | 164.0 |
| | 6 | 3.1 | 176.8 | 178.1 | 4.3 | 78.3 | 169.0 | 20.3 | 2.3 | 830.3 |
| | 7 | 2.8 | 781.3 | 426.2 | 1.3 | 61.4 | 742.4 | 37.3 | 1.7 | 644.5 |
| Sand - 1 | 8 | 4.0 | 897.6 | 523.2 | 3.3 | 89.4 | 986.7 | 66.1 | 3.6 | 755.1 |
| | 9 | 2.6 | 688.4 | 382.9 | 2.5 | 50.1 | 639.9 | 43.2 | 0.0 | 519.1 |
| | 10 | 3.1 | 1047.0 | 539.8 | 3.8 | 100.7 | 1052.0 | 71.0 | 2.8 | 858.6 |
| Sand - 2 | 11 | 3.2 | 720.9 | 382.7 | 3.5 | 100.4 | 660.7 | 44.0 | 4.7 | 591.5 |
| | 12 | 2.8 | 866.1 | 475.6 | 1.8 | 59.4 | 886.3 | 34.5 | 1.0 | 654.5 |
| | 13 | 1.7 | 78.1 | 161.4 | 0.8 | 32.3 | 120.4 | 11.0 | 1.7 | 98.7 |
| Silty Clay | 14 | 2.0 | 92.7 | 188.8 | 0.9 | 26.0 | 144.5 | 7.8 | 3.3 | 310.2 |
| | 15 | 1.6 | 87.2 | 174.6 | 0.8 | 29.2 | 138.0 | 8.8 | 1.8 | 326.6 |
| | 16 | 1.2 | 22.1 | 55.4 | 0.1 | 13.3 | 76.7 | 6.2 | 0.1 | 52.5 |
| Apatite -1 | 17 | 1.9 | 19.8 | 55.0 | 1.7 | 16.9 | 71.3 | 6.1 | 1.1 | 28.2 |
| | 18 | 1.4 | 16.8 | 48.7 | 1.0 | 13.6 | 71.0 | 4.0 | 1.0 | 22.3 |
| | 19 | 1.4 | 38.9 | 93.9 | 0.2 | 9.9 | 117.0 | 7.6 | 0.5 | 47.3 |
| Apatite -2 | 20 | 1.3 | 29.1 | 70.9 | 0.5 | 10.9 | 86.9 | 7.7 | 0.0 | 25.0 |
| | 21 | 1.4 | 36.9 | 104.4 | 0.4 | 12.4 | 127.6 | 5.4 | 0.0 | 45.9 |
| | 22 | 2.6 | 50.7 | 58.3 | 0.5 | 15.2 | 66.2 | 2.2 | 0.4 | 40.3 |
| Acivated Carbon | 23 | 2.3 | 32.7 | 43.3 | 1.3 | 10.7 | 44.8 | 2.9 | 1.0 | 977.3 |
| | 24 | 2.8 | 41.5 | 42.6 | 0.8 | 12.4 | 45.9 | 2.5 | 3.0 | 110.6 |
| | 25 | 14.0 | 392.3 | 209.9 | 53.1 | 173.0 | 737.3 | 207.7 | 6.0 | 1027.0 |
| MRM | 26 | 22.8 | 244.4 | 191.8 | 39.5 | 112.4 | 550.2 | 141.4 | 10.0 | 556.6 |
| | 27 | 16.4 | 449.9 | 241.1 | 41.4 | 122.1 | 841.3 | 190.5 | 4.8 | 1113.0 |
| | 28 | 1.3 | 34.3 | 153.1 | 0.1 | 7.6 | 205.0 | 9.9 | 1.0 | 1168.0 |
| MAAC | 29 | 1.1 | 37.2 | 90.7 | 0.3 | 10.2 | 155.5 | 11.1 | 0.4 | 67.6 |
| | 30 | 1.0 | 44.2 | 52.1 | 0.0 | | 143.8 | 12.1 | 0.0 | 44.8 |

Table A1.55. Metal concentrations (µg $L^{-1}$) measured by sediment DGT probes in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm), raw data (Part I: tanks 4-15).

| Sample ID | | | | | Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Pb |
| | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| 4-DGT-S-A | 3.44 | 287.70 | 296.60 | 36.53 | 166.40 | 2.16 | 4.39 | 187.00 | 6.47 |
| 4-DGT-S-B | 2.06 | 162.00 | 168.10 | 22.71 | 142.60 | 1.79 | 4.07 | 110.00 | 6.16 |
| 4-DGT-S-C | 1.72 | 52.80 | 50.78 | 11.74 | 22.37 | 1.73 | 3.52 | 37.58 | 4.41 |
| 5-DGT-S-A | 2.95 | 328.20 | 172.40 | 34.58 | 1754.00 | 2.52 | 6.33 | 254.60 | 4.53 |
| 5-DGT-S-B | 2.58 | 246.00 | 128.30 | 22.64 | 147.90 | 1.45 | 2.18 | 167.80 | 4.98 |
| 5-DGT-S-C | 2.16 | 51.94 | 56.53 | 10.99 | 25.72 | 1.03 | 2.76 | 40.23 | 3.70 |
| 6-DGT-S-A | 4.22 | 317.60 | 168.90 | 46.14 | 368.40 | 2.63 | 4.36 | 224.40 | 9.70 |
| 6-DGT-S-B | 4.12 | 300.40 | 158.50 | 36.93 | 1068.00 | 2.66 | 4.49 | 212.50 | 9.37 |
| 6-DGT-S-C | 2.52 | 81.07 | 46.90 | 13.30 | 102.40 | 1.68 | 3.13 | 58.47 | 4.60 |
| 7-DGT-S-CAP | 0.61 | 154.40 | 72.24 | 22.27 | 118.10 | 2.49 | 6.13 | 100.50 | 5.92 |
| 7-DGT-S-A | 0.85 | 17.38 | 25.10 | 5.04 | -1.00 | 1.52 | 3.67 | 24.07 | 2.18 |
| 7-DGT-S-B | 2.23 | 2.69 | 19.62 | 8.95 | 47.49 | 0.90 | 3.49 | 8.39 | 1.81 |
| 8-DGT-S-CAP | 0.41 | 231.60 | 118.10 | 21.85 | 90.13 | 2.18 | 5.07 | 153.60 | 4.91 |
| 8-DGT-S-A | 0.61 | 29.54 | 24.99 | 10.51 | 15.52 | 1.19 | 4.29 | 33.45 | 3.56 |
| 8-DGT-S-B | 0.14 | -5.60 | 6.32 | 1.82 | -2.91 | 0.30 | 1.41 | 5.86 | 0.77 |
| 9-DGT-S-CAP | 0.93 | 120.50 | 59.65 | 17.70 | 53.93 | 1.74 | 3.18 | 97.51 | 6.09 |
| 9-DGT-S-A | 0.89 | 31.89 | 34.34 | 11.18 | 43.05 | 1.35 | 2.94 | 41.35 | 4.46 |
| 9-DGT-S-B | 0.90 | -3.83 | 11.57 | 2.52 | 0.49 | 0.55 | 1.77 | 7.17 | 2.16 |
| 10-DGT-S-CAPa | 0.88 | 278.40 | 136.70 | 28.90 | 90.93 | 1.69 | 3.42 | 194.20 | 6.01 |
| 10-DGT-S-CAPb | 1.20 | 141.40 | 71.66 | 34.15 | 263.90 | 1.94 | 5.13 | 114.40 | 11.60 |
| 10-DGT-S-A | 0.77 | 4.56 | 11.48 | 8.75 | -0.08 | 1.09 | 3.60 | 15.01 | 3.54 |
| 10-DGT-S-B | 1.11 | -1.18 | 10.75 | 7.01 | 10.96 | 0.58 | 1.60 | 7.15 | 3.48 |
| 11-DGT-S-CAPa | 2.75 | 324.50 | 295.20 | 38.69 | 334.40 | 2.58 | 4.54 | 418.90 | 26.91 |
| 11-DGT-S-CAPb | 1.29 | 134.50 | 70.24 | 25.37 | 54.80 | 2.38 | 5.03 | 120.70 | 9.71 |
| 11-DGT-S-A | 0.89 | 0.26 | 29.44 | 4.32 | -4.80 | 0.46 | 1.88 | 11.53 | 1.84 |
| 11-DGT-S-B | 1.05 | -1.55 | 18.91 | 3.30 | -13.84 | 0.33 | 1.30 | 6.09 | 2.24 |
| 12-DGT-S-CAPa | 1.70 | 236.60 | 126.70 | 18.24 | 145.30 | 2.26 | 4.27 | 169.90 | 10.39 |
| 12-DGT-S-CAPb | 1.09 | 137.60 | 69.86 | 22.05 | 48.22 | 1.46 | 3.42 | 106.60 | 7.26 |
| 12-DGT-S-A | 1.02 | 8.25 | 48.54 | 8.24 | 21.59 | 1.02 | 3.46 | 19.67 | 3.43 |
| 12-DGT-S-B | 0.54 | -4.23 | 27.38 | 2.06 | 128.40 | 0.43 | 2.38 | 5.64 | 1.46 |
| 13-DGT-S-CAP | 1.99 | 167.10 | 155.40 | 30.07 | 105.80 | 2.18 | 7.96 | 87.11 | 7.23 |
| 13-DGT-S-A | 2.03 | 100.00 | 107.10 | 36.38 | 834.40 | 1.50 | 4.19 | 62.26 | 4.98 |
| 13-DGT-S-B | 1.26 | 23.66 | 31.74 | 22.34 | 58.18 | 0.67 | 4.02 | 14.95 | 3.74 |
| 14-DGT-S-CAP | 0.73 | 138.00 | 108.40 | 25.79 | 269.50 | 1.28 | 5.72 | 82.84 | 3.53 |
| 14-DGT-S-A | 1.49 | 34.69 | 49.40 | 29.61 | 51.41 | 1.78 | 5.15 | 20.99 | 5.73 |
| 14-DGT-S-B | 0.92 | 17.89 | 28.36 | 16.36 | 146.00 | 0.63 | 3.07 | 11.04 | 3.69 |
| 15-DGT-S-CAP | 0.95 | 149.60 | 122.80 | 30.24 | 124.90 | 1.27 | 4.91 | 87.00 | 4.21 |
| 15-DGT-S-A | 0.86 | 54.67 | 61.24 | 28.68 | 627.30 | 1.51 | 5.81 | 35.58 | 4.14 |
| 15-DGT-S-B | 1.25 | 45.59 | 59.80 | 27.52 | 67.76 | 0.67 | 2.33 | 31.70 | 5.14 |

Table A1.56. Metal concentrations (µg $L^{-1}$) measured by sediment DGT probes in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm), raw data (Part II: tanks 16-30).

| Sample ID | | | | | Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cr | Co | Ni | Cu | Zn | As | Se | Cd | Pb |
| | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| 16-DGT-S-CAP | 0.79 | 32.12 | 53.57 | 6.08 | 57.94 | 0.24 | 2.47 | 12.47 | 1.57 |
| 16-DGT-S-A | 0.96 | 12.38 | 35.48 | 5.09 | 139.30 | 0.32 | 2.56 | 10.07 | 0.30 |
| 16-DGT-S-B | 1.11 | 7.79 | 29.58 | 2.95 | 385.50 | 0.52 | 3.29 | 7.05 | 0.49 |
| 17-DGT-S-CAP | 1.30 | 47.62 | 69.63 | 8.36 | 758.50 | 0.25 | 2.31 | 20.63 | 2.24 |
| 17-DGT-S-A | 1.30 | 7.33 | 29.08 | 4.31 | 1421.00 | 0.24 | 3.03 | 8.90 | 0.53 |
| 17-DGT-S-B | 1.46 | 17.42 | 42.89 | 5.48 | 429.40 | 0.26 | 3.08 | 6.39 | 0.76 |
| 18-DGT-S-CAP | 2.70 | 42.95 | 67.37 | 12.37 | 1329.00 | 0.88 | 3.18 | 18.66 | 3.86 |
| 18-DGT-S-A | 1.34 | 12.71 | 35.78 | 7.23 | 57.79 | 0.59 | 3.66 | 8.79 | 0.99 |
| 18-DGT-S-B | 2.04 | 16.04 | 37.63 | 5.59 | 1017.00 | 0.95 | 4.16 | 10.06 | 1.61 |
| 22-DGT-S-A | 0.97 | 18.95 | 49.94 | 4.22 | 74.05 | 1.72 | 3.12 | 19.31 | 1.09 |
| 22-DGT-S-B | 1.07 | 22.52 | 37.21 | 5.15 | 90.47 | 1.33 | 3.09 | 22.42 | 1.45 |
| 22-DGT-S-C | 1.74 | 13.65 | 20.31 | 4.77 | 78.55 | 1.55 | 3.66 | 10.05 | 3.18 |
| 23-DGT-S-A | 0.94 | 8.42 | 15.12 | 6.19 | 21.68 | 1.81 | 2.63 | 8.04 | 1.25 |
| 23-DGT-S-B | 1.22 | 10.93 | 17.35 | 5.10 | 49.51 | 1.03 | 0.45 | 10.85 | 2.02 |
| 23-DGT-S-C | 1.55 | 9.78 | 15.69 | 5.65 | 193.50 | 1.51 | 1.95 | 6.17 | 2.90 |
| 24-DGT-S-A | 1.34 | 15.72 | 23.81 | 7.43 | 851.20 | 2.33 | 3.21 | 24.60 | 2.33 |
| 24-DGT-S-B | 1.34 | 22.52 | 23.86 | 99.07 | 701.50 | 1.67 | 3.44 | 26.06 | 3.03 |
| 24-DGT-S-C | 3.57 | 16.04 | 32.89 | 15.58 | 90.47 | 2.21 | 3.48 | 14.47 | 7.11 |
| 25-DGT-S-CAP | 7.45 | 66.14 | 163.20 | 7.95 | 681.30 | 1.96 | 1.80 | 140.50 | 62.39 |
| 25-DGT-S-A | 1.44 | 47.68 | 72.96 | 2.76 | 270.90 | 2.31 | 2.09 | 8.73 | 3.79 |
| 25-DGT-S-B | 18.45 | 41.01 | 57.67 | 24.86 | 147.30 | 0.29 | -0.18 | 5.35 | 5.37 |
| 26-DGT-S-CAP | 20.67 | 142.20 | 384.00 | 88.00 | 694.20 | 7.53 | 3.38 | 187.30 | 88.47 |
| 26-DGT-S-A | 1.43 | 53.09 | 81.39 | 1.60 | 233.60 | 3.34 | 1.28 | 28.59 | 13.65 |
| 26-DGT-S-B | 1.16 | 46.38 | 37.31 | 2.00 | 73.53 | 0.84 | 1.30 | 7.51 | 5.75 |
| 26D-DGT-S-CAP | 67.77 | 235.60 | 1080.00 | 200.40 | 880.20 | 16.14 | 3.95 | 378.10 | 213.00 |
| 26D-DGT-S-A | 8.42 | 87.78 | 212.60 | 9.08 | 1099.00 | 4.09 | 0.66 | 100.90 | 35.40 |
| 26D-DGT-S-B | 2.89 | 81.36 | 83.61 | 5.99 | 1295.00 | 3.51 | 2.33 | 18.83 | 12.32 |
| 27-DGT-S-CAP | 13.31 | 156.30 | 414.80 | 10.02 | 447.70 | 4.00 | 1.32 | 234.90 | 47.74 |
| 27-DGT-S-A | 3.16 | 84.09 | 150.00 | 3.27 | 167.80 | 2.98 | 2.91 | 64.78 | 16.41 |
| 27-DGT-S-B | 1.82 | 77.18 | 63.61 | 4.97 | 314.40 | 1.41 | 1.65 | 12.73 | 7.47 |
| 28-DGT-S-CAP | 1.32 | 85.90 | 125.80 | 1.98 | 24.72 | 0.73 | 1.83 | 6.98 | 2.12 |
| 28-DGT-S-A | 1.80 | 36.91 | 59.39 | 1.92 | 65.76 | 1.53 | 1.71 | 1.31 | 1.09 |
| 28-DGT-S-B | 2.26 | 43.23 | 31.08 | 2.72 | 59.99 | 1.35 | 2.67 | 1.26 | 2.06 |
| 29-DGT-S-CAP | 1.49 | 79.53 | 153.90 | 7.60 | 50.92 | 1.18 | 0.58 | 16.68 | 5.23 |
| 29-DGT-S-A | 1.73 | 44.35 | 61.35 | 2.58 | 994.60 | 0.72 | -0.39 | 0.87 | 1.09 |
| 29-DGT-S-B | 2.44 | 55.52 | 50.35 | 7.50 | 73.61 | 1.20 | 1.43 | 1.39 | 2.73 |
| 30-DGT-S-CAP | 2.31 | 39.65 | 139.20 | 9.05 | 42.73 | 0.82 | 2.30 | 15.98 | 3.45 |
| 30-DGT-S-A | 1.91 | 46.38 | 90.84 | 2.29 | 44.34 | 0.59 | 0.34 | 2.02 | 1.15 |
| 30-DGT-S-B | 2.40 | 65.26 | 56.59 | 3.12 | 32.25 | 1.45 | 1.39 | 0.84 | 2.24 |

Table A1.57. Cadmium (Cd) concentrations (µg/l) measured by sediment DGT probes ($C_{DGT}$) in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm), raw data, calculated concentration after factoring in 4-fold dilution of original sample ($C_e$) and accumulated mass of Cd (M).

| | | Cap-1 inch | | | | Cap-2 inch | | | | A | | | | B | | | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Sample ID | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| | | Raw data | Ce | M | Cd-Cdgt | Raw data | Ce | M | Cd-Cdgt | Raw data | Ce | M | Cd-Cdgt | Raw data | Ce | M | Cd-Cdgt | Raw data | Ce | M | Cd-Cdgt |
| Sediment | 4 | | | | | | | | | 187.0 | 748.0 | 1.7 | 695.1 | 110.0 | 440.0 | 1.0 | 408.9 | 37.6 | 150.3 | 0.3 | 139.7 |
| | 5 | | | | | | | | | 254.6 | 1018.4 | 2.3 | 946.4 | 167.8 | 671.2 | 1.5 | 623.8 | 40.2 | 160.9 | 0.4 | 149.5 |
| | 6 | | | | | | | | | 224.4 | 897.6 | 2.0 | 834.2 | 212.5 | 850.0 | 1.9 | 789.9 | 58.5 | 233.9 | 0.5 | 217.4 |
| Sand - 1 inch | 7 | 100.5 | 402.0 | 0.9 | 373.6 | | | | | 24.1 | 96.3 | 0.2 | 89.5 | 8.4 | 33.6 | 0.1 | 31.2 | | | | |
| | 8 | 153.6 | 614.4 | 1.4 | 571.0 | | | | | 33.5 | 133.8 | 0.3 | 124.3 | 5.9 | 23.4 | 0.1 | 21.8 | | | | |
| | 9 | 97.5 | 390.0 | 0.9 | 362.5 | | | | | 41.4 | 165.4 | 0.4 | 153.7 | 7.2 | 28.7 | 0.1 | 26.7 | | | | |
| Sand-2 inch | 10 | 194.2 | 776.8 | 1.8 | 721.9 | 114.4 | 457.6 | 1.0 | 425.3 | 15.0 | 60.0 | 0.1 | 55.8 | 7.2 | 28.6 | 0.1 | 26.6 | | | | |
| | 12 | 169.9 | 679.6 | 1.5 | 631.6 | 106.6 | 426.4 | 1.0 | 396.3 | 19.7 | 78.7 | 0.2 | 73.1 | 5.6 | 22.6 | 0.1 | 21.0 | | | | |
| Silty Clay | 13 | 87.1 | 348.4 | 0.8 | 323.8 | | | | | 62.3 | 249.0 | 0.6 | 231.4 | 15.0 | 59.8 | 0.1 | 55.6 | | | | |
| | 14 | 82.8 | 331.4 | 0.7 | 307.9 | | | | | 21.0 | 84.0 | 0.2 | 78.0 | 11.0 | 44.2 | 0.1 | 41.0 | | | | |
| | 15 | 87.0 | 348.0 | 0.8 | 323.4 | | | | | 35.6 | 142.3 | 0.3 | 132.3 | 31.7 | 126.8 | 0.3 | 117.8 | | | | |
| A- 1 inch | 16 | 12.5 | 49.9 | 0.1 | 46.4 | | | | | 10.1 | 40.3 | 0.1 | 37.4 | 7.0 | 28.2 | 0.1 | 26.2 | | | | |
| | 17 | 20.6 | 82.5 | 0.2 | 76.7 | | | | | 8.9 | 35.6 | 0.1 | 33.1 | 6.4 | 25.6 | 0.1 | 23.7 | | | | |
| | 18 | 18.7 | 74.6 | 0.2 | 69.4 | | | | | 8.8 | 35.1 | 0.1 | 32.7 | 10.1 | 40.2 | 0.1 | 37.4 | | | | |
| AC | 22 | | | | | | | | | 19.3 | 77.2 | 0.2 | 71.8 | 22.4 | 89.7 | 0.2 | 83.3 | 10.1 | 40.2 | 0.1 | 37.4 |
| | 23 | | | | | | | | | 8.0 | 32.2 | 0.1 | 29.9 | 10.9 | 43.4 | 0.1 | 40.3 | 6.2 | 24.7 | 0.1 | 23.0 |
| | 24 | | | | | | | | | 24.6 | 98.4 | 0.2 | 91.4 | 26.1 | 104.2 | 0.2 | 96.9 | 14.5 | 57.9 | 0.1 | 53.8 |
| MRM | 25 | 140.5 | 562.0 | 1.3 | 522.3 | | | | | 8.7 | 34.9 | 0.1 | 32.4 | 5.4 | 21.4 | 0.0 | 19.9 | | | | |
| | 26 | 187.3 | 749.2 | 1.7 | 696.3 | | | | | 28.6 | 114.4 | 0.3 | 106.3 | 7.5 | 30.0 | 0.1 | 27.9 | | | | |
| | 27 | 234.9 | 939.6 | 2.1 | 873.2 | | | | | 64.8 | 259.1 | 0.6 | 240.8 | 12.7 | 50.9 | 0.1 | 47.3 | | | | |
| MAAC | 28 | 7.0 | 27.9 | 0.1 | 25.9 | | | | | 1.3 | 5.2 | 0.0 | 4.9 | 1.3 | 5.0 | 0.0 | 4.7 | | | | |
| | 29 | 16.7 | 66.7 | 0.2 | 62.0 | | | | | 0.9 | 3.5 | 0.0 | 3.2 | 1.4 | 5.6 | 0.0 | 5.2 | | | | |
| | 30 | 16.0 | 63.9 | 0.1 | 59.4 | | | | | 2.0 | 8.1 | 0.0 | 7.5 | 0.8 | 3.4 | 0.0 | 3.1 | | | | |

Table A1.58. Cobalt (Co) concentrations (µg/l) measured by sediment DGT probes ($C_{DGT}$) in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm), raw data, calculated concentration after factoring in 4-fold of dilution of original sample ($C_e$) and accumulated mass of Co (M).

| Treatments | Sample | Cap-1 inch | | | | Cap-2 inch | | | | A | | | | B | | | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Raw data | Ce | M | Co-Cdgt | Raw data | Ce | M | Co-Cdgt | Raw data | Ce | M | Co-Cdgt | Raw data | Ce | M | Co-Cdgt | Raw data | Ce | M | Co-Cdgt |
| | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| Sediment | 4 | | | | | | | | | 287.7 | 1150.8 | 2.6 | 1095.0 | 162.0 | 648.0 | 1.5 | 616.6 | 52.8 | 211.2 | 0.5 | 201.0 |
| | 5 | | | | | | | | | 328.2 | 1312.8 | 3.0 | 1249.2 | 246.0 | 984.0 | 2.2 | 936.3 | 51.9 | 207.8 | 0.5 | 197.7 |
| | 6 | | | | | | | | | 317.6 | 1270.4 | 2.9 | 1208.8 | 300.4 | 1201.6 | 2.7 | 1143.4 | 81.1 | 324.3 | 0.7 | 308.6 |
| Sand - 1 inch | 7 | 154.4 | 617.6 | 1.4 | 587.7 | | | | | 17.4 | 69.5 | 0.2 | 66.2 | 2.7 | 10.7 | 0.0 | 10.2 | | | | |
| | 8 | 231.6 | 926.4 | 2.1 | 881.5 | | | | | 29.5 | 118.2 | 0.3 | 112.4 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| | 9 | 120.5 | 482.0 | 1.1 | 458.6 | | | | | 31.9 | 127.6 | 0.3 | 121.4 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| Sand-2 inch | 10 | 278.4 | 1113.6 | 2.5 | 1059.6 | 141.4 | 565.6 | 1.3 | 538.2 | 4.6 | 18.2 | 0.0 | 17.4 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| | 12 | 236.6 | 946.4 | 2.1 | 900.5 | 137.6 | 550.4 | 1.2 | 523.7 | 8.3 | 33.0 | 0.1 | 31.4 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| Silty Clay | 13 | 167.1 | 668.4 | 1.5 | 636.0 | | | | | 100.0 | 400.0 | 0.9 | 380.6 | 23.7 | 94.6 | 0.2 | 90.1 | | | | |
| | 14 | 138.0 | 552.0 | 1.2 | 525.3 | | | | | 34.7 | 138.8 | 0.3 | 132.0 | 17.9 | 71.6 | 0.2 | 68.1 | | | | |
| | 15 | 149.6 | 598.4 | 1.4 | 569.4 | | | | | 54.7 | 218.7 | 0.5 | 208.1 | 45.6 | 182.4 | 0.4 | 173.5 | | | | |
| A -1 inch | 16 | 32.1 | 128.5 | 0.3 | 122.3 | | | | | 12.4 | 49.5 | 0.1 | 47.1 | 7.8 | 31.2 | 0.1 | 29.6 | | | | |
| | 17 | 47.6 | 190.5 | 0.4 | 181.3 | | | | | 7.3 | 29.3 | 0.1 | 27.9 | 17.4 | 69.7 | 0.2 | 66.3 | | | | |
| | 18 | 43.0 | 171.8 | 0.4 | 163.5 | | | | | 12.7 | 50.8 | 0.1 | 48.4 | 16.0 | 64.2 | 0.1 | 61.1 | | | | |
| AC | 22 | | | | | | | | | 19.0 | 75.8 | 0.2 | 72.1 | 22.5 | 90.1 | 0.2 | 85.7 | 13.7 | 54.6 | 0.1 | 52.0 |
| | 23 | | | | | | | | | 8.4 | 33.7 | 0.1 | 32.1 | 10.9 | 43.7 | 0.1 | 41.6 | 9.8 | 39.1 | 0.1 | 37.2 |
| | 24 | | | | | | | | | 15.7 | 62.9 | 0.1 | 59.8 | 22.5 | 90.1 | 0.2 | 85.7 | 16.0 | 64.2 | 0.1 | 61.1 |
| MRM | 25 | 66.1 | 264.6 | 0.6 | 251.7 | | | | | 47.7 | 190.7 | 0.4 | 181.5 | 41.0 | 164.0 | 0.4 | 156.1 | | | | |
| | 26 | 142.2 | 568.8 | 1.3 | 541.2 | | | | | 53.1 | 212.4 | 0.5 | 202.1 | 46.4 | 185.5 | 0.4 | 176.5 | | | | |
| | 27 | 156.3 | 625.2 | 1.4 | 594.9 | | | | | 84.1 | 336.4 | 0.8 | 320.1 | 77.2 | 308.7 | 0.7 | 293.8 | | | | |
| MAAC | 28 | 85.9 | 343.6 | 0.8 | 327.0 | | | | | 36.9 | 147.6 | 0.3 | 140.5 | 43.2 | 172.9 | 0.4 | 164.5 | | | | |
| | 29 | 79.5 | 318.1 | 0.7 | 302.7 | | | | | 44.4 | 177.4 | 0.4 | 168.8 | 55.5 | 222.1 | 0.5 | 211.3 | | | | |
| | 30 | 39.7 | 158.6 | 0.4 | 150.9 | | | | | 46.4 | 185.5 | 0.4 | 176.5 | 65.3 | 261.0 | 0.6 | 248.4 | | | | |

Table A1.59. Copper (Cu) concentrations (µg/l) measured by sediment DGT probes ($C_{DGT}$) in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm), raw data, calculated concentration after factoring in 4-fold of dilution of original sample ($C_e$), and accumulated mass of Cu (M).

| Treatments | Sample | Cap-1 inch | | | | Cap-2 inch | | | | A | | | | B | | | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Raw data | Ce | M | Cu-Cdgt | Raw data | Ce | M | Cu-Cdgt | Raw data | Ce | M | Cu-Cdgt | Raw data | Ce | M | Cu-Cdgt | Raw data | Ce | M | Cu-Cdgt |
| | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| Sediment | 4 | | | | | | | | | 36.5 | 146.1 | 0.3 | 132.4 | 22.7 | 90.8 | 0.2 | 82.3 | 11.7 | 47.0 | 0.1 | 42.6 |
| | 5 | | | | | | | | | 34.6 | 138.3 | 0.3 | 125.4 | 22.6 | 90.6 | 0.2 | 82.1 | 11.0 | 44.0 | 0.1 | 39.8 |
| | 6 | | | | | | | | | 46.1 | 184.6 | 0.4 | 167.3 | 36.9 | 147.7 | 0.3 | 133.9 | 13.3 | 53.2 | 0.1 | 48.2 |
| Sand - 1 inch | 7 | 22.3 | 89.1 | 0.2 | 80.7 | | | | | 5.0 | 20.1 | 0.0 | 18.3 | 9.0 | 35.8 | 0.1 | 32.5 | | | | |
| | 8 | 21.9 | 87.4 | 0.2 | 79.2 | | | | | 10.5 | 42.0 | 0.1 | 38.1 | 1.8 | 7.3 | 0.0 | 6.6 | | | | |
| | 9 | 17.7 | 70.8 | 0.2 | 64.2 | | | | | 11.2 | 44.7 | 0.1 | 40.5 | 2.5 | 10.1 | 0.0 | 9.2 | | | | |
| Sand-2 inch | 10 | 28.9 | 115.6 | 0.3 | 104.8 | 34.2 | 136.6 | 0.3 | 123.8 | 8.8 | 35.0 | 0.1 | 31.7 | 7.0 | 28.1 | 0.1 | 25.4 | | | | |
| | 12 | 18.2 | 73.0 | 0.2 | 66.1 | 22.1 | 88.2 | 0.2 | 79.9 | 8.2 | 33.0 | 0.1 | 29.9 | 2.1 | 8.2 | 0.0 | 7.5 | | | | |
| Silty Clay | 13 | 30.1 | 120.3 | 0.3 | 109.0 | | | | | 36.4 | 145.5 | 0.3 | 131.9 | 22.3 | 89.4 | 0.2 | 81.0 | | | | |
| | 14 | 25.8 | 103.2 | 0.2 | 93.5 | | | | | 29.6 | 118.4 | 0.3 | 107.4 | 16.4 | 65.4 | 0.1 | 59.3 | | | | |
| | 15 | 30.2 | 121.0 | 0.3 | 109.6 | | | | | 28.7 | 114.7 | 0.3 | 104.0 | 27.5 | 110.1 | 0.2 | 99.8 | | | | |
| A -1 inch | 16 | 6.1 | 24.3 | 0.1 | 22.0 | | | | | 5.1 | 20.3 | 0.0 | 18.4 | 3.0 | 11.8 | 0.0 | 10.7 | | | | |
| | 17 | 8.4 | 33.5 | 0.1 | 30.3 | | | | | 4.3 | 17.2 | 0.0 | 15.6 | 5.5 | 21.9 | 0.0 | 19.9 | | | | |
| | 18 | 12.4 | 49.5 | 0.1 | 44.8 | | | | | 7.2 | 28.9 | 0.1 | 26.2 | 5.6 | 22.3 | 0.1 | 20.2 | | | | |
| AC | 22 | | | | | | | | | 4.2 | 16.9 | 0.0 | 15.3 | 5.1 | 20.6 | 0.0 | 18.7 | 4.8 | 19.1 | 0.0 | 17.3 |
| | 23 | | | | | | | | | 6.2 | 24.7 | 0.1 | 22.4 | 5.1 | 20.4 | 0.0 | 18.5 | 5.7 | 22.6 | 0.1 | 20.5 |
| MRM | 27 | 10.0 | 40.1 | 0.1 | 36.3 | | | | | 3.3 | 13.1 | 0.0 | 11.9 | 5.0 | 19.9 | 0.0 | 18.0 | | | | |
| MAAC | 28 | 2.0 | 7.9 | 0.0 | 7.2 | | | | | 1.9 | 7.7 | 0.0 | 7.0 | 2.7 | 10.9 | 0.0 | 9.9 | | | | |
| | 29 | 7.6 | 30.4 | 0.1 | 27.6 | | | | | 2.6 | 10.3 | 0.0 | 9.4 | 7.5 | 30.0 | 0.1 | 27.2 | | | | |
| | 30 | 9.1 | 36.2 | 0.1 | 32.8 | | | | | 2.3 | 9.2 | 0.0 | 8.3 | 3.1 | 12.5 | 0.0 | 11.3 | | | | |

Table A1.60. Nickel (Ni) concentrations (µg/l) measured by sediment DGT probes ($C_{DGT}$) in cap materials and individual layers of sediment (layer A: 0-2.5 cm, layer B: 2.5 – 5.0 cm, and layer C: 5 - 7.5 cm), raw data, calculated concentration after factoring in 4-fold of dilution of original sample ($C_e$) and accumulated mass of Ni (M).

| Treatments | Sample | Cap-1 inch | | | | Cap-2 inch | | | | A | | | | B | | | | C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Raw data | Ce | M | Ni-Cdgt | Raw data | Ce | M | Ni-Cdgt | Raw data | Ce | M | Ni-Cdgt | Raw data | Ce | M | Ni-Cdgt | Raw data | Ce | M | Ni-Cdgt |
| | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| Sediment | 4 | | | | | | | | | 296.6 | 1186.4 | 2.7 | 1161.3 | 168.1 | 672.4 | 1.5 | 658.2 | 50.8 | 203.1 | 0.5 | 198.8 |
| | 5 | | | | | | | | | 172.4 | 689.6 | 1.6 | 675.0 | 128.3 | 513.2 | 1.2 | 502.3 | 56.5 | 226.1 | 0.5 | 221.3 |
| | 6 | | | | | | | | | 168.9 | 675.6 | 1.5 | 661.3 | 158.5 | 634.0 | 1.4 | 620.6 | 46.9 | 187.6 | 0.4 | 183.6 |
| Sand - 1 inch | 7 | 72.2 | 289.0 | 0.7 | 282.8 | | | | | 25.1 | 100.4 | 0.2 | 98.3 | 19.6 | 78.5 | 0.2 | 76.8 | | | | |
| | 8 | 118.1 | 472.4 | 1.1 | 462.4 | | | | | 25.0 | 100.0 | 0.2 | 97.8 | 6.3 | 25.3 | 0.1 | 24.7 | | | | |
| | 9 | 59.7 | 238.6 | 0.5 | 233.6 | | | | | 34.3 | 137.4 | 0.3 | 134.5 | 11.6 | 46.3 | 0.1 | 45.3 | | | | |
| Sand-2 inch | 10 | 136.7 | 546.8 | 1.2 | 535.2 | 71.7 | 286.6 | 0.6 | 280.6 | 11.5 | 45.9 | 0.1 | 44.9 | 10.8 | 43.0 | 0.1 | 42.1 | | | | |
| | 12 | 126.7 | 506.8 | 1.1 | 496.1 | 69.9 | 279.4 | 0.6 | 273.5 | 48.5 | 194.2 | 0.4 | 190.1 | 27.4 | 109.5 | 0.2 | 107.2 | | | | |
| Silty Clay | 13 | 155.4 | 621.6 | 1.4 | 608.5 | | | | | 107.1 | 428.4 | 1.0 | 419.3 | 31.7 | 127.0 | 0.3 | 124.3 | | | | |
| | 14 | 108.4 | 433.6 | 1.0 | 424.4 | | | | | 49.4 | 197.6 | 0.4 | 193.4 | 28.4 | 113.4 | 0.3 | 111.0 | | | | |
| | 15 | 122.8 | 491.2 | 1.1 | 480.8 | | | | | 61.2 | 245.0 | 0.6 | 239.8 | 59.8 | 239.2 | 0.5 | 234.1 | | | | |
| A-1 inch | 16 | 53.6 | 214.3 | 0.5 | 209.7 | | | | | 35.5 | 141.9 | 0.3 | 138.9 | 29.6 | 118.3 | 0.3 | 115.8 | | | | |
| | 17 | 69.6 | 278.5 | 0.6 | 272.6 | | | | | 29.1 | 116.3 | 0.3 | 113.9 | 42.9 | 171.6 | 0.4 | 167.9 | | | | |
| | 18 | 67.4 | 269.5 | 0.6 | 263.8 | | | | | 35.8 | 143.1 | 0.3 | 140.1 | 37.6 | 150.5 | 0.3 | 147.3 | | | | |
| AC | 22 | | | | | | | | | 49.9 | 199.8 | 0.5 | 195.5 | 37.2 | 148.8 | 0.3 | 145.7 | 20.3 | 81.2 | 0.2 | 79.5 |
| | 23 | | | | | | | | | 15.1 | 60.5 | 0.1 | 59.2 | 17.4 | 69.4 | 0.2 | 67.9 | 15.7 | 62.8 | 0.1 | 61.4 |
| | 24 | | | | | | | | | 23.8 | 95.2 | 0.2 | 93.2 | 23.9 | 95.4 | 0.2 | 93.4 | 32.9 | 131.6 | 0.3 | 128.8 |
| MRM | 25 | 163.2 | 652.8 | 1.5 | 639.0 | | | | | 73.0 | 291.8 | 0.7 | 285.7 | 57.7 | 230.7 | 0.5 | 225.8 | | | | |
| | 26 | 384.0 | 1536.0 | 3.5 | 1503.5 | | | | | 81.4 | 325.6 | 0.7 | 318.7 | 37.3 | 149.2 | 0.3 | 146.1 | | | | |
| | 27 | 414.8 | 1659.2 | 3.8 | 1624.1 | | | | | 150.0 | 600.0 | 1.4 | 587.3 | 63.6 | 254.4 | 0.6 | 249.1 | | | | |
| MAAC | 28 | 125.8 | 503.2 | 1.1 | 492.6 | | | | | 59.4 | 237.6 | 0.5 | 232.5 | 31.1 | 124.3 | 0.3 | 121.7 | | | | |
| | 29 | 153.9 | 615.6 | 1.4 | 602.6 | | | | | 61.4 | 245.4 | 0.6 | 240.2 | 50.4 | 201.4 | 0.5 | 197.1 | | | | |
| | 30 | 139.2 | 556.8 | 1.3 | 545.0 | | | | | 90.8 | 363.4 | 0.8 | 355.7 | 56.6 | 226.4 | 0.5 | 221.6 | | | | |

Table A1. 61. Raw data of metal concentrations in pore water samples collected on 2/1/2017 before addition of spike solutions. Experiment I: uncapped sediment (7-9), sediment with sand caps (10-11; 12 is missing), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | Cu $\mu g\ L^{-1}$ | Zn $\mu g\ L^{-1}$ | As $\mu g\ L^{-1}$ | Cd $\mu g\ L^{-1}$ | Pb $\mu g\ L^{-1}$ |
|---|---|---|---|---|---|
| Experiment I (multiple element spike solution) | | | | | |
| 7-PW1 | 0.62 | 36.0 | 1.52 | 0.61 | 0.16 |
| 8-PW1 | 0.65 | 43.7 | 1.29 | 0.59 | 0.06 |
| 9-PW1 | 0.75 | 39.4 | 1.54 | 0.57 | 0.05 |
| 10-PW1 | 0.98 | 36.5 | 1.55 | 0.72 | 0.09 |
| 11-PW1 | 0.65 | 38.7 | 1.61 | 0.71 | 0.13 |
| 12-PW1 | missing | | | | |
| 13-PW1 | 0.73 | 38.4 | 1.57 | 0.43 | 0.09 |
| 14-PW1 | 0.71 | 38.3 | 1.85 | 0.51 | 0.16 |
| 15-PW1 | 0.56 | 33.0 | 1.65 | 0.76 | 0.10 |
| 16-PW1 | 0.42 | 35.9 | 1.59 | 0.57 | 0.05 |
| 17-PW1 | 0.65 | 30.5 | 1.57 | 0.52 | 0.05 |
| 18-PW1 | 0.65 | 24.2 | 1.45 | 0.32 | 0.06 |
| 19-PW1 | 0.87 | 37.4 | 1.06 | 0.53 | 0.16 |
| 20-PW1 | 0.93 | 30.4 | 1.05 | 0.34 | 0.23 |
| 21-PW1 | 0.69 | 44.3 | 1.45 | 0.57 | 0.18 |
| Experiment II (Cu spike solution) | | | | | |
| 25-PW1 | 0.93 | 34.0 | 1.95 | 0.62 | 0.07 |
| 26-PW1 | 0.57 | 46.2 | 1.37 | 0.50 | 0.00 |
| 27-PW1 | 0.65 | 34.6 | 1.25 | 0.69 | 0.07 |
| 28--PW1 | missing | | | | |
| 29-PW1 | 0.83 | 27.8 | 1.53 | 0.88 | 0.09 |
| 30-PW1 | 0.98 | 40.5 | 1.83 | 0.80 | 0.14 |

Table A1. 62. Raw data of metal concentrations in pore water samples collected on 4/11/2017 at 1536 h. Experiment I: uncapped sediment (7-9), sediment with sand caps (10-11; 12 is missing), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | Cu | Zn | As | Cd | Pb |
|---|---|---|---|---|---|
| | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ |
| Experiment I (multiple element spike solution) | | | | | |
| 7-PW2 | 1.43 | 45.2 | 4.20 | 1.37 | 0.39 |
| 8-PW2 | 1.35 | 50.5 | 3.54 | 1.18 | 0.93 |
| 9-PW2 | 1.12 | 56.7 | 3.09 | 1.45 | 0.44 |
| 10-PW2 | 1.70 | 79.9 | 3.54 | 2.85 | 0.96 |
| 11-PW2 | 1.20 | 67.6 | 2.01 | 2.70 | 0.63 |
| 13-PW2 | 1.05 | 41.2 | 2.18 | 0.71 | 0.08 |
| 14-PW2 | 0.97 | 47.4 | 2.14 | 0.86 | 0.08 |
| 15-PW2 | 0.24 | 25.9 | 2.38 | 0.80 | 0.05 |
| 16-PW2 | 0.12 | 31.7 | 2.27 | 0.52 | 0.18 |
| 17-PW2 | 0.00 | 29.3 | 2.12 | 0.52 | 0.09 |
| 19-PW2 | 0.42 | 38.5 | 2.12 | 0.31 | 0.08 |
| 20-PW2 | 0.29 | 29.3 | 1.96 | 0.51 | 0.05 |
| 21-PW2 | 0.28 | 33.0 | 2.11 | 0.60 | 0.07 |
| Experiment II (Cu spike solution) | | | | | |
| 25-PW2 | 1.15 | 44.4 | 1.97 | 0.90 | 0.11 |
| 26-PW2 | missing | | | | |
| 27-PW2 | 1.02 | 51.3 | 1.93 | 0.68 | 0.11 |
| 29-PW2 | 0.45 | 29.4 | 2.38 | 0.62 | 0.17 |
| 30-PW2 | 0.42 | 40.6 | 1.70 | 0.59 | 0.14 |

Table A1. 63. Raw data of metal concentrations in pore water samples collected on 6/6/2017 at 2880 h. Experiment I: uncapped sediment (7-9), sediment with sand caps (10-11; 12 is missing), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-17; 18 is missing). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | Cu | Zn | As | Cd | Pb |
|---|---|---|---|---|---|
| | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ | $\mu g\ L^{-1}$ |
| Experiment I (multiple element spike solution) | | | | | |
| 7-PW3 | 0.91 | 46.4 | 4.33 | 1.41 | 0.30 |
| 8-PW3 | 0.55 | 31.1 | 3.35 | 1.72 | 0.24 |
| 9-PW3 | 0.50 | 31.1 | 1.92 | 0.83 | 0.15 |
| 10-PW3 | 2.23 | 57.2 | 3.33 | 2.03 | 0.90 |
| 11-PW3 | 0.84 | 54.3 | 2.57 | 1.02 | 0.36 |
| 13-PW3 | 0.51 | 30.5 | 2.46 | 1.47 | 0.09 |
| 14-PW3 | 0.67 | 35.9 | 2.33 | 0.76 | 0.25 |
| 15-PW3 | 0.40 | 26.0 | 2.42 | 0.77 | 0.00 |
| 16-PW3 | 0.95 | 24.1 | 1.85 | 1.12 | 0.32 |
| 17-PW3 | 0.45 | 27.6 | 2.63 | 0.68 | 0.24 |
| 18-PW3 | missing | | | | |
| 20-PW3 | 0.35 | 36.9 | 3.56 | 0.61 | 0.22 |
| 21-PW3 | 0.56 | 25.9 | 2.96 | 0.80 | 0.12 |
| Experiment II (Cu spike solution) | | | | | |
| 25-PW3 | 0.80 | 60.0 | 2.32 | 0.84 | 0.04 |
| 27-PW3 | 0.33 | 33.9 | 2.52 | 0.81 | 0.06 |
| 29-PW3 | 0.23 | 46.3 | 3.48 | 0.41 | 0.00 |
| 30-PW3 | 0.34 | 34.1 | 3.39 | 0.42 | 0.08 |

Table A1. 64. Raw data for pH of surface water samples collected from time 0 to 2880 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | 0 | 24 | 48 | 72 | 96 | 192 | 360 | 528 | 696 | 864 | 1032 | 1200 | 1368 | 1536 | 1704 | 1872 | 2040 | 2208 | 2376 | 2544 | 2712 | 2880 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | | | | | | | | | | | Hours | | | | | | | | | | | |
| | Experiment I | | | | | | | | | | | | | | | | | | | | | |
| 4 | 7.42 | 7.41 | 7.05 | 7.34 | 7.36 | 7.33 | 7.27 | 7.19 | 6.96 | 7.02 | 6.93 | 7.10 | 7.04 | 6.92 | 6.83 | 6.85 | 6.99 | 6.88 | 7.00 | 7.20 | 6.99 | 6.95 |
| 5 | 7.40 | 7.40 | 7.14 | 7.35 | 7.36 | 7.36 | 7.23 | 7.18 | 7.07 | 7.02 | 7.01 | 7.10 | 7.05 | 6.93 | 6.87 | 6.90 | 6.89 | 6.89 | 7.02 | 7.25 | 6.89 | 7.03 |
| 6 | 7.42 | 7.45 | 7.05 | 7.31 | 7.36 | 7.36 | 7.28 | 7.23 | 7.13 | 7.08 | 7.03 | 7.06 | 7.06 | 6.99 | 6.90 | 6.90 | 6.95 | 6.97 | 6.99 | 7.27 | 6.95 | 7.05 |
| 7 | 7.50 | 7.50 | 7.19 | 7.21 | 7.34 | 7.30 | 7.33 | 7.35 | 7.08 | 7.16 | 7.08 | 7.20 | 7.18 | 7.12 | 6.94 | 7.05 | 6.98 | 7.05 | 7.00 | 7.20 | 6.98 | 7.13 |
| 8 | 7.48 | 7.49 | 7.29 | 7.19 | 7.35 | 7.30 | 7.36 | 7.38 | 7.09 | 7.19 | 7.00 | 7.21 | 7.17 | 7.20 | 6.99 | 7.03 | 7.07 | 7.09 | 7.07 | 7.40 | 7.07 | 7.16 |
| 9 | 7.47 | 7.47 | 7.28 | 7.24 | 7.43 | 7.32 | 7.27 | 7.36 | 7.23 | 7.19 | 7.06 | 7.21 | 7.20 | 7.18 | 7.00 | 7.00 | 6.98 | 7.10 | 7.00 | 7.36 | 6.98 | 7.15 |
| 10 | 7.40 | 7.40 | 7.22 | 7.13 | 7.34 | 7.47 | 7.51 | 7.31 | 7.19 | 7.28 | 7.20 | 7.16 | 6.98 | 7.19 | 6.97 | 7.03 | 7.08 | 7.10 | 7.10 | 7.08 | 7.08 | 7.13 |
| 11 | 7.49 | 7.49 | 7.36 | 7.16 | 7.37 | 7.44 | 7.50 | 7.32 | 7.22 | 7.26 | 7.18 | 7.20 | 6.99 | 7.17 | 7.00 | 7.00 | 7.10 | 7.20 | 7.13 | 7.10 | 7.10 | 7.15 |
| 12 | 7.48 | 7.46 | 7.30 | 7.20 | 7.43 | 7.47 | 7.46 | 7.38 | 7.22 | 7.28 | 7.16 | 7.20 | 7.01 | 7.06 | 7.04 | 7.07 | 7.00 | 6.99 | 7.10 | 7.10 | 7.00 | 7.16 |
| 13 | 7.76 | 7.76 | 7.80 | 7.71 | 7.74 | 7.73 | 7.99 | 7.77 | 7.70 | 7.75 | 7.85 | 7.75 | 7.70 | 7.89 | 7.80 | 7.90 | 7.60 | 7.71 | 7.88 | 7.84 | 7.60 | 7.92 |
| 14 | 7.80 | 7.82 | 7.76 | 7.71 | 7.72 | 7.72 | 7.84 | 7.72 | 7.80 | 7.73 | 7.76 | 7.82 | 7.70 | 7.82 | 7.80 | 7.85 | 7.62 | 7.63 | 7.87 | 9.91 | 7.62 | 7.96 |
| 15 | 7.78 | 7.78 | 7.79 | 7.79 | 7.71 | 7.77 | 7.85 | 7.82 | 7.80 | 7.76 | 7.76 | 7.85 | 7.73 | 7.82 | 7.75 | 7.85 | 7.69 | 7.71 | 7.88 | 7.98 | 7.69 | 7.97 |
| 16 | 8.05 | 8.12 | 8.06 | 8.07 | 8.06 | 8.02 | 8.10 | 8.20 | 8.05 | 7.99 | 8.00 | 8.03 | 7.92 | 8.04 | 8.00 | 7.90 | 7.82 | 7.80 | 8.03 | 7.85 | 7.82 | 7.91 |
| 17 | 8.16 | 8.16 | 8.07 | 8.04 | 8.03 | 8.03 | 8.10 | 8.21 | 8.03 | 8.03 | 7.99 | 8.01 | 7.94 | 8.03 | 8.00 | 8.00 | 7.83 | 7.79 | 7.96 | 7.80 | 7.83 | 7.92 |
| 18 | 8.18 | 8.11 | 8.07 | 8.03 | 8.03 | 8.02 | 8.08 | 8.12 | 8.03 | 7.99 | 8.02 | 8.00 | 7.98 | 8.07 | 8.04 | 7.99 | 7.86 | 7.83 | 7.95 | 7.85 | 7.86 | 7.92 |
| 19 | 8.00 | 7.99 | 7.90 | 7.73 | 7.72 | 7.82 | 7.99 | 7.83 | 7.64 | 7.85 | 7.85 | 7.83 | 7.85 | 8.00 | 7.97 | 8.00 | 7.80 | 7.92 | 7.80 | 7.95 | 7.80 | 7.89 |
| 20 | 8.01 | 8.01 | 7.96 | 7.84 | 7.80 | 7.86 | 8.02 | 8.91 | 7.80 | 7.79 | 7.82 | 7.84 | 7.92 | 8.07 | 7.98 | 7.99 | 7.82 | 7.92 | 7.96 | 7.98 | 7.82 | 7.91 |
| 21 | 8.04 | 8.04 | 7.96 | 7.87 | 7.80 | 7.85 | 8.06 | 7.92 | 7.84 | 7.84 | 7.90 | 7.92 | 7.96 | 8.00 | 7.96 | 8.05 | 7.85 | 7.99 | 7.95 | 7.96 | 7.85 | 7.99 |
| | Experiment II | | | | | | | | | | | | | | | | | | | | | |
| 22 | 7.52 | 7.42 | 7.44 | 7.36 | 7.30 | 7.30 | 7.35 | 7.30 | 7.24 | 7.30 | 7.16 | 7.21 | 7.20 | 7.24 | 7.16 | 7.07 | 7.07 | 7.10 | 7.12 | 7.14 | 7.07 | 7.15 |
| 23 | 7.47 | 7.40 | 7.46 | 7.39 | 7.24 | 7.24 | 7.37 | 7.36 | 7.18 | 7.32 | 7.18 | 7.29 | 7.19 | 7.26 | 7.17 | 7.05 | 7.05 | 7.08 | 7.10 | 7.25 | 7.05 | 7.13 |
| 24 | 7.45 | 7.45 | 7.45 | 7.40 | 7.27 | 7.30 | 7.30 | 7.34 | 7.24 | 7.33 | 7.19 | 7.30 | 7.20 | 7.20 | 7.17 | 7.07 | 7.07 | 7.05 | 7.15 | 7.25 | 7.07 | 7.18 |
| 25 | 7.53 | 7.43 | 7.55 | 7.36 | 7.47 | 7.47 | 7.50 | 7.51 | 7.19 | 7.35 | 7.19 | 7.20 | 7.25 | 7.16 | 7.40 | 7.27 | 7.22 | 7.08 | 7.25 | 7.12 | 7.22 | 7.28 |
| 26 | 7.50 | 7.46 | 7.58 | 7.36 | 7.46 | 7.40 | 7.53 | 7.45 | 7.07 | 7.35 | 7.2 | 7.30 | 7.26 | 7.19 | 7.43 | 7.21 | 7.20 | 7.10 | 7.16 | 7.14 | 7.20 | 7.25 |
| 27 | 7.49 | 7.49 | 7.53 | 7.31 | 7.45 | 7.45 | 7.53 | 7.48 | 7.16 | 7.36 | 7.2 | 7.31 | 7.30 | 7.20 | 7.39 | 7.26 | 7.20 | 7.10 | 7.20 | 7.20 | 7.20 | 7.30 |
| 28 | 8.00 | 7.96 | 7.93 | 7.93 | 7.91 | 7.93 | 8.10 | 7.99 | 7.66 | 7.93 | 7.99 | 7.84 | 7.99 | 8.02 | 8.04 | 8.11 | 7.90 | 8.00 | 7.93 | 8.04 | 7.90 | 8.02 |
| 29 | 7.98 | 7.91 | 7.91 | 7.93 | 7.89 | 7.93 | 8.08 | 8.02 | 7.90 | 7.99 | 7.89 | 7.92 | 7.99 | 8.05 | 8.00 | 8.11 | 7.96 | 8.00 | 7.97 | 8.01 | 7.96 | 8.05 |
| 30 | 8.00 | 7.94 | 7.93 | 7.91 | 7.88 | 7.92 | 8.05 | 7.97 | 7.66 | 7.97 | 7.89 | 7.96 | 8.02 | 8.05 | 8.02 | 8.10 | 7.98 | 8.03 | 7.98 | 8.05 | 7.98 | 8.00 |

Table A1. 65. Raw data for electrical conductivity (EC) of surface water samples collected from time 0 to 2880 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | 0 | 24 | 48 | 72 | 96 | 192 | 360 | 528 | 696 | 864 | 1032 | 1200 | 1368 | 1536 | 1704 | 1872 | 2040 | 2208 | 2376 | 2544 | 2712 | 2880 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | | | | | | | | | | | Hours | | | | | | | | | | | |
| | Experiment I | | | | | | | | | | | | | | | | | | | | | |
| 4 | 98.4 | 88.1 | 89.7 | 100.9 | 93.2 | 100.0 | 96.0 | 99.9 | 99.9 | 96.6 | 99.6 | 87.1 | 92.0 | 93.0 | 95.8 | 94.3 | 97.9 | 99.7 | 95.6 | 105.0 | 97.9 | 112.0 |
| 5 | 96.3 | 83.2 | 88.3 | 83.4 | 95.4 | 102.0 | 97.0 | 92.9 | 92.9 | 96.5 | 96.5 | 87.5 | 94.1 | 87.2 | 85.0 | 95.3 | 96.7 | 104.6 | 96.3 | 106.0 | 96.7 | 115.6 |
| 6 | 96.3 | 75.3 | 91.7 | 98.8 | 96.6 | 99.9 | 96.0 | 93.4 | 93.4 | 97.5 | 98.5 | 87.3 | 92.1 | 92.1 | 91.4 | 94.7 | 97.8 | 97.6 | 95.5 | 102.0 | 97.8 | 120.6 |
| 7 | 91.0 | 91.0 | 89.5 | 89.2 | 91.8 | 99.0 | 93.0 | 92.4 | 92.4 | 92.9 | 95.9 | 89.2 | 98.9 | 98.6 | 95.1 | 100.0 | 102.0 | 103.5 | 3.2 | 110.0 | 102.0 | 111.8 |
| 8 | 83.2 | 96.0 | 84.9 | 87.4 | 84.9 | 92.0 | 90.6 | 90.6 | 90.6 | 87.1 | 94.2 | 83.8 | 91.9 | 88.9 | 92.8 | 95.9 | 88.9 | 91.5 | 95.3 | 115.0 | 88.9 | 103.5 |
| 9 | 74.2 | 96.0 | 80.2 | 82.3 | 85.5 | 91.9 | 89.7 | 89.3 | 89.3 | 93.0 | 93.7 | 87.4 | 93.0 | 93.6 | 94.3 | 94.4 | 91.9 | 96.0 | 94.2 | 110.0 | 91.9 | 106.3 |
| 10 | 91.6 | 620.1 | 94.6 | 101.0 | 99.7 | 107.0 | 97.0 | 88.2 | 88.2 | 88.2 | 89.1 | 88.3 | 93.2 | 92.6 | 92.1 | 93.2 | 98.9 | 99.8 | 95.1 | 112.0 | 98.9 | 118.8 |
| 11 | 92.0 | 708.0 | 94.8 | 99.3 | 102.5 | 108.0 | 99.0 | 91.4 | 91.4 | 93.2 | 94.1 | 86.1 | 93.5 | 92.0 | 92.1 | 94.8 | 97.9 | 97.6 | 91.3 | 113.0 | 97.9 | 113.0 |
| 12 | 93.8 | 680.0 | 94.5 | 98.8 | 100.3 | 106.0 | 98.0 | 98.0 | 98.0 | 100.0 | 101.0 | 81.7 | 90.5 | 88.8 | 102.6 | 95.8 | 98.7 | 97.7 | 89.6 | 112.0 | 98.7 | 111.5 |
| 13 | 607.9 | 226.0 | 641.0 | 616.4 | 613.7 | 610.0 | 583.0 | 512.0 | 512.0 | 466.0 | 468.0 | 406.6 | 412.3 | 396.4 | 348.2 | 388.2 | 375.9 | 336.7 | 355.5 | 356.0 | 375.9 | 345.0 |
| 14 | 688.5 | 181.0 | 707.5 | 620.0 | 674.0 | 680.0 | 624.0 | 576.6 | 576.6 | 527.0 | 525.0 | 408.0 | 401.0 | 408.2 | 367.5 | 384.9 | 384.0 | 355.6 | 346.8 | 369.0 | 384.0 | 341.8 |
| 15 | 653.7 | 219.0 | 660.0 | 630.9 | 645.8 | 646.0 | 596.0 | 564.9 | 564.9 | 528.0 | 532.0 | 400.1 | 400.0 | 408.6 | 367.2 | 384.4 | 370.0 | 336.5 | 359.0 | 354.0 | 370.0 | 342.8 |
| 16 | 206.5 | 1153.0 | 188.0 | 194.7 | 184.9 | 189.9 | 168.0 | 171.8 | 171.8 | 150.0 | 145.0 | 138.6 | 141.5 | 146.4 | 140.7 | 142.0 | 130.0 | 133.8 | 129.5 | 146.0 | 130.0 | 132.0 |
| 17 | 236.5 | 1188.0 | 193.0 | 187.0 | 190.0 | 189.4 | 162.0 | 162.0 | 162.0 | 150.0 | 149.0 | 136.1 | 153.4 | 143.5 | 137.6 | 136.0 | 126.0 | 129.4 | 120.0 | 147.0 | 126.0 | 138.5 |
| 18 | 201.6 | 1350.0 | 201.0 | 200.9 | 199.7 | 190.9 | 178.6 | 159.6 | 159.6 | 148.0 | 143.7 | 134.1 | 153.9 | 142.1 | 136.8 | 134.0 | 124.9 | 122.5 | 119.3 | 131.9 | 124.9 | 130.0 |
| 19 | 1151.0 | 83.9 | 1135.0 | 1104.0 | 1074.0 | 1126.0 | 1096.0 | 1004.0 | 1004.0 | 933.0 | 933.8 | 761.6 | 859.7 | 629.4 | 640.3 | 677.9 | 723.0 | 672.4 | 635.0 | 630.0 | 723.0 | 654.0 |
| 20 | 1225.0 | 83.8 | 1128.0 | 1160.0 | 1137.0 | 1038.0 | 920.0 | 841.0 | 841.0 | 742.0 | 739.6 | 750.6 | 773.0 | 805.5 | 829.2 | 844.2 | 847.0 | 764.1 | 677.0 | 720.0 | 847.0 | 678.0 |
| 21 | 1263.0 | 82.4 | 1494.0 | 1505.0 | 1451.0 | 1381.0 | 1286.0 | 1135.0 | 1135.0 | 1034.0 | 980.6 | 750.2 | 697.2 | 712.3 | 657.2 | 693.8 | 610.0 | 571.5 | 554.0 | 650.0 | 610.0 | 610.0 |
| | Experiment II | | | | | | | | | | | | | | | | | | | | | |
| 22 | 86.1 | 94.7 | 88.6 | 97.7 | 98.6 | 99.0 | 99.0 | 86.0 | 86.0 | 96.4 | 95.7 | 99.3 | 102.7 | 100.0 | 101.1 | 100.3 | 105.8 | 108.4 | 100.0 | 112.0 | 105.8 | 111.0 |
| 23 | 86.9 | 80.6 | 90.0 | 104.8 | 99.0 | 101.0 | 97.0 | 89.0 | 89.0 | 96.0 | 94.4 | 96.6 | 101.0 | 99.0 | 95.8 | 99.0 | 101.1 | 108.2 | 94.9 | 115.0 | 101.1 | 118.0 |
| 24 | 87.7 | 82.9 | 86.5 | 91.7 | 90.9 | 97.0 | 93.0 | 91.2 | 91.2 | 92.8 | 94.6 | 97.8 | 103.2 | 100.0 | 92.0 | 95.6 | 99.5 | 104.4 | 98.3 | 120.0 | 99.5 | 124.0 |
| 25 | 98.0 | 1091.0 | 88.7 | 95.8 | 94.9 | 88.7 | 86.7 | 85.6 | 85.6 | 85.1 | 86.0 | 91.8 | 92.0 | 95.8 | 92.0 | 94.7 | 92.3 | 100.5 | 99.1 | 124.0 | 92.3 | 115.0 |
| 26 | 78.9 | 1035.0 | 79.0 | 81.3 | 84.3 | 92.3 | 98.0 | 97.0 | 97.0 | 99.9 | 89.9 | 94.0 | 96.5 | 96.2 | 103.4 | 99.5 | 104.0 | 104.5 | 100.2 | 133.0 | 104.0 | 116.0 |
| 27 | 83.3 | 987.0 | 82.7 | 82.9 | 82.7 | 89.4 | 88.9 | 93.0 | 93.0 | 90.0 | 89.8 | 94.0 | 96.4 | 95.5 | 95.1 | 95.6 | 93.6 | 95.0 | 95.8 | 118.0 | 93.6 | 111.5 |
| 28 | 936.9 | 83.9 | 1066.0 | 1087.0 | 1080.0 | 1049.0 | 1052.0 | 1034.0 | 1034.0 | 920.0 | 912.8 | 726.0 | 790.0 | 730.3 | 739.4 | 664.7 | 642.0 | 627.5 | 580.0 | 667.0 | 642.0 | 623.0 |
| 29 | 1070.0 | 83.9 | 1036.0 | 1001.0 | 920.0 | 874.0 | 996.4 | 830.0 | 830.0 | 730.0 | 757.0 | 816.0 | 767.5 | 751.6 | 669.2 | 655.0 | 634.0 | 567.7 | 598.0 | 598.0 | 634.0 | 630.0 |
| 30 | 962.0 | 82.5 | 982.0 | 995.2 | 976.0 | 1010.0 | 946.6 | 964.0 | 964.0 | 873.0 | 867.5 | 831.5 | 825.1 | 775.6 | 708.1 | 673.0 | 654.0 | 610.5 | 599.0 | 589.0 | 654.0 | 654.0 |

Table A1. 66. Raw data for dissolved oxygen (DO) of surface water samples collected from time 0 to 2880 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | 0 | 24 | 48 | 72 | 96 | 192 | 360 | 528 | 696 | 864 | 1032 | 1200 | 1368 | 1536 | 1704 | 1872 | 2040 | 2208 | 2376 | 2544 | 2712 | 2880 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | | | | | | | | | | | Hours | | | | | | | | | | | |
| Experiment I | | | | | | | | | | | | | | | | | | | | | | |
| 4 | 7.1 | 7.0 | 7.0 | 7.0 | 6.9 | 7.0 | 7.0 | 7.1 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 |
| 5 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 |
| 6 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.1 | 0.1 | 7.0 | 7.1 | 7.1 | 7.0 | 7.1 | 7.0 | 7.2 | 7.2 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 |
| 7 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 0.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 |
| 8 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.1 | 7.1 | 7.2 | 7.3 | 7.2 | 7.2 | 7.2 | 7.3 | 7.3 |
| 9 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 |
| 10 | 7.0 | 7.2 | 7.0 | 7.0 | 7.0 | 7.1 | 7.2 | 7.2 | 7.0 | 7.0 | 7.1 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.3 |
| 11 | 7.1 | 7.3 | 7.1 | 7.1 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.1 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 |
| 12 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.1 | 7.2 | 7.1 | 7.1 |
| 13 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.3 |
| 14 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 7.1 | 7.0 | 7.2 | 7.1 | 7.2 | 7.2 | 7.1 | 7.1 | 7.2 | 7.3 | 7.3 | 7.2 | 7.2 | 7.3 | 7.3 |
| 15 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.0 | 7.0 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 |
| 16 | 7.1 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.1 | 7.1 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 | 7.3 | 7.3 | 7.2 | 7.1 | 7.3 | 7.3 |
| 17 | 7.0 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.3 | 7.2 | 7.3 |
| 18 | 7.0 | 7.3 | 7.2 | 7.2 | 7.2 | 7.0 | 7.0 | 7.1 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.3 | 7.3 | 7.3 | 7.2 | 7.3 | 7.3 |
| 19 | 7.1 | 7.3 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.1 | 7.0 | 7.1 | 7.1 | 7.2 | 7.1 | 7.1 | 7.2 |
| 20 | 7.1 | 7.3 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.3 |
| 21 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.1 | 7.1 | 7.2 | 7.1 | 7.1 | 7.2 |
| Experiment II | | | | | | | | | | | | | | | | | | | | | | |
| 22 | 7.0 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 6.8 | 6.8 | 7.0 | 7.0 | 6.8 | 6.9 | 6.9 | 7.0 | 7.0 | 7.0 | 7.0 | 6.9 | 7.0 | 7.1 |
| 23 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 6.9 | 6.9 | 7.0 | 7.1 | 7.1 | 6.9 | 6.9 | 6.8 | 7.0 | 7.1 | 7.0 | 7.0 | 7.0 | 7.1 | 7.1 |
| 24 | 7.0 | 7.2 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 6.9 | 7.0 | 7.0 | 7.1 | 6.9 | 6.9 | 6.8 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| 25 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 6.9 | 6.8 | 7.1 | 7.1 | 7.1 | 7.0 | 7.1 | 7.1 |
| 26 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 6.9 | 7.0 | 7.0 | 7.1 | 7.0 | 7.0 | 7.2 |
| 27 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.2 | 7.1 | 7.1 | 7.0 | 7.2 | 7.1 | 7.1 | 7.0 | 7.0 | 6.8 | 6.9 | 7.1 | 7.0 | 7.1 | 7.1 | 7.1 | 7.1 |
| 28 | 7.1 | 7.3 | 7.1 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.0 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.1 | 7.3 | 7.1 | 7.2 | 7.1 |
| 29 | 7.1 | 7.1 | 7.2 | 7.2 | 7.1 | 7.2 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.1 | 7.2 | 7.3 | 7.2 | 7.3 | 7.1 | 7.3 | 7.2 |
| 30 | 7.1 | 7.1 | 7.1 | 7.1 | 7.0 | 7.2 | 7.1 | 7.1 | 7.0 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.1 | 7.3 | 7.1 | 7.2 | 7.2 |

Table A1. 67. Raw data for turbidity of surface water samples collected from time 0 to 2880 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| | 0 | 24 | 48 | 72 | 96 | 192 | 360 | 528 | 696 | 864 | 1032 | 1200 | 1368 | 1536 | 1704 | 1872 | 2040 | 2208 | 2376 | 2544 | 2712 | 2880 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | | | | | | | | | | | Hours | | | | | | | | | | | |
| | Experiment I | | | | | | | | | | | | | | | | | | | | | |
| 4 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 | 0.7 | 0.9 |
| 5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 | 0.8 | 0.8 | 0.9 | 0.6 | 0.9 |
| 6 | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.7 | 0.7 | 0.9 | 0.9 | 1.1 | 0.7 | 0.1 |
| 7 | 265.0 | 243.0 | 232.0 | 212.0 | 198.0 | 212.0 | 188.0 | 210.0 | 210.0 | 210.0 | 235.0 | 210.0 | 221.0 | 232.0 | 245.0 | 256.0 | 266.0 | 254.0 | 254.0 | 256.0 | 266.0 | 266.0 |
| 8 | 278.0 | 256.0 | 245.0 | 234.0 | 235.0 | 222.0 | 210.0 | 205.0 | 213.0 | 210.0 | 240.0 | 234.0 | 232.0 | 245.0 | 256.0 | 245.0 | 276.0 | 245.0 | 267.0 | 260.0 | 276.0 | 276.0 |
| 9 | 239.0 | 239.0 | 243.0 | 239.0 | 212.0 | 198.0 | 198.0 | 215.0 | 199.0 | 211.0 | 239.0 | 219.0 | 222.0 | 246.0 | 257.0 | 260.0 | 265.0 | 250.0 | 275.0 | 245.0 | 265.0 | 265.0 |
| 10 | 39.0 | 35.0 | 38.0 | 43.0 | 48.0 | 45.0 | 38.0 | 32.0 | 31.0 | 32.0 | 31.0 | 29.0 | 32.0 | 34.0 | 37.0 | 45.0 | 49.0 | 53.0 | 45.0 | 46.0 | 49.0 | 49.0 |
| 11 | 41.0 | 30.0 | 45.0 | 39.0 | 29.0 | 39.0 | 39.0 | 37.0 | 32.0 | 31.0 | 38.0 | 32.0 | 35.0 | 36.0 | 39.0 | 51.0 | 47.0 | 48.0 | 43.0 | 47.0 | 47.0 | 47.0 |
| 12 | 32.0 | 32.0 | 46.0 | 29.0 | 43.0 | 25.0 | 32.0 | 36.0 | 32.0 | 30.0 | 36.0 | 30.0 | 29.0 | 37.0 | 42.0 | 45.0 | 45.0 | 51.0 | 49.0 | 50.0 | 45.0 | 45.0 |
| 13 | 32.0 | 22.0 | 43.0 | 32.0 | 27.0 | 43.0 | 43.0 | 49.0 | 43.0 | 35.0 | 35.0 | 38.0 | 35.0 | 38.0 | 42.0 | 46.0 | 43.0 | 44.0 | 42.0 | 45.0 | 43.0 | 43.0 |
| 14 | 35.0 | 20.0 | 44.0 | 31.0 | 23.0 | 38.0 | 38.0 | 43.0 | 41.0 | 41.0 | 38.0 | 38.0 | 41.0 | 45.0 | 50.0 | 48.0 | 53.0 | 48.0 | 51.0 | 46.0 | 53.0 | 53.0 |
| 15 | 25.0 | 16.0 | 27.0 | 27.0 | 34.0 | 28.0 | 39.0 | 38.0 | 39.0 | 32.0 | 36.0 | 37.0 | 42.0 | 45.0 | 51.0 | 43.0 | 45.0 | 46.0 | 49.0 | 52.0 | 45.0 | 45.0 |
| 16 | 265.0 | 234.0 | 189.0 | 189.0 | 178.0 | 208.0 | 199.0 | 187.0 | 207.0 | 219.0 | 235.0 | 232.0 | 236.0 | 254.0 | 265.0 | 268.0 | 287.0 | 265.0 | 276.0 | 276.0 | 287.0 | 287.0 |
| 17 | 235.0 | 224.0 | 212.0 | 232.0 | 189.0 | 212.0 | 209.0 | 200.0 | 209.0 | 210.0 | 229.0 | 213.0 | 233.0 | 245.0 | 276.0 | 256.0 | 267.0 | 259.0 | 256.0 | 258.0 | 267.0 | 267.0 |
| 18 | 267.0 | 230.0 | 223.0 | 243.0 | 212.0 | 209.0 | 208.0 | 196.0 | 210.0 | 230.0 | 230.0 | 225.0 | 239.0 | 239.0 | 287.0 | 249.0 | 287.0 | 265.0 | 267.0 | 276.0 | 287.0 | 287.0 |
| 19 | 43.0 | 47.0 | 49.0 | 37.0 | 37.0 | 39.0 | 38.0 | 29.0 | 31.0 | 42.0 | 37.0 | 29.0 | 32.0 | 37.0 | 43.0 | 41.0 | 39.0 | 43.0 | 35.0 | 43.0 | 39.0 | 39.0 |
| 20 | 56.0 | 34.0 | 43.0 | 43.0 | 41.0 | 32.0 | 32.0 | 32.0 | 31.0 | 37.0 | 35.0 | 28.0 | 30.0 | 32.0 | 39.0 | 39.0 | 39.0 | 39.0 | 39.0 | 36.0 | 39.0 | 39.0 |
| 21 | 45.0 | 35.0 | 43.0 | 54.0 | 34.0 | 40.0 | 29.0 | 31.0 | 29.0 | 43.0 | 41.0 | 34.0 | 34.0 | 39.0 | 48.0 | 47.0 | 43.0 | 45.0 | 42.0 | 39.0 | 43.0 | 43.0 |
| | Experiment II | | | | | | | | | | | | | | | | | | | | | |
| 22 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.7 | 0.8 | 0.9 | 0.9 | 0.9 | 0.8 | 0.9 |
| 23 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.7 | 0.9 | 0.9 | 1.0 | 0.9 | 0.9 | 0.9 |
| 24 | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 | 0.7 | 0.8 | 0.9 | 1.0 | 1.0 | 0.8 | 1.0 |
| 25 | 256.0 | 260.0 | 215.0 | 234.0 | 250.0 | 210.0 | 234.0 | 210.0 | 212.0 | 226.0 | 238.0 | 219.0 | 232.0 | 245.0 | 258.0 | 256.0 | 267.0 | 264.0 | 256.0 | 256.0 | 267.0 | 267.0 |
| 26 | 249.0 | 250.0 | 198.0 | 254.0 | 216.0 | 216.0 | 216.0 | 199.0 | 199.0 | 213.0 | 247.0 | 220.0 | 236.0 | 256.0 | 265.0 | 245.0 | 287.0 | 276.0 | 245.0 | 260.0 | 287.0 | 287.0 |
| 27 | 267.0 | 267.0 | 225.0 | 221.0 | 198.0 | 198.0 | 221.0 | 178.0 | 209.0 | 234.0 | 232.0 | 223.0 | 245.0 | 265.0 | 269.0 | 267.0 | 275.0 | 274.0 | 256.0 | 272.0 | 275.0 | 275.0 |
| 28 | 37.0 | 39.0 | 43.0 | 35.0 | 28.0 | 28.0 | 43.0 | 39.0 | 31.0 | 43.0 | 38.0 | 35.0 | 29.0 | 37.0 | 43.0 | 43.0 | 38.0 | 45.0 | 34.0 | 43.0 | 38.0 | 38.0 |
| 29 | 41.0 | 42.0 | 46.0 | 46.0 | 34.0 | 32.0 | 32.0 | 28.0 | 29.0 | 35.0 | 35.0 | 32.0 | 30.0 | 45.0 | 54.0 | 39.0 | 42.0 | 47.0 | 43.0 | 43.0 | 42.0 | 42.0 |
| 30 | 42.0 | 34.0 | 32.0 | 47.0 | 42.0 | 42.0 | 42.0 | 35.0 | 26.0 | 42.0 | 37.0 | 34.0 | 33.0 | 46.0 | 53.0 | 38.0 | 41.0 | 49.0 | 35.0 | 39.0 | 41.0 | 41.0 |

Table A1. 68. Raw data for hardness of surface water samples collected from time 0 to 2880 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time (h) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1200 | 1368 | 2376 | 2544 | 2712 | 2880 |
| | mg $L^{-1}$ | | | | | | |
| 4 | 20.8 | 21 | 22 | 23.2 | 22 | 22 | 27.6 |
| 5 | 20 | 21.4 | 21 | 25.6 | 22 | 24 | 26 |
| 6 | 21 | 21.6 | 20.6 | 22 | 22 | 22 | 24 |
| 7 | 19 | 18.8 | 20 | 20 | 22 | 24 | 26 |
| 8 | 21 | 20.4 | 19.8 | 20 | 21.4 | 21.1 | 24 |
| 9 | 20 | 21.4 | 20 | 21.4 | 22 | 20 | 24.8 |
| 10 | 21 | 21.8 | 21 | 22 | 24 | 22 | 30 |
| 11 | 22 | 22 | 20 | 23.6 | 21.2 | 22 | 27.2 |
| 12 | 20.2 | 20 | 19.6 | 25.6 | 22 | 22 | 24.4 |
| 13 | 197 | 182 | 186 | 170 | 160 | 185 | 190 |
| 14 | 190 | 178 | 184 | 160 | 150 | 190 | 190 |
| 15 | 190 | 180 | 178 | 150 | 175 | 180 | 180 |
| 16 | 33 | 32 | 33 | 34 | 30 | 34.4 | 38.4 |
| 17 | 32 | 29 | 30 | 32 | 30 | 36 | 36 |
| 18 | 29 | 33 | 32 | 28.8 | 31.2 | 32 | 27.6 |
| 19 | 275 | 289 | 250 | 270 | 285 | 260 | 265 |
| 20 | 260 | 289 | 304 | 320 | 290 | 305 | 270 |
| 21 | 250 | 256 | 236 | 230 | 270 | 275 | 270 |
| 22 | 20.6 | 23 | 22 | 22 | 22 | 20 | 23.6 |
| 23 | 24 | 24 | 21 | 24 | 21 | 22 | 23.2 |
| 24 | 22 | 23 | 22 | 20 | 22 | 20 | 21.6 |
| 25 | 20.5 | 20.5 | 20.8 | 21 | 24 | 21.4 | 22.8 |
| 26 | 24 | 23.8 | 21 | 20 | 20 | 20 | 26 |
| 27 | 23.8 | 24 | 20.8 | 22.8 | 22 | 20 | 27.6 |
| 28 | 280 | 280 | 280 | 275 | 275 | 280 | 280 |
| 29 | 265 | 260 | 280 | 270 | 280 | 270 | 280 |
| 30 | 245 | 265 | 302 | 250 | 280 | 275 | 265 |

Table A1. 69. Raw data for metal concentrations in surface water samples collected at time 0 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 0 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | µg $L^{-1}$ | | | | | | | | | |
| 4 | 0 | 28.68 | 1.674 | 0.519 | 0.075 | 0 | 27.8 | 1.622 | 0.502 | 0.037 |
| 5 | 0.607 | 39.14 | 1.959 | 0.517 | 0.096 | 0 | 38.6 | 1.325 | 0.501 | 0.045 |
| 6 | 0.673 | 27.7 | 1.29 | 0.421 | 0.081 | 0 | 26.9 | 0.928 | 0.412 | 0.057 |
| 7 | 0.529 | 37.57 | 1.231 | 0.614 | 0.162 | 0 | 37 | 0.645 | 0.604 | 0.053 |
| 8 | 0.708 | 25.67 | 0.976 | 0.663 | 0.333 | 0 | 24.8 | 0.63 | 0.638 | 0.076 |
| 9 | 0.633 | 38.87 | 1.756 | 0.774 | 0.429 | 0 | 38.45 | 1.542 | 0.768 | 0.05 |
| 10 | 0.817 | 24.32 | 1.502 | 0.714 | 0.152 | 0 | 23.78 | 0.892 | 0.695 | 0.068 |
| 11 | 0.58 | 30.95 | 1.815 | 0.789 | 0.179 | 0 | 29.67 | 1.556 | 0.763 | 0.138 |
| 12 | 0.538 | 34.5 | 1.856 | 0.824 | 0.176 | 0 | 33.15 | 1.529 | 0.812 | 0.067 |
| 13 | 0.731 | 31.05 | 2.561 | 1.02 | 0.114 | 0.704 | 30.1 | 2.044 | 1.008 | 0.071 |
| 14 | 0.871 | 29.81 | 1.698 | 0.899 | 0 | 0.683 | 28.2 | 1.445 | 0.887 | 0 |
| 15 | 0.771 | 29.18 | 2.334 | 1.263 | 0.27 | 0.626 | 28.1 | 1.595 | 1.254 | 0.125 |
| 16 | 0.744 | 34.85 | 1.027 | 0.712 | 0.181 | 0.648 | 34.07 | 1.016 | 0.699 | 0.107 |
| 17 | 0.839 | 24.89 | 0.681 | 0.498 | 0.155 | 0 | 24.85 | 0.568 | 0.49 | 0.077 |
| 18 | 0 | 19.06 | 0.896 | 0.43 | 0.157 | 0 | 18.69 | 0.808 | 0.423 | 0.086 |
| 19 | 0.758 | 36.02 | 2.425 | 0.9 | 0.464 | 0.675 | 35.4 | 1.689 | 0.889 | 0.243 |
| 20 | 0.544 | 32.64 | 2.345 | 0.683 | 0.251 | 0.458 | 32.4 | 1.671 | 0.678 | 0.165 |
| 21 | 0.559 | 35.85 | 3.012 | 0.736 | 0.491 | 0.546 | 35 | 2.303 | 0.726 | 0.209 |
| 22 | 0 | 24.95 | 1.818 | 0.588 | 0.056 | 0 | 24 | 0.986 | 0.576 | 0.045 |
| 23 | 0 | 27.53 | 1.898 | 0.616 | 0.055 | 0 | 26.9 | 0.995 | 0.602 | 0.032 |
| 24 | 0 | 31.14 | 0.636 | 0.524 | 0 | 0 | 30.6 | 0.502 | 0.512 | 0 |
| 25 | 0.706 | 21.5 | 1.451 | 0.63 | 0.218 | 0 | 20.5 | 0.584 | 0.619 | 0.139 |
| 26 | 0.687 | 31.77 | 1.52 | 0.723 | 0.299 | 0 | 30 | 1.155 | 0.699 | 0.167 |
| 27 | 0.772 | 27.54 | 1.912 | 0.651 | 0.224 | 0 | 26 | 1.67 | 0.638 | 0.1382 |
| 28 | 0.497 | 19.65 | 2.408 | 0.714 | 0.354 | 0 | 18.7 | 1.702 | 0.708 | 0.221 |
| 29 | 0.934 | 17.52 | 2.226 | 0.632 | 0.193 | 0.661 | 16.7 | 1.407 | 0.624 | 0.155 |
| 30 | 0.798 | 22.57 | 2.227 | 1.12 | 0.2703 | 0 | 21.7 | 1.434 | 1.109 | 0.114 |

Table A1. 70. Raw data for metal concentrations in surface water samples collected at time 192 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 192 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | $\mu g\ L^{-1}$ | | | | | | | | | |
| 4 | 6.055 | 60.74 | 69.47 | 7.653 | 8.697 | 1.108 | 60.02 | 69.1 | 7.315 | 0.051 |
| 5 | 8.587 | 63.79 | 65.53 | 7.015 | 8.166 | 1.191 | 62.81 | 65.435 | 6.95 | 0.258 |
| 6 | 6.482 | 62.23 | 64.64 | 7.059 | 7.748 | 1.412 | 61.54 | 64 | 6.948 | 0.267 |
| 7 | 6.521 | 44.28 | 36.23 | 3.722 | 9.626 | 0.783 | 41.41 | 32.23 | 1.656 | 0.056 |
| 8 | 2.964 | 44.62 | 24.46 | 2.638 | 9.607 | 0 | 43.12 | 21.108 | 1.582 | 0 |
| 9 | 7.949 | 45.07 | 28.53 | 3.831 | 10.17 | 0 | 41.41 | 25.42 | 1.471 | 0.119 |
| 10 | 3.959 | 61.4 | 49.67 | 4.254 | 8.207 | 1.212 | 59.45 | 49.043 | 3.293 | 0.182 |
| 11 | 5.106 | 62.17 | 49.83 | 4.14 | 8.896 | 0.946 | 60.71 | 48.6 | 3.589 | 0.258 |
| 12 | 5.081 | 67.62 | 50.39 | 4.94 | 9.251 | 1.205 | 66.46 | 48.9 | 3.126 | 0.173 |
| 13 | 2.011 | 41.98 | 12.21 | 1.549 | 2.288 | 1.243 | 41.22 | 12.123 | 0.951 | 0 |
| 14 | 1.438 | 35.5 | 8.611 | 1.462 | 1.255 | 1.167 | 34.25 | 8.567 | 0.838 | 0 |
| 15 | 1.146 | 27.65 | 6.183 | 1.166 | 0.905 | 0.565 | 27.63 | 6.111 | 1.074 | 0 |
| 16 | 5.364 | 34.44 | 34.91 | 2.843 | 5.899 | 0 | 33.12 | 33.45 | 0.483 | 0.052 |
| 17 | 5.758 | 29.91 | 30.17 | 2.386 | 6.87 | 0 | 27.81 | 28.78 | 0.703 | 0.076 |
| 18 | 3.394 | 38.51 | 31.36 | 2.116 | 5.786 | 0 | 36.12 | 29.8 | 0.761 | 0 |
| 19 | 1.199 | 40.71 | 20.43 | 1.509 | 2.561 | 0.673 | 39.89 | 19.29 | 1.092 | 0 |
| 20 | 2.835 | 37.3 | 14.96 | 1.578 | 2.052 | 0.909 | 36.87 | 13.6 | 1.476 | 0.122 |
| 21 | 1.93 | 32 | 12.91 | 1.939 | 3.898 | 0.605 | 31.26 | 12.1 | 0.939 | 0 |
| 22 | 5.852 | 31.13 | 0.29 | 0.345 | 0 | 1.034 | 30.456 | 0.175 | 0.339 | 0 |
| 23 | 6.53 | 30.78 | 0.487 | 0.392 | 0 | 1.218 | 29.876 | 0.27 | 0.244 | 0 |
| 24 | 5.328 | 30.57 | 0 | 0.346 | 0 | 0.953 | 29.76 | 0 | 0.342 | 0 |
| 25 | 3.247 | 35.74 | 0 | 0.641 | 0.283 | 0 | 34.567 | 0 | 0.583 | 0 |
| 26 | 4.198 | 29.52 | 0 | 0.536 | 0.248 | 0.51 | 28.3 | 0 | 0.528 | 0 |
| 27 | 3.31 | 35.22 | 0 | 0.734 | 0.228 | 0 | 34.678 | 0 | 0.676 | 0 |
| 28 | 1.128 | 24.01 | 1.425 | 0.709 | 0.749 | 0.525 | 24 | 1.101 | 0.643 | 0 |
| 29 | 4.038 | 28.12 | 2.036 | 0.927 | 1.826 | 1.14 | 28.098 | 1.01 | 0.597 | 0 |
| 30 | 1.78 | 32.25 | 1.969 | 0.847 | 1.758 | 0.953 | 32.22 | 1.362 | 0.625 | 0 |

Table A1. 71. Raw data for metal concentrations in surface water samples collected at time 360 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 360 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | µg $L^{-1}$ | | | | | | | | | |
| 4 | 10.18 | 88.51 | 113.2 | 9.08 | 11.52 | 7.762 | 79.89 | 94.66 | 8.36 | 0.85 |
| 5 | 11.95 | 93.22 | 110.1 | 10.23 | 13.83 | 9.358 | 85.61 | 91.24 | 9.773 | 0.995 |
| 6 | 11.26 | 108.7 | 114.5 | 10.51 | 14.15 | 8.954 | 98.93 | 93.4 | 9.221 | 0.921 |
| 7 | 6.22 | 63.35 | 69.59 | 4.729 | 9.037 | 1.289 | 34.6 | 55.01 | 1.192 | 0.288 |
| 8 | 6.249 | 62.88 | 45 | 3.563 | 9.119 | 0.803 | 44.32 | 33.88 | 0.987 | 0.096 |
| 9 | 6.2345 | 54.43 | 44.3 | 2.658 | 6.55 | 0.636 | 39.1 | 38.49 | 0.458 | 0.081 |
| 10 | 3.479 | 75.76 | 81.02 | 5.797 | 5.615 | 1.112 | 74.13 | 58.39 | 5.42 | 0.159 |
| 11 | 3.704 | 78.43 | 76.7 | 5.5 | 5.999 | 1.467 | 77.13 | 59.07 | 4.822 | 0.271 |
| 12 | 4.469 | 75.75 | 91.67 | 6.124 | 5.288 | 2.256 | 73.17 | 69.59 | 4.942 | 0.268 |
| 13 | 1.594 | 32.07 | 12.03 | 0.763 | 1.536 | 1.535 | 30.78 | 9.16 | 0.691 | 0.051 |
| 14 | 1.471 | 33.05 | 13.1 | 0.821 | 0.983 | 1.283 | 31.69 | 9.678 | 0.81 | 0 |
| 15 | 1.459 | 39.02 | 10.33 | 0.687 | 0.675 | 0.969 | 37.38 | 7.466 | 0.643 | 0 |
| 16 | 6.229 | 59.19 | 55.52 | 1.79 | 9.241 | 0.825 | 47.94 | 49.11 | 0.885 | 0.133 |
| 17 | 6.189 | 55.25 | 54.5 | 2.772 | 9.91 | 0.559 | 41.24 | 41.67 | 0.359 | 0.071 |
| 18 | 5.692 | 60.31 | 54.89 | 1.463 | 8.747 | 0.87 | 42.65 | 42.95 | 0.467 | 0.095 |
| 19 | 2.576 | 41.57 | 20.1 | 1.757 | 3.948 | 1.146 | 40.63 | 19.58 | 1.071 | 0.081 |
| 20 | 2.825 | 45.85 | 19.92 | 1.051 | 3.612 | 1.694 | 44.47 | 15.805 | 1.002 | 0.081 |
| 21 | 2.7005 | 40.25 | 15.74 | 0.739 | 1.186 | 1.42 | 38.93 | 12.03 | 0.676 | 0 |
| 22 | 9.339 | 60.38 | 1.575 | 0.547 | 0 | 1.717 | 58.123 | 0.448 | 0.53 | 0 |
| 23 | 12.58 | 59.71 | 1.003 | 0.536 | 0 | 2.147 | 59.12 | 0.497 | 0.527 | 0 |
| 24 | 9.276 | 57.03 | 1.093 | 0.613 | 0 | 1.613 | 56.69 | 0.436 | 0.474 | 0 |
| 25 | 3.628 | 46.46 | 1.162 | 0.407 | 0.233 | 0.512 | 43.98 | 0.606 | 0.294 | 0 |
| 26 | 7.875 | 49.15 | 1.294 | 0.307 | 0.254 | 0.967 | 47.11 | 0.58 | 0.247 | 0.069 |
| 27 | 4.833 | 47.15 | 1.36 | 0.649 | 0.215 | 1.577 | 46.8 | 0.611 | 0.526 | 0 |
| 28 | 1.931 | 28.46 | 2.55 | 0.359 | 0.637 | 1.121 | 27.87 | 1.759 | 0.342 | 0.051 |
| 29 | 3.234 | 44.81 | 2.245 | 0.381 | 0.828 | 1.897 | 43.98 | 1.403 | 0.373 | 0 |
| 30 | 2.075 | 35.43 | 2.646 | 0.472 | 0.862 | 1.509 | 34.87 | 2.194 | 0.422 | 0.052 |

Table A1. 72. Raw data for metal concentrations in surface water samples collected at time 528 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 528 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | µg $L^{-1}$ | | | | | | | | | |
| 4 | 17.45 | 101.6 | 122.415 | 12.81 | 15.8 | 16.08 | 101 | 120 | 12.65 | 1.374 |
| 5 | 20.02 | 109.5 | 117.812 | 13.44 | 17.92 | 19.42 | 108.7 | 114 | 13.234 | 2.06 |
| 6 | 19.46 | 114.7 | 119.668 | 14.84 | 16.87 | 18.82 | 113.897 | 115 | 14.567 | 1.35 |
| 7 | 13.15 | 70.2 | 71.79 | 7.381 | 15.53 | 3.37 | 48.93 | 48.91 | 5.436 | 0.856 |
| 8 | 13.418 | 62.5 | 75.69 | 5.6 | 16.33 | 2.874 | 34.6 | 49.25 | 4.56 | 0.124 |
| 9 | 14.29 | 67.56 | 77.58 | 6.9 | 16.1 | 2.934 | 44.32 | 44.97 | 4.187 | 0.157 |
| 10 | 16.682 | 70.345 | 85.44 | 6.505 | 8.664 | 12.35 | 69.456 | 84.87 | 5.34 | 1.259 |
| 11 | 14.739 | 82.234 | 82.12 | 7.521 | 8.733 | 11.733 | 81.06 | 81.1 | 5.898 | 0.829 |
| 12 | 13.147 | 87.345 | 105.7 | 8.083 | 8.849 | 10.295 | 86.91 | 104.36 | 6.937 | 0.806 |
| 13 | 2.317 | 25.97 | 15.17 | 1.512 | 1.273 | 1.833 | 24.6 | 15.09 | 1.148 | 0.112 |
| 14 | 2.017 | 22.25 | 13.84 | 1.408 | 1.264 | 0 | 21.987 | 10.87 | 1.173 | 0.051 |
| 15 | 2.732 | 38.89 | 12.53 | 1.747 | 2.804 | 0 | 37.908 | 10.524 | 1.03 | 0 |
| 16 | 6.998 | 52.89 | 71.21 | 3.448 | 10.38 | 0 | 10.8 | 14.41 | 2.29 | 1.156 |
| 17 | 11.99 | 61.03 | 65.65 | 3.007 | 11.89 | 0 | 19.67 | 17.25 | 2.328 | 1.106 |
| 18 | 15.76 | 63.87 | 71.4 | 3.805 | 10.91 | 0 | 17.08 | 21.08 | 2.308 | 1.096 |
| 19 | 3.005 | 34.67 | 26.32 | 2.024 | 3.161 | 0 | 32.27 | 24.781 | 1.61 | 0 |
| 20 | 4.566 | 36.14 | 27.12 | 1.345 | 5.463 | 0.726 | 35.8 | 26.7 | 0.689 | 0.087 |
| 21 | 2.274 | 30.95 | 22.5 | 1.369 | 1.771 | 1.466 | 29.2 | 21.15 | 0.761 | 0.093 |
| 22 | 14.82 | 36.74 | 1.575 | 0.575 | 0.06 | 12.832 | 34.32 | 1.233 | 0.378 | 0 |
| 23 | 19.82 | 36.9 | 1.003 | 0.554 | 0.07 | 15.561 | 35.7 | 0.654 | 0.543 | 0.068 |
| 24 | 16.96 | 46.15 | 1.093 | 0.599 | 0.072 | 15.117 | 45.7 | 0.938 | 0.58 | 0.117 |
| 25 | 16.783 | 46.46 | 1.162 | 0.886 | 0.295 | 12.87 | 45.8 | 1.124 | 0.514 | 0.114 |
| 26 | 13.55 | 49.15 | 1.294 | 0.903 | 0.461 | 3.018 | 48.84 | 1.273 | 0.509 | 0.079 |
| 27 | 12.287 | 47.15 | 1.36 | 0.705 | 0.244 | 3.394 | 46.24 | 1.305 | 0.596 | 0.052 |
| 28 | 4.781 | 28.46 | 2.55 | 1.02 | 0.722 | 2.876 | 27.19 | 2.248 | 0.683 | 0.114 |
| 29 | 5.867 | 44.81 | 2.245 | 1.045 | 1.179 | 3.612 | 43.6 | 2.063 | 0.733 | 0.101 |
| 30 | 4.848 | 35.43 | 2.646 | 0.991 | 0.86 | 3.625 | 35.27 | 2.285 | 0.801 | 0.099 |

Table A1. 73. Raw data for metal concentrations in surface water samples collected at time 864 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 864 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | µg $L^{-1}$ | | | | | | | | | |
| 4 | 24.88 | 116.5 | 162.415 | 16.04 | 25.8 | 18.608 | 111 | 150 | 9.986 | 11.374 |
| 5 | 23.73 | 127.8 | 161.812 | 16.54 | 27.92 | 17.028 | 124.7 | 151 | 11.1 | 11.06 |
| 6 | 25.04 | 123.9 | 159.668 | 16.71 | 26.87 | 17.352 | 119.9 | 149 | 11.19 | 11.35 |
| 7 | 21.03 | 67.79 | 84.79 | 8.779 | 18.53 | 1.261 | 58.93 | 58.91 | 1.746 | 0.826 |
| 8 | 17.44 | 51.62 | 85.69 | 6.638 | 19.33 | 1.022 | 44.6 | 59.25 | 1.323 | 0.831 |
| 9 | 24.52 | 68.77 | 97.58 | 6.599 | 21.1 | 1.596 | 62.32 | 74.97 | 1.235 | 0.827 |
| 10 | 16.682 | 87 | 105.44 | 6.505 | 12.664 | 12.923 | 84.456 | 94.87 | 2.464 | 1.259 |
| 11 | 14.739 | 92.234 | 110.7 | 7.521 | 14.733 | 10.444 | 88.06 | 100.11 | 4.563 | 2.829 |
| 12 | 15.147 | 87.345 | 105.7 | 8.083 | 12.849 | 12.75 | 84.91 | 100.36 | 5.689 | 1.806 |
| 13 | 2.94 | 43.69 | 20.15 | 1.709 | 2.273 | 1.679 | 40.6 | 15.09 | 1.161 | 0.769 |
| 14 | 2.785 | 44.02 | 17.57 | 1.501 | 2.264 | 1.504 | 41.987 | 10.87 | 1.156 | 0.789 |
| 15 | 4.057 | 43.11 | 18.47 | 2.069 | 2.804 | 1.431 | 41.908 | 10.524 | 0.999 | 1.027 |
| 16 | 16.58 | 53.47 | 83.11 | 4.908 | 11.38 | 2.032 | 45.8 | 14.41 | 1.551 | 0.918 |
| 17 | 18.27 | 61.85 | 82.26 | 5.639 | 11.89 | 3.006 | 55.67 | 17.25 | 1.357 | 0.919 |
| 18 | 19.41 | 67.54 | 79.91 | 5.255 | 11.91 | 3.244 | 60.08 | 21.08 | 1.474 | 0.92 |
| 19 | 3.005 | 42.03 | 24.32 | 2.086 | 3.161 | 1.523 | 39.27 | 20.781 | 2.051 | 0.898 |
| 20 | 4.527 | 49.32 | 27.12 | 2.244 | 2.463 | 2.108 | 47.8 | 22.7 | 0.965 | 0.893 |
| 21 | 3.297 | 51.16 | 25.5 | 1.851 | 1.886 | 3.142 | 49.2 | 21.15 | 0.58 | 0.87 |
| 22 | 23.4 | 24.5 | 1.575 | 0.529 | 0.834 | 13.503 | 24.32 | 1.233 | 0.502 | 0.087 |
| 23 | 23.13 | 36.05 | 1.003 | 0.542 | 0.856 | 13.515 | 35.7 | 0.654 | 0.522 | 0.0903 |
| 24 | 23.64 | 28.11 | 1.093 | 0.561 | 0.853 | 15.419 | 27.7 | 0.938 | 0.5059 | 0.0936 |
| 25 | 24.11 | 27.04 | 1.326 | 0.972 | 0.842 | 1.099 | 25.8 | 1.124 | 0.7009 | 0.378 |
| 26 | 21.04 | 35.06 | 1.45 | 0.724 | 0.863 | 1.164 | 34.84 | 1.273 | 0.699 | 0.0622 |
| 27 | 18.33 | 39.72 | 1.299 | 0.489 | 0.87 | 1.228 | 38.24 | 1.205 | 0.4608 | 0.066 |
| 28 | 6.17 | 33.8 | 0.885 | 0.603 | 0.861 | 3.164 | 31.19 | 0.654 | 0.6 | 0.0482 |
| 29 | 5.221 | 38.14 | 1.365 | 0.621 | 0.854 | 2.202 | 37.6 | 0.938 | 0.603 | 0.0541 |
| 30 | 5.213 | 32.08 | 0.824 | 0.741 | 0.849 | 2.625 | 31.27 | 0.624 | 0.521 | 0.06 |

Table A1. 74. Raw data for metal concentrations in surface water samples collected at time 1200 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 1200 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | µg $L^{-1}$ | | | | | | | | | |
| 4 | 27.15 | 138.7 | 164.7 | 14.84 | 27.8 | 20.42 | 129.48 | 159.1 | 13.611 | 9.374 |
| 5 | 28.87 | 123.6 | 153.3 | 15.14 | 28.92 | 19.688 | 118.3 | 147.8 | 14.322 | 12.06 |
| 6 | 27.772 | 136.03 | 161.38 | 15.25 | 26.87 | 18.71 | 124.54 | 157.3 | 15.101 | 11.35 |
| 7 | 21.63 | 87.94 | 92 | 5.369 | 17.53 | 1.567 | 75.07 | 76.45 | 3.098 | 0.856 |
| 8 | 23.285 | 70.75 | 75.38 | 4.857 | 18.33 | 1.437 | 58.74 | 59.28 | 3.012 | 0.124 |
| 9 | 25.345 | 81.64 | 86.91 | 4.083 | 16.1 | 1.714 | 67.62 | 71.9 | 2.338 | 0.157 |
| 10 | 25.505 | 74.2 | 117.7 | 8.466 | 12.664 | 13.301 | 69.76 | 115.2 | 7.44 | 1.119 |
| 11 | 19.01 | 92.95 | 142.9 | 9.449 | 14.733 | 13.549 | 83.83 | 136.6 | 7.842 | 1.136 |
| 12 | 21.05 | 91.18 | 119.82 | 9.64 | 13.849 | 12.842 | 83.77 | 112.6 | 8.899 | 1.147 |
| 13 | 3.589 | 29.73 | 43.73 | 1.051 | 2.273 | 1.758 | 28.02 | 41.61 | 0.933 | 0.412 |
| 14 | 3.923 | 36.96 | 42.81 | 3.384 | 3.264 | 1.824 | 35.94 | 40.6 | 0.907 | 0.373 |
| 15 | 4.89 | 37.7 | 45.83 | 3.32 | 2.804 | 1.83 | 35.08 | 43.09 | 0.99 | 0.258 |
| 16 | 17.242 | 72.92 | 83.34 | 2.461 | 15.38 | 1.311 | 65.16 | 43.3 | 0.829 | 1.286 |
| 17 | 19.88 | 72.82 | 87.5 | 3.534 | 14.89 | 1.534 | 66.84 | 46.5 | 0.722 | 1.247 |
| 18 | 14.24 | 75.01 | 86.6 | 3.973 | 14.91 | 1.541 | 64.66 | 43.8 | 0.933 | 1.269 |
| 19 | 3.188 | 45.13 | 52.1 | 3.107 | 3.161 | 1.87 | 42.07 | 49.72 | 1.13 | 0.579 |
| 20 | 4.13 | 47.94 | 49.76 | 3.938 | 4.463 | 1.783 | 45.68 | 45.75 | 1.154 | 0.452 |
| 21 | 3.919 | 39.5 | 46.31 | 3.082 | 3.771 | 2.084 | 37.13 | 43.46 | 1.132 | 0.544 |
| 22 | 26.49 | 40.44 | 2.315 | 0.591 | 0.06 | 12.36 | 39.63 | 2.14 | 0.582 | 0 |
| 23 | 27.07 | 46.23 | 2.279 | 0.592 | 0.07 | 15.59 | 44.52 | 2.09 | 0.567 | 0.068 |
| 24 | 28.65 | 29.42 | 1.907 | 0.457 | 0.072 | 13.76 | 28.1 | 1.79 | 0.059 | 0.117 |
| 25 | 18.58 | 42.48 | 0.943 | 0.87 | 0.295 | 2.599 | 41.23 | 0.867 | 0.509 | 0.114 |
| 26 | 19.653 | 56.98 | 1.301 | 0.875 | 0.461 | 4.003 | 55.54 | 1.082 | 0.69 | 0.079 |
| 27 | 19.96 | 38.31 | 0.971 | 1.016 | 0.244 | 3.569 | 36.13 | 0.472 | 0.608 | 0.052 |
| 28 | 4.429 | 44.57 | 2.825 | 1.203 | 0.722 | 3.393 | 42.9 | 2.068 | 0.914 | 0.114 |
| 29 | 5.303 | 46.77 | 3.33 | 1.121 | 1.179 | 3.104 | 45.87 | 2.587 | 0.803 | 0.101 |
| 30 | 6.809 | 43.13 | 2.426 | 0.941 | 0.86 | 2.152 | 41.1 | 2.073 | 0.721 | 0.099 |

Table A1. 75. Raw data for metal concentrations in surface water samples collected at time 1872 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 1872 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | $\mu g\ L^{-1}$ | | | | | | | | | |
| 4 | 24.23 | 126 | 181.4 | 15.9 | 33.27 | 19.32 | 125.67 | 175.8 | 14.689 | 12.987 |
| 5 | 26.67 | 123.76 | 180.8 | 14.95 | 33.69 | 21.76 | 120.56 | 173.8 | 13.567 | 13.67 |
| 6 | 23.35 | 116.5 | 181.9 | 16.99 | 35.77 | 20.12 | 114.78 | 177.6 | 14.989 | 14.57 |
| 7 | 21.63 | 70.19 | 94.49 | 8.99 | 17.87 | 2.36 | 59.76 | 75.98 | 4.251 | 0.879 |
| 8 | 20.29 | 78.67 | 84.07 | 6.116 | 18.67 | 2.35 | 69.32 | 67.34 | 3.869 | 1.353 |
| 9 | 21.35 | 80.23 | 107.1 | 6.01 | 19.52 | 1.935 | 70.45 | 88.06 | 3.092 | 0.919 |
| 10 | 19.34 | 81.26 | 137.9 | 9.202 | 11.8 | 14.234 | 77.76 | 129.9 | 7.018 | 1.456 |
| 11 | 21.01 | 82.36 | 153.9 | 9.711 | 17.85 | 11.87 | 79.37 | 145.5 | 6.134 | 1.609 |
| 12 | 23.05 | 87.23 | 145.9 | 9.563 | 14.657 | 13.79 | 81.29 | 132.87 | 7.269 | 1.589 |
| 13 | 3.589 | 26.79 | 43.73 | 1.519 | 2.298 | 1.854 | 25.09 | 39.55 | 1.137 | 0 |
| 14 | 2.923 | 32.42 | 42.94 | 1.193 | 1.174 | 2.004 | 30.87 | 38.93 | 1.105 | 0.282 |
| 15 | 3.68 | 23.32 | 43.2 | 1.492 | 1.946 | 2.45 | 21.32 | 38.15 | 1.146 | 0.258 |
| 16 | 15.88 | 55.65 | 93.67 | 3.555 | 11.56 | 2.432 | 49.16 | 83.37 | 0.886 | 1.876 |
| 17 | 14.21 | 41.53 | 92.4 | 3.268 | 15.67 | 2.347 | 33.65 | 85.67 | 1.041 | 1.345 |
| 18 | 15.02 | 50.2 | 81.57 | 4.359 | 13.57 | 1.989 | 44.58 | 72.69 | 0.904 | 1.154 |
| 19 | 3.19 | 46.66 | 55.761 | 3.053 | 3.786 | 1.45 | 42.94 | 49.72 | 1.663 | 0.399 |
| 20 | 4.13 | 45.71 | 53.95 | 3.606 | 4.154 | 2.231 | 41.36 | 45.75 | 1.652 | 0.218 |
| 21 | 3.919 | 39.83 | 57.24 | 3.52 | 4.456 | 1.987 | 36.79 | 51.46 | 1.582 | 0.467 |
| 22 | 29.13 | 24.36 | 2.315 | 0.627 | 0.233 | 16.76 | 23.56 | 2.14 | 0.609 | 0 |
| 23 | 28.53 | 26.12 | 2.279 | 0.748 | 0.158 | 18.98 | 24.43 | 2.09 | 0.735 | 0 |
| 24 | 29.2 | 32.48 | 1.907 | 0.71 | 1.466 | 19.354 | 30.51 | 1.69 | 0.444 | 0 |
| 25 | 18.06 | 25.11 | 1.316 | 1.316 | 0.345 | 2.987 | 24.54 | 0.976 | 0.708 | 0.014 |
| 26 | 19.65 | 25.37 | 1.301 | 0.91 | 1.083 | 3.546 | 24.98 | 0.765 | 0.682 | 0.079 |
| 27 | 19.96 | 26.81 | 2.67 | 1.174 | 0.405 | 4.098 | 25.76 | 1.467 | 0.698 | 0.052 |
| 28 | 4.43 | 24.94 | 1.978 | 0.845 | 0.678 | 3.654 | 24.43 | 1.3 | 0.751 | 0.074 |
| 29 | 5.30 | 30.98 | 2.234 | 1.365 | 0.979 | 3.765 | 29.67 | 1.134 | 0.754 | 0 |
| 30 | 5.33 | 26.95 | 2.78 | 1.344 | 0.798 | 3.254 | 26.08 | 2.073 | 0.753 | 0.099 |

Table A1. 76. Raw data for metal concentrations in surface water samples collected at time 2880 h. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30).

| Sample ID | Time - 2880 h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Recoverable (unfiltered samples) | | | | | Dissolved (filtered samples) | | | | |
| | Cu | Zn | As | Cd | Pb | Cu | Zn | As | Cd | Pb |
| | $\mu g\ L^{-1}$ | | | | | | | | | |
| 4 | 34.38 | 125 | 166.2 | 13.81 | 41 | 28.45 | 111 | 158.5 | 12.22 | 19.962 |
| 5 | 24.98 | 123.9 | 153.4 | 12.09 | 38.51 | 20.79 | 107.4 | 150.6 | 10.607 | 15.135 |
| 6 | 22.41 | 120.09 | 153.8 | 13.363 | 39.65 | 18.98 | 105.6 | 150.5 | 11.746 | 13.351 |
| 7 | 20.84 | 91.5 | 106.9 | 13.06 | 21 | 4.156 | 84.78 | 89.35 | 3.804 | 0.448 |
| 8 | 17.93 | 77.72 | 97.92 | 10.08 | 23.55 | 3.219 | 69.71 | 85.85 | 2.374 | 0.431 |
| 9 | 21.52 | 77.69 | 113.2 | 11.27 | 22.18 | 4.356 | 72.05 | 101 | 3.363 | 0.679 |
| 10 | 18.95 | 80.23 | 130.9 | 8.202 | 16.56 | 6.596 | 77.76 | 123 | 5.547 | 1.262 |
| 11 | 19.01 | 81.77 | 129.1 | 9.902 | 18.43 | 7.109 | 79.37 | 125.4 | 6.664 | 1.284 |
| 12 | 18.05 | 83.74 | 125.67 | 9.563 | 15.46 | 6.826 | 81.29 | 119.48 | 7.269 | 1.427 |
| 13 | 2.468 | 43.62 | 39.55 | 1.398 | 1.576 | 1.826 | 42.28 | 36.29 | 1.335 | 0.247 |
| 14 | 3.131 | 42.06 | 36.93 | 1.534 | 1.522 | 2.346 | 39.38 | 32.34 | 1.154 | 0.025 |
| 15 | 2.389 | 50.68 | 38.15 | 1.441 | 1.645 | 1.601 | 49.6 | 33.36 | 1.258 | 0.073 |
| 16 | 11.314 | 51.69 | 91.3 | 2.68 | 11.76 | 2.177 | 43.56 | 83.37 | 1.125 | 0.126 |
| 17 | 12.03 | 56.89 | 98.6 | 3.446 | 14.42 | 2.551 | 49.91 | 85.67 | 1.399 | 0.269 |
| 18 | 14.56 | 58.94 | 84.75 | 3.198 | 16.85 | 1.289 | 50.1 | 72.69 | 1.321 | 0.171 |
| 19 | 3.324 | 41.29 | 45.98 | 3.273 | 4.36 | 1.685 | 37.09 | 42.72 | 1.563 | 0.019 |
| 20 | 4.291 | 54.08 | 39.32 | 2.528 | 5.151 | 1.585 | 49.69 | 36.75 | 1.732 | 0.136 |
| 21 | 3.441 | 50.48 | 38.72 | 3.353 | 5.32 | 1.468 | 45.45 | 35.46 | 1.53 | 0.12 |
| 22 | 29.54 | 44.36 | 2.274 | 0.531 | 0.139 | 16.59 | 42.01 | 2.14 | 0.424 | 0 |
| 23 | 28.8 | 54.38 | 2.42 | 0.586 | 0.251 | 18.96 | 53.83 | 2.09 | 0.576 | 0 |
| 24 | 30.2 | 33.97 | 2.442 | 0.564 | 0.152 | 17.7 | 31.2 | 1.69 | 0.516 | 0 |
| 25 | 16.32 | 40.6 | 0.613 | 1.354 | 1.299 | 5.014 | 38.54 | 0.576 | 0.616 | 0.014 |
| 26 | 16.41 | 35.34 | 1.228 | 0.911 | 0.496 | 5.041 | 34.98 | 0.765 | 0.604 | 0.079 |
| 27 | 15.95 | 48.04 | 1.526 | 0.739 | 0.271 | 6.471 | 46.76 | 1.467 | 0.615 | 0.052 |
| 28 | 5.418 | 44.58 | 2.41 | 0.914 | 1.149 | 1.614 | 42.43 | 1.3 | 0.67 | 0.074 |
| 29 | 5.084 | 31.24 | 2.609 | 0.878 | 1.457 | 1.294 | 29.67 | 1.134 | 0.65 | 0 |
| 30 | 5.077 | 31.22 | 2.351 | 0.735 | 0.496 | 1.781 | 29.08 | 2.073 | 0.642 | 0.099 |

Table A1. 77. Raw data for mortality and survival of *Lumbriculus variegates* measured after one and ten days of exposure. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30),

| Sample ID | Mortality | | Survival | |
|---|---|---|---|---|
| | After one day | After 10 days | After one day | After 10 days |
| | % | % | % | % |
| 4 | 9.4 | 24.7 | 90.6 | 75.3 |
| 5 | 17.8 | 32.4 | 82.2 | 67.6 |
| 6 | 2.3 | 33.1 | 97.7 | 66.9 |
| 7 | 11.9 | 42.6 | 88.1 | 57.4 |
| 8 | 14.4 | none | 85.6 | none |
| 9 | 2.5 | 59.9 | 97.5 | 40.1 |
| 10 | 17.5 | 28.0 | 82.5 | 72.0 |
| 11 | 4.9 | 28.3 | 95.1 | 71.7 |
| 12 | 36.4 | 31.8 | 63.6 | 68.2 |
| 13 | 15.5 | 20.6 | 84.5 | 79.4 |
| 14 | 6.1 | 2.1 | 93.9 | 97.9 |
| 15 | 6.4 | 12.0 | 93.6 | 88.0 |
| 16 | 5.7 | 23.9 | 94.3 | 76.1 |
| 17 | 0.0 | 31.3 | 100.0 | 68.7 |
| 18 | 4.5 | 28.0 | 95.5 | 72.0 |
| 19 | 2.8 | 20.9 | 97.2 | 79.1 |
| 20 | 4.0 | 8.5 | 96.0 | 91.5 |
| 21 | 8.1 | 9.3 | 91.9 | 90.7 |
| 22 | 1.5 | 35.3 | 98.5 | 64.7 |
| 23 | 12.6 | 39.9 | 87.4 | 60.1 |
| 24 | 10.2 | 25.4 | 89.8 | 74.6 |
| 25 | 14.5 | 25.2 | 85.5 | 74.8 |
| 26 | 17.9 | 49.5 | 82.1 | 50.5 |
| 27 | 13.1 | 29.4 | 86.9 | 70.6 |
| 28 | 8.5 | 16.5 | 91.5 | 83.5 |
| 29 | 9.1 | 7.1 | 90.9 | 92.9 |
| 30 | 9.2 | 13.9 | 90.8 | 86.1 |

Table A1. 78. Raw data for whole body average metal concentrations (in mg/kg) in *Lumbriculus variegates* measured after ten days of exposure. Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30), BG 1-3 - background, Rep – replicated measurements.

| Sample Id | Mass | Cu | Zn | As | Cd | Pb |
|---|---|---|---|---|---|---|
| | g | | | mg kg$^{-1}$ | | |
| 4-10 Day Worms | 0.258 | 86.42 | 193.55 | 2.25 | 55.30 | 154.08 |
| 5-10 Day Worms | 0.259 | 115.36 | 231.02 | 1.99 | 72.42 | 309.04 |
| 6-10 Day Worms | 0.25 | 105.92 | 206.65 | 1.67 | 51.21 | 192.14 |
| 7-10 Day Worms | 0.257 | 26.82 | 133.47 | 7.65 | 9.89 | 3.50 |
| 9-10 Day Worms | 0.25 | 26.26 | 135.87 | 9.02 | 9.98 | 4.21 |
| 10-10 Day Worms | 0.256 | 36.27 | 163.80 | 7.40 | 25.39 | 20.27 |
| 11-10 Day Worms | 0.254 | 27.56 | 157.42 | 7.32 | 13.44 | 9.64 |
| 12-10 Day Worms | 0.257 | 36.61 | 155.92 | 8.13 | 21.42 | 21.69 |
| 13-10 Day Worms | 0.253 | 21.56 | 136.02 | 4.30 | 1.26 | 1.15 |
| 14-10 Day Worms | 0.254 | 20.64 | 141.23 | 5.14 | 1.32 | 1.21 |
| 15-10 Day Worms | 0.255 | 22.39 | 138.93 | 4.06 | 1.35 | 1.14 |
| 16-10 Day Worms | 0.259 | 22.62 | 139.28 | 6.88 | 3.71 | 3.02 |
| 18-10 Day Worms | 0.257 | 25.93 | 144.77 | 5.70 | 6.45 | 6.22 |
| 19-10 Day Worms | 0.25 | 20.91 | 144.59 | 4.19 | 0.67 | 0.57 |
| 20-10 Day Worms | 0.258 | 23.18 | 144.28 | 3.54 | 0.79 | 0.89 |
| 21-10 Day Worms | 0.25 | 21.22 | 128.93 | 2.75 | 0.74 | 0.80 |
| 23-10 Day Worms | 0.253 | 105.22 | 141.39 | 1.02 | 0.57 | 0.88 |
| 24-10 Day Worms | 0.255 | 112.33 | 156.00 | 0.89 | 0.49 | 0.81 |
| 25-10 Day Worms | 0.253 | 25.34 | 138.91 | 1.18 | 0.80 | 1.55 |
| BG3 10-Day | 0.258 | 17.92 | 134.63 | 0.78 | 0.11 | 0.21 |
| BG2 10-Day | 0.258 | 17.14 | 130.53 | 0.72 | 0.08 | 0.23 |
| BG1 10-Day | 0.255 | 17.63 | 133.03 | 0.80 | 0.11 | 0.21 |
| 27-10 Day Worms | 0.259 | 21.32 | 135.89 | 0.88 | 0.52 | 0.53 |
| 28-10 Day Worms | 0.259 | 21.32 | 144.00 | 0.95 | 0.46 | 0.41 |
| 29-10 Day Worms | 0.253 | 21.05 | 141.84 | 0.95 | 0.54 | 0.40 |
| 30-10 Day Worms | 0.253 | 19.34 | 131.74 | 0.74 | 0.30 | 0.37 |
| 29-10 Day Worms Rep. | 0.258 | 21.16 | 140.45 | 0.90 | 0.53 | 0.40 |
| 14-10 Day Worms Rep. | 0.256 | 20.76 | 138.25 | 5.07 | 1.24 | 1.17 |

Table A1. 79. Raw data for Cd concentrations measured by water DGT probes ($C_{DGT}$) in surface water and calulation of ($C_{DGT}$). Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30). VNO3 – amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; Δg is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit.

| Sample ID | Cd µg $L^{-1}$ | VNO3 ml | Vgel ml | FE | Ce | M | delta G cm | D Cu 21o | time s | A cm2 | C Cdgt | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 37.13 | 1 | 0.15 | 0.8 | 185.65 | 266.8719 | 0.096 | 0.00000546 | 86400 | 3.14 | 17.296 | 16.442 | 1.114547 |
| 5 | 36.17 | 1 | 0.15 | 0.8 | 180.85 | 259.9719 | 0.096 | 0.00000546 | 86400 | 3.14 | 16.849 | | |
| 6 | 32.59 | 1 | 0.15 | 0.8 | 162.95 | 234.2406 | 0.096 | 0.00000546 | 86400 | 3.14 | 15.181 | | |
| 7 | 7.332 | 1 | 0.15 | 0.8 | 36.66 | 52.69875 | 0.096 | 0.00000546 | 86400 | 3.14 | 3.415 | 3.401 | 0.020422 |
| 8 | 7.27 | 1 | 0.15 | 0.8 | 36.35 | 52.25313 | 0.096 | 0.00000546 | 86400 | 3.14 | 3.386 | | |
| 10 | 19.84 | 1 | 0.15 | 0.8 | 99.2 | 142.6 | 0.096 | 0.00000546 | 86400 | 3.14 | 9.242 | 9.529 | 1.919045 |
| 11 | 24.85 | 1 | 0.15 | 0.8 | 124.25 | 178.6094 | 0.096 | 0.00000546 | 86400 | 3.14 | 11.575 | | |
| 12 | 16.68 | 1 | 0.15 | 0.8 | 83.4 | 119.8875 | 0.096 | 0.00000546 | 86400 | 3.14 | 7.770 | | |
| 13 | 1.479 | 1 | 0.15 | 0.8 | 7.395 | 10.63031 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.689 | 0.632 | 0.049295 |
| 14 | 1.29 | 1 | 0.15 | 0.8 | 6.45 | 9.271875 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.601 | | |
| 15 | 1.302 | 1 | 0.15 | 0.8 | 6.51 | 9.358125 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.606 | | |
| 17 | 3.142 | 1 | 0.15 | 0.8 | 15.71 | 22.58313 | 0.096 | 0.00000546 | 86400 | 3.14 | 1.464 | 1.325 | 0.196311 |
| 18 | 2.546 | 1 | 0.15 | 0.8 | 12.73 | 18.29938 | 0.096 | 0.00000546 | 86400 | 3.14 | 1.186 | | |
| 19 | 2.185 | 1 | 0.15 | 0.8 | 10.925 | 15.70469 | 0.096 | 0.00000546 | 86400 | 3.14 | 1.018 | 1.270 | 0.265128 |
| 20 | 3.32 | 1 | 0.15 | 0.8 | 16.6 | 23.8625 | 0.096 | 0.00000546 | 86400 | 3.14 | 1.547 | | |
| 21 | 2.677 | 1 | 0.15 | 0.8 | 13.385 | 19.24094 | 0.096 | 0.00000546 | 86400 | 3.14 | 1.247 | | |
| 23 | 0.91 | 1 | 0.15 | 0.8 | 4.55 | 6.540625 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.424 | 0.391 | 0.047101 |
| 24 | 0.767 | 1 | 0.15 | 0.8 | 3.835 | 5.512813 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.357 | | |
| 25 | 0.751 | 1 | 0.15 | 0.8 | 3.755 | 5.397813 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.350 | 0.338 | 0.014473 |
| 26 | 0.691 | 1 | 0.15 | 0.8 | 3.455 | 4.966563 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.322 | | |
| 27 | 0.735 | 1 | 0.15 | 0.8 | 3.675 | 5.282813 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.342 | | |
| 28 | 0.801 | 1 | 0.15 | 0.8 | 4.005 | 5.757188 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.373 | 0.379 | 0.005236 |
| 29 | 0.823 | 1 | 0.15 | 0.8 | 4.115 | 5.915313 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.383 | | |
| 30 | 0.816 | 1 | 0.15 | 0.8 | 4.08 | 5.865 | 0.096 | 0.00000546 | 86400 | 3.14 | 0.380 | | |

Table A1. 80. Raw data for Cu concentrations measured by water DGT probes ($C_{DGT}$) in surface water and calulation of ($C_{DGT}$). See Table A1.79 for additional details.

| Sample ID | Cu µg $L^{-1}$ | VNO3 ml | Vgel ml | FE | Ce | M | delta G cm | D Cu 21o | time s | A cm2 | C Cdgt | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 31.43 | 1 | 0.15 | 0.8 | 157.15 | 225.9031 | 0.096 | 5.58E-06 | 86400 | 3.14 | 14.326 | 13.027 | 1.126667 |
| 5 | 27.29 | 1 | 0.15 | 0.8 | 136.45 | 196.1469 | 0.096 | 5.58E-06 | 86400 | 3.14 | 12.439 | | |
| 6 | 27.02 | 1 | 0.15 | 0.8 | 135.1 | 194.2063 | 0.096 | 5.58E-06 | 86400 | 3.14 | 12.316 | | |
| 7 | 5.54 | 1 | 0.15 | 0.8 | 27.7 | 39.81875 | 0.096 | 5.58E-06 | 86400 | 3.14 | 2.525 | 2.334 | 0.270407 |
| 8 | 4.701 | 1 | 0.15 | 0.8 | 23.505 | 33.78844 | 0.096 | 5.58E-06 | 86400 | 3.14 | 2.143 | | |
| 10 | 7.667 | 1 | 0.15 | 0.8 | 38.335 | 55.10656 | 0.096 | 5.58E-06 | 86400 | 3.14 | 3.495 | 3.527 | 0.158807 |
| 11 | 7.43 | 1 | 0.15 | 0.8 | 37.15 | 53.40313 | 0.096 | 5.58E-06 | 86400 | 3.14 | 3.387 | | |
| 12 | 8.116 | 1 | 0.15 | 0.8 | 40.58 | 58.33375 | 0.096 | 5.58E-06 | 86400 | 3.14 | 3.699 | | |
| 13 | 2.018 | 1 | 0.15 | 0.8 | 10.09 | 14.50438 | 0.096 | 5.58E-06 | 86400 | 3.14 | 0.920 | 0.949 | 0.133032 |
| 14 | 1.828 | 1 | 0.15 | 0.8 | 9.14 | 13.13875 | 0.096 | 5.58E-06 | 86400 | 3.14 | 0.833 | | |
| 15 | 2.401 | 1 | 0.15 | 0.8 | 12.005 | 17.25719 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.094 | | |
| 17 | 2.587 | 1 | 0.15 | 0.8 | 12.935 | 18.59406 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.179 | 1.287 | 0.152769 |
| 18 | 3.061 | 1 | 0.15 | 0.8 | 15.305 | 22.00094 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.395 | | |
| 19 | 2.124 | 1 | 0.15 | 0.8 | 10.62 | 15.26625 | 0.096 | 5.58E-06 | 86400 | 3.14 | 0.968 | 1.251 | 0.30296 |
| 20 | 2.664 | 1 | 0.15 | 0.8 | 13.32 | 19.1475 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.214 | | |
| 21 | 3.446 | 1 | 0.15 | 0.8 | 17.23 | 24.76813 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.571 | | |
| 23 | 29.32 | 1 | 0.15 | 0.8 | 146.6 | 210.7375 | 0.096 | 5.58E-06 | 86400 | 3.14 | 13.364 | 12.965 | 0.56402 |
| 24 | 27.57 | 1 | 0.15 | 0.8 | 137.85 | 198.1594 | 0.096 | 5.58E-06 | 86400 | 3.14 | 12.566 | | |
| 25 | 4.484 | 1 | 0.15 | 0.8 | 22.42 | 32.22875 | 0.096 | 5.58E-06 | 86400 | 3.14 | 2.044 | 2.151 | 0.152176 |
| 26 | 5.102 | 1 | 0.15 | 0.8 | 25.51 | 36.67063 | 0.096 | 5.58E-06 | 86400 | 3.14 | 2.325 | | |
| 27 | 4.574 | 1 | 0.15 | 0.8 | 22.87 | 32.87563 | 0.096 | 5.58E-06 | 86400 | 3.14 | 2.085 | | |
| 28 | 2.42 | 1 | 0.15 | 0.8 | 12.1 | 17.39375 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.103 | 1.313 | 0.192561 |
| 29 | 3.25 | 1 | 0.15 | 0.8 | 16.25 | 23.35938 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.481 | | |
| 30 | 2.972 | 1 | 0.15 | 0.8 | 14.86 | 21.36125 | 0.096 | 5.58E-06 | 86400 | 3.14 | 1.355 | | |

Table A1. 81. Raw data for Pb concentrations measured by water DGT probes ($C_{DGT}$) in surface water and calulation of ($C_{DGT}$). See Table A1.79 for additional details.

| Sample ID | Pb µg $L^{-1}$ | VNO3 ml | Vgel ml | FE | Ce | M | delta G cm | D Cu 21o | time s | A cm2 | C Cdgt | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 43.45 | 1 | 0.15 | 0.8 | 217.25 | 312.2969 | 0.096 | 0.00000719 | 86400 | 3.14 | 15.370 | 17.109 | 2.271023 |
| 5 | 46.02 | 1 | 0.15 | 0.8 | 230.1 | 330.7688 | 0.096 | 0.00000719 | 86400 | 3.14 | 16.279 | | |
| 6 | 55.63 | 1 | 0.15 | 0.8 | 278.15 | 399.8406 | 0.096 | 0.00000719 | 86400 | 3.14 | 19.678 | | |
| 7 | 3.142 | 1 | 0.15 | 0.8 | 15.71 | 22.58313 | 0.096 | 0.00000719 | 86400 | 3.14 | 1.111 | 0.963 | 0.209357 |
| 8 | 2.305 | 1 | 0.15 | 0.8 | 11.525 | 16.56719 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.815 | | |
| 10 | 7.778 | 1 | 0.15 | 0.8 | 38.89 | 55.90438 | 0.096 | 0.00000719 | 86400 | 3.14 | 2.751 | 2.571 | 0.601029 |
| 11 | 8.656 | 1 | 0.15 | 0.8 | 43.28 | 62.215 | 0.096 | 0.00000719 | 86400 | 3.14 | 3.062 | | |
| 12 | 5.374 | 1 | 0.15 | 0.8 | 26.87 | 38.62563 | 0.096 | 0.00000719 | 86400 | 3.14 | 1.901 | | |
| 13 | 1.714 | 1 | 0.15 | 0.8 | 8.57 | 12.31938 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.606 | 0.591 | 0.071865 |
| 14 | 1.448 | 1 | 0.15 | 0.8 | 7.24 | 10.4075 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.512 | | |
| 15 | 1.847 | 1 | 0.15 | 0.8 | 9.235 | 13.27531 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.653 | | |
| 17 | 1.984 | 1 | 0.15 | 0.8 | 9.92 | 14.26 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.702 | 0.766 | 0.090796 |
| 18 | 2.347 | 1 | 0.15 | 0.8 | 11.735 | 16.86906 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.830 | | |
| 19 | 2.429 | 1 | 0.15 | 0.8 | 12.145 | 17.45844 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.859 | 0.917 | 0.155967 |
| 20 | 2.254 | 1 | 0.15 | 0.8 | 11.27 | 16.20063 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.797 | | |
| 21 | 3.09 | 1 | 0.15 | 0.8 | 15.45 | 22.20938 | 0.096 | 0.00000719 | 86400 | 3.14 | 1.093 | | |
| 23 | 0.576 | 1 | 0.15 | 0.8 | 2.88 | 4.14 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.204 | 0.212 | 0.012006 |
| 24 | 0.624 | 1 | 0.15 | 0.8 | 3.12 | 4.485 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.221 | | |
| 25 | 0.49 | 1 | 0.15 | 0.8 | 2.45 | 3.521875 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.173 | 0.119 | 0.052912 |
| 26 | 0.191 | 1 | 0.15 | 0.8 | 0.955 | 1.372813 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.068 | | |
| 27 | 0.332 | 1 | 0.15 | 0.8 | 1.66 | 2.38625 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.117 | | |
| 28 | 0.597 | 1 | 0.15 | 0.8 | 2.985 | 4.290938 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.211 | 0.147 | 0.071856 |
| 29 | 0.196 | 1 | 0.15 | 0.8 | 0.98 | 1.40875 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.069 | | |
| 30 | 0.453 | 1 | 0.15 | 0.8 | 2.265 | 3.255938 | 0.096 | 0.00000719 | 86400 | 3.14 | 0.160 | | |

Table A1. 82. Raw data for Zn concentrations measured by water DGT probes ($C_{DGT}$) in surface water and calulation of ($C_{DGT}$). See Table A1.79 for additional details.

| Sample ID | Zn µg $L^{-1}$ | VNO3 ml | Vgel ml | FE | Ce | M | delta G cm | D Cu 21o | time s | A cm2 | C Cdgt | AVG | STDEV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 832.1 | 1 | 0.15 | 0.8 | 4160.5 | 5980.719 | 0.096 | 0.00000544 | 86400 | 3.14 | 389.029 | 369.050 | 56.83723 |
| 5 | 883.8 | 1 | 0.15 | 0.8 | 4419 | 6352.313 | 0.096 | 0.00000544 | 86400 | 3.14 | 413.200 | | |
| 6 | 652.2 | 1 | 0.15 | 0.8 | 3261 | 4687.688 | 0.096 | 0.00000544 | 86400 | 3.14 | 304.921 | | |
| 7 | 541.3 | 1 | 0.15 | 0.8 | 2706.5 | 3890.594 | 0.096 | 0.00000544 | 86400 | 3.14 | 253.072 | 230.210 | 32.33186 |
| 8 | 443.5 | 1 | 0.15 | 0.8 | 2217.5 | 3187.656 | 0.096 | 0.00000544 | 86400 | 3.14 | 207.348 | | |
| 10 | 637.9 | 1 | 0.15 | 0.8 | 3189.5 | 4584.906 | 0.096 | 0.00000544 | 86400 | 3.14 | 298.236 | 283.992 | 19.79012 |
| 11 | 559.1 | 1 | 0.15 | 0.8 | 2795.5 | 4018.531 | 0.096 | 0.00000544 | 86400 | 3.14 | 261.394 | | |
| 12 | 625.3 | 1 | 0.15 | 0.8 | 3126.5 | 4494.344 | 0.096 | 0.00000544 | 86400 | 3.14 | 292.345 | | |
| 13 | 432.4 | 1 | 0.15 | 0.8 | 2162 | 3107.875 | 0.096 | 0.00000544 | 86400 | 3.14 | 202.159 | 188.756 | 24.39732 |
| 14 | 435.3 | 1 | 0.15 | 0.8 | 2176.5 | 3128.719 | 0.096 | 0.00000544 | 86400 | 3.14 | 203.515 | | |
| 15 | 343.5 | 1 | 0.15 | 0.8 | 1717.5 | 2468.906 | 0.096 | 0.00000544 | 86400 | 3.14 | 160.596 | | |
| 17 | 269.7 | 1 | 0.15 | 0.8 | 1348.5 | 1938.469 | 0.096 | 0.00000544 | 86400 | 3.14 | 126.092 | 116.625 | 13.38896 |
| 18 | 229.2 | 1 | 0.15 | 0.8 | 1146 | 1647.375 | 0.096 | 0.00000544 | 86400 | 3.14 | 107.157 | | |
| 19 | 323.9 | 1 | 0.15 | 0.8 | 1619.5 | 2328.031 | 0.096 | 0.00000544 | 86400 | 3.14 | 151.432 | 186.107 | 30.9079 |
| 20 | 419.5 | 1 | 0.15 | 0.8 | 2097.5 | 3015.156 | 0.096 | 0.00000544 | 86400 | 3.14 | 196.128 | | |
| 21 | 450.8 | 1 | 0.15 | 0.8 | 2254 | 3240.125 | 0.096 | 0.00000544 | 86400 | 3.14 | 210.761 | | |
| 23 | 171 | 1 | 0.15 | 0.8 | 855 | 1229.063 | 0.096 | 0.00000544 | 86400 | 3.14 | 79.947 | 75.856 | 5.785353 |
| 24 | 153.5 | 1 | 0.15 | 0.8 | 767.5 | 1103.281 | 0.096 | 0.00000544 | 86400 | 3.14 | 71.765 | | |
| 25 | 114.3 | 1 | 0.15 | 0.8 | 571.5 | 821.5313 | 0.096 | 0.00000544 | 86400 | 3.14 | 53.438 | 53.173 | 3.257404 |
| 26 | 106.5 | 1 | 0.15 | 0.8 | 532.5 | 765.4688 | 0.096 | 0.00000544 | 86400 | 3.14 | 49.792 | | |
| 27 | 120.4 | 1 | 0.15 | 0.8 | 602 | 865.375 | 0.096 | 0.00000544 | 86400 | 3.14 | 56.290 | | |
| 28 | 123.9 | 1 | 0.15 | 0.8 | 619.5 | 890.5313 | 0.096 | 0.00000544 | 86400 | 3.14 | 57.927 | 63.350 | 5.108897 |
| 29 | 145.6 | 1 | 0.15 | 0.8 | 728 | 1046.5 | 0.096 | 0.00000544 | 86400 | 3.14 | 68.072 | | |
| 30 | 137 | 1 | 0.15 | 0.8 | 685 | 984.6875 | 0.096 | 0.00000544 | 86400 | 3.14 | 64.051 | | |

Table A1. 83. Raw data for Cd, Cu, Pb, and Zn concentrations measured by DGT probes ($C_{DGT}$) in cap and sediment and calulation of ($C_{DGT}$). See Table A1.79 for additional details

| Sample ID | Treatment | Experiment | Treatment 2 | Layer | Rep | Element | Raw data | Ce | VNO3 ml | Vgel ml | FE | Ce | M | delta G cm | D Cu 21o | time s | A cm2 | Cdgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-S-Cap | SC-MS | MS | SC | Cap | 1 | Cu | 6.772 | 33.86 | 0.75 | 0.158 | 0.8 | 33.86 | 38.4311 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.627 |
| 11-S-Cap | SC-MS | MS | SC | Cap | 2 | Cu | 7.875 | 39.375 | 0.75 | 0.158 | 0.8 | 39.375 | 44.69063 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.892 |
| 12-S-Cap | SC-MS | MS | SC | Cap | 3 | Cu | 8.057 | 40.285 | 0.75 | 0.158 | 0.8 | 40.285 | 45.72348 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.936 |
| 13-S-Cap | A-MS | MS | A | Cap | 1 | Cu | 1.273 | 6.365 | 0.75 | 0.158 | 0.8 | 6.365 | 7.224275 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.306 |
| 14-S-Cap | A-MS | MS | A | Cap | 2 | Cu | 2.112 | 10.56 | 0.75 | 0.158 | 0.8 | 10.56 | 11.9856 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.507 |
| 15-S-Cap | A-MS | MS | A | Cap | 3 | Cu | 1.952 | 9.76 | 0.75 | 0.158 | 0.8 | 9.76 | 11.0776 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.469 |
| 19-S-Cap | MC-MS | MS | MC | Cap | 1 | Cu | 1.23 | 6.15 | 0.75 | 0.158 | 0.8 | 6.15 | 6.98025 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.296 |
| 20-S-Cap | MC-MS | MS | MC | Cap | 2 | Cu | 1.26 | 6.3 | 0.75 | 0.158 | 0.8 | 6.3 | 7.1505 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.303 |
| 21-S-Cap | MC-MS | MS | MC | Cap | 3 | Cu | 1.802 | 9.01 | 0.75 | 0.158 | 0.8 | 9.01 | 10.22635 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.433 |
| 28-S-Cap | MC-CuS | CuS | MC | Cap | 1 | Cu | 1.414 | 7.07 | 0.75 | 0.158 | 0.8 | 7.07 | 8.02445 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.340 |
| 29-S-Cap | MC-CuS | CuS | MC | Cap | 2 | Cu | 1.545 | 7.725 | 0.75 | 0.158 | 0.8 | 7.725 | 8.767875 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.371 |
| 30-S-Cap | MC-CuS | CuS | MC | Cap | 3 | Cu | 1.154 | 5.77 | 0.75 | 0.158 | 0.8 | 5.77 | 6.54895 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.277 |
| 7-S-A | SED-MS | MS | SED | A | 1 | Cu | 4.745 | 23.725 | 0.75 | 0.158 | 0.8 | 23.725 | 26.92788 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.140 |
| 8-S-A | SED-MS | MS | SED | A | 2 | Cu | 3.82 | 19.1 | 0.75 | 0.158 | 0.8 | 19.1 | 21.6785 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.918 |
| 9-S-A | SED-MS | MS | SED | A | 3 | Cu | 4.522 | 22.61 | 0.75 | 0.158 | 0.8 | 22.61 | 25.66235 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.087 |
| 10-S-A | SC-MS | MS | SC | A | 1 | Cu | 4.894 | 24.47 | 0.75 | 0.158 | 0.8 | 24.47 | 27.77345 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.176 |
| 11-S-A | SC-MS | MS | SC | A | 2 | Cu | 5.708 | 28.54 | 0.75 | 0.158 | 0.8 | 28.54 | 32.3929 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.371 |
| 12-S-A | SC-MS | MS | SC | A | 3 | Cu | 3.563 | 17.815 | 0.75 | 0.158 | 0.8 | 17.815 | 20.22003 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.856 |
| 13-S-A | A-MS | MS | A | A | 1 | Cu | 1.536 | 7.68 | 0.75 | 0.158 | 0.8 | 7.68 | 8.7168 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.369 |
| 14-S-A | A-MS | MS | A | A | 2 | Cu | 1.888 | 9.44 | 0.75 | 0.158 | 0.8 | 9.44 | 10.7144 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.454 |
| 15-S-A | A-MS | MS | A | A | 3 | Cu | 2.201 | 11.005 | 0.75 | 0.158 | 0.8 | 11.005 | 12.49068 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.529 |
| 16-S-A | AC-MS | MS | AC | A | 1 | Cu | 1.828 | 9.14 | 0.75 | 0.158 | 0.8 | 9.14 | 10.3739 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.439 |
| 17-S-A | AC-MS | MS | AC | A | 2 | Cu | 1.709 | 8.545 | 0.75 | 0.158 | 0.8 | 8.545 | 9.698575 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.411 |
| 18-S-A | AC-MS | MS | AC | A | 3 | Cu | 2.322 | 11.61 | 0.75 | 0.158 | 0.8 | 11.61 | 13.17735 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.558 |
| 19-S-A | MC-MS | MS | MC | A | 1 | Cu | 1.301 | 6.505 | 0.75 | 0.158 | 0.8 | 6.505 | 7.383175 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.313 |
| 20-S-A | MC-MS | MS | MC | A | 2 | Cu | 2.525 | 12.625 | 0.75 | 0.158 | 0.8 | 12.625 | 14.32938 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.607 |
| 21-S-A | MC-MS | MS | MC | A | 3 | Cu | 1.152 | 5.76 | 0.75 | 0.158 | 0.8 | 5.76 | 6.5376 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.277 |
| 25-S-A | SED-CuS | CuS | SED | A | 1 | Cu | 5.821 | 29.105 | 0.75 | 0.158 | 0.8 | 29.105 | 33.03418 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.399 |
| 26-S-A | SED-CuS | CuS | SED | A | 2 | Cu | 4.32 | 21.61 | 0.75 | 0.158 | 0.8 | 21.61 | 24.52735 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.038 |
| 27-S-A | SED-CuS | CuS | SED | A | 3 | Cu | 5.839 | 29.195 | 0.75 | 0.158 | 0.8 | 29.195 | 33.13633 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.403 |
| 28-S-A | MC-CuS | CuS | MC | A | 1 | Cu | 1.699 | 8.495 | 0.75 | 0.158 | 0.8 | 8.495 | 9.641825 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.408 |
| 29-S-A | MC-CuS | CuS | MC | A | 2 | Cu | 1.168 | 5.84 | 0.75 | 0.158 | 0.8 | 5.84 | 6.6284 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.281 |
| 30-S-A | MC-CuS | CuS | MC | A | 3 | Cu | 1.227 | 6.135 | 0.75 | 0.158 | 0.8 | 6.135 | 6.963225 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.295 |
| 7-S-B | SED-MS | MS | SED | B | 1 | Cu | 5.84 | 29.195 | 0.75 | 0.158 | 0.8 | 29.195 | 33.13633 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.403 |
| 8-S-B | SED-MS | MS | SED | B | 2 | Cu | 5.69 | 28.455 | 0.75 | 0.158 | 0.8 | 28.455 | 32.29643 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.367 |
| 9-S- B | SED-MS | MS | SED | B | 3 | Cu | 3.20 | 15.995 | 0.75 | 0.158 | 0.8 | 15.995 | 18.15433 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.769 |
| 10-S-B | SC-MS | MS | SC | B | 1 | Cu | 1.304 | 6.52 | 0.75 | 0.158 | 0.8 | 6.52 | 7.4002 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.313 |
| 11-S-B | SC-MS | MS | SC | B | 2 | Cu | 2.884 | 14.42 | 0.75 | 0.158 | 0.8 | 14.42 | 16.3667 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.693 |
| 12-S-B | SC-MS | MS | SC | B | 3 | Cu | 2.028 | 10.14 | 0.75 | 0.158 | 0.8 | 10.14 | 11.5089 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.487 |
| 13-S-B | A-MS | MS | A | B | 1 | Cu | 1.028 | 5.14 | 0.75 | 0.158 | 0.8 | 5.14 | 5.8339 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.247 |
| 14-S-B | A-MS | MS | A | B | 2 | Cu | 1.047 | 5.235 | 0.75 | 0.158 | 0.8 | 5.235 | 5.941725 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.252 |
| 15-S-B | A-MS | MS | A | B | 3 | Cu | 1.288 | 6.44 | 0.75 | 0.158 | 0.8 | 6.44 | 7.3094 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.309 |
| 16-S-B | AC-MS | MS | AC | B | 1 | Cu | 1.011 | 5.055 | 0.75 | 0.158 | 0.8 | 5.055 | 5.737425 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.243 |
| 17-S-B | AC-MS | MS | AC | B | 2 | Cu | 1.198 | 5.99 | 0.75 | 0.158 | 0.8 | 5.99 | 6.79865 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.288 |
| 18-S-B | AC-MS | MS | AC | B | 3 | Cu | 1.668 | 8.34 | 0.75 | 0.158 | 0.8 | 8.34 | 9.4659 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.401 |
| 19-S-B | MC-MS | MS | MC | B | 1 | Cu | 0.981 | 4.905 | 0.75 | 0.158 | 0.8 | 4.905 | 5.567175 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.236 |
| 20-S-B | MC-MS | MS | MC | B | 2 | Cu | 0.928 | 4.64 | 0.75 | 0.158 | 0.8 | 4.64 | 5.2664 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.223 |
| 21-S-B | MC-MS | MS | MC | B | 3 | Cu | 1.048 | 5.24 | 0.75 | 0.158 | 0.8 | 5.24 | 5.9474 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.252 |
| 25-S-B | SED-CuS | CuS | SED | B | 1 | Cu | 3.42 | 17.1 | 0.75 | 0.158 | 0.8 | 17.1 | 19.4085 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.822 |
| 26-S-B | SED-CuS | CuS | SED | B | 2 | Cu | 2.037 | 10.185 | 0.75 | 0.158 | 0.8 | 10.185 | 11.55998 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.489 |
| 27-S-B | SED-CuS | CuS | SED | B | 3 | Cu | 3.383 | 16.915 | 0.75 | 0.158 | 0.8 | 16.915 | 19.19853 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.813 |
| 28-S-B | MC-CuS | CuS | MC | B | 1 | Cu | 0.948 | 4.74 | 0.75 | 0.158 | 0.8 | 4.74 | 5.3799 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.228 |
| 29-S-B | MC-CuS | CuS | MC | B | 2 | Cu | 1.197 | 5.985 | 0.75 | 0.158 | 0.8 | 5.985 | 6.792975 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.288 |
| 30-S-B | MC-CuS | CuS | MC | B | 3 | Cu | 0.867 | 4.335 | 0.75 | 0.158 | 0.8 | 4.335 | 4.920225 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.208 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7-S-C | SED-MS | MS | SED | C | 1 | Cu | 3.202 | 16.01 | 0.75 | 0.158 | 0.8 | 16.01 | 18.17135 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.769 |
| 8-S-C | SED-MS | MS | SED | C | 2 | Cu | 4.41 | 22.05 | 0.75 | 0.158 | 0.8 | 22.05 | 25.02675 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.060 |
| 9-S-C | SED-MS | MS | SED | C | 3 | Cu | 4.171 | 20.855 | 0.75 | 0.158 | 0.8 | 20.855 | 23.67043 | 0.096 | 0.00000574 | 86400 | 4.572 | 1.002 |
| 10-S-C | SC-MS | MS | SC | C | 1 | Cu | 1.632 | 8.16 | 0.75 | 0.158 | 0.8 | 8.16 | 9.2616 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.392 |
| 11-S-C | SC-MS | MS | SC | C | 2 | Cu | 2.418 | 12.09 | 0.75 | 0.158 | 0.8 | 12.09 | 13.72215 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.581 |
| 12-S-C | SC-MS | MS | SC | C | 3 | Cu | 1.381 | 6.905 | 0.75 | 0.158 | 0.8 | 6.905 | 7.837175 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.332 |
| 13-S-C | A-MS | MS | A | C | 1 | Cu | 1.005 | 5.025 | 0.75 | 0.158 | 0.8 | 5.025 | 5.703375 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.241 |
| 14-S-C | A-MS | MS | A | C | 2 | Cu | 1.412 | 7.06 | 0.75 | 0.158 | 0.8 | 7.06 | 8.0131 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.339 |
| 15-S-C | A-MS | MS | A | C | 3 | Cu | 1.334 | 6.67 | 0.75 | 0.158 | 0.8 | 6.67 | 7.57045 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.321 |
| 16-S-C | AC-MS | MS | AC | C | 1 | Cu | 1.679 | 8.395 | 0.75 | 0.158 | 0.8 | 8.395 | 9.528325 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.403 |
| 17-S-C | AC-MS | MS | AC | C | 2 | Cu | 1.902 | 9.51 | 0.75 | 0.158 | 0.8 | 9.51 | 10.79385 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.457 |
| 18-S-C | AC-MS | MS | AC | C | 3 | Cu | 2.121 | 10.605 | 0.75 | 0.158 | 0.8 | 10.605 | 12.03668 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.510 |
| 19-S-C | MC-MS | MS | MC | C | 1 | Cu | 1.7 | 8.5 | 0.75 | 0.158 | 0.8 | 8.5 | 9.6475 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.408 |
| 20-S-C | MC-MS | MS | MC | C | 2 | Cu | 1.341 | 6.705 | 0.75 | 0.158 | 0.8 | 6.705 | 7.610175 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.322 |
| 21-S-C | MC-MS | MS | MC | C | 3 | Cu | 1.533 | 7.665 | 0.75 | 0.158 | 0.8 | 7.665 | 8.699775 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.368 |
| 25-S-C | SED-CuS | CuS | SED | C | 1 | Cu | 2.627 | 13.135 | 0.75 | 0.158 | 0.8 | 13.135 | 14.90823 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.631 |
| 26-S-C | SED-CuS | CuS | SED | C | 2 | Cu | 2.468 | 12.34 | 0.75 | 0.158 | 0.8 | 12.34 | 14.0059 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.593 |
| 27-S-C | SED-CuS | CuS | SED | C | 3 | Cu | 2.851 | 14.255 | 0.75 | 0.158 | 0.8 | 14.255 | 16.17943 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.685 |
| 28-S-C | MC-CuS | CuS | MC | C | 1 | Cu | 1.175 | 5.875 | 0.75 | 0.158 | 0.8 | 5.875 | 6.668125 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.282 |
| 29-S-C | MC-CuS | CuS | MC | C | 2 | Cu | 1.329 | 6.645 | 0.75 | 0.158 | 0.8 | 6.645 | 7.542075 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.319 |
| 30-S-C | MC-CuS | CuS | MC | C | 3 | Cu | 1.294 | 6.47 | 0.75 | 0.158 | 0.8 | 6.47 | 7.34345 | 0.096 | 0.00000574 | 86400 | 4.572 | 0.311 |
| 10-S-Cap | SC-MS | MS | SC | Cap | 1 | Zn | 601.5 | 3007.5 | 0.75 | 0.158 | 0.8 | 3007.5 | 3413.513 | 0.096 | 0.0000056 | 86400 | 4.572 | 148.137 |
| 11-S-Cap | SC-MS | MS | SC | Cap | 2 | Zn | 623.2 | 3116 | 0.75 | 0.158 | 0.8 | 3116 | 3536.66 | 0.096 | 0.0000056 | 86400 | 4.572 | 153.482 |
| 12-S-Cap | SC-MS | MS | SC | Cap | 3 | Zn | 693.7 | 3468.5 | 0.75 | 0.158 | 0.8 | 3468.5 | 3936.748 | 0.096 | 0.0000056 | 86400 | 4.572 | 170.844 |
| 13-S-Cap | A-MS | MS | A | Cap | 1 | Zn | 368.1 | 1840.5 | 0.75 | 0.158 | 0.8 | 1840.5 | 2088.968 | 0.096 | 0.0000056 | 86400 | 4.572 | 90.656 |
| 14-S-Cap | A-MS | MS | A | Cap | 2 | Zn | 377.86 | 1889.3 | 0.75 | 0.158 | 0.8 | 1889.3 | 2144.356 | 0.096 | 0.0000056 | 86400 | 4.572 | 93.059 |
| 15-S-Cap | A-MS | MS | A | Cap | 3 | Zn | 359 | 1795 | 0.75 | 0.158 | 0.8 | 1795 | 2037.325 | 0.096 | 0.0000056 | 86400 | 4.572 | 88.415 |
| 19-S-Cap | MC-MS | MS | MC | Cap | 1 | Zn | 216.8 | 1084 | 0.75 | 0.158 | 0.8 | 1084 | 1230.34 | 0.096 | 0.0000056 | 86400 | 4.572 | 53.393 |
| 20-S-Cap | MC-MS | MS | MC | Cap | 2 | Zn | 147.9 | 739.5 | 0.75 | 0.158 | 0.8 | 739.5 | 839.3325 | 0.096 | 0.0000056 | 86400 | 4.572 | 36.425 |
| 21-S-Cap | MC-MS | MS | MC | Cap | 3 | Zn | 210.7 | 1053.5 | 0.75 | 0.158 | 0.8 | 1053.5 | 1195.723 | 0.096 | 0.0000056 | 86400 | 4.572 | 51.891 |
| 28-S-Cap | MC-CuS | MS | MC | Cap | 1 | Zn | 88.3 | 441.5 | 0.75 | 0.158 | 0.8 | 441.5 | 501.1025 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.747 |
| 29-S-Cap | MC-CuS | MS | MC | Cap | 2 | Zn | 96.1 | 480.5 | 0.75 | 0.158 | 0.8 | 480.5 | 545.3675 | 0.096 | 0.0000056 | 86400 | 4.572 | 23.668 |
| 30-S-Cap | MC-CuS | MS | MC | Cap | 3 | Zn | 68.37 | 341.85 | 0.75 | 0.158 | 0.8 | 341.85 | 387.9998 | 0.096 | 0.0000056 | 86400 | 4.572 | 16.838 |
| 7-S-A | SED-MS | MS | SED | A | 1 | Zn | 675.1 | 3375.5 | 0.75 | 0.158 | 0.8 | 3375.5 | 3831.193 | 0.096 | 0.0000056 | 86400 | 4.572 | 166.264 |
| 8-S-A | SED-MS | MS | SED | A | 2 | Zn | 664.1 | 3320.5 | 0.75 | 0.158 | 0.8 | 3320.5 | 3768.768 | 0.096 | 0.0000056 | 86400 | 4.572 | 163.555 |
| 9-S-A | SED-MS | MS | SED | A | 3 | Zn | 652.31 | 3261.55 | 0.75 | 0.158 | 0.8 | 3261.55 | 3701.859 | 0.096 | 0.0000056 | 86400 | 4.572 | 160.651 |
| 10-S-A | SC-MS | MS | SC | A | 1 | Zn | 557.6 | 2788 | 0.75 | 0.158 | 0.8 | 2788 | 3164.38 | 0.096 | 0.0000056 | 86400 | 4.572 | 137.326 |
| 11-S-A | SC-MS | MS | SC | A | 2 | Zn | 468.89 | 2344.45 | 0.75 | 0.158 | 0.8 | 2344.45 | 2660.951 | 0.096 | 0.0000056 | 86400 | 4.572 | 115.478 |
| 12-S-A | SC-MS | MS | SC | A | 3 | Zn | 532.1 | 2660.5 | 0.75 | 0.158 | 0.8 | 2660.5 | 3019.668 | 0.096 | 0.0000056 | 86400 | 4.572 | 131.046 |
| 13-S-A | A-MS | MS | A | A | 1 | Zn | 68.92 | 344.6 | 0.75 | 0.158 | 0.8 | 344.6 | 391.121 | 0.096 | 0.0000056 | 86400 | 4.572 | 16.974 |
| 14-S-A | A-MS | MS | A | A | 2 | Zn | 169.6 | 848 | 0.75 | 0.158 | 0.8 | 848 | 962.48 | 0.096 | 0.0000056 | 86400 | 4.572 | 41.769 |
| 15-S-A | A-MS | MS | A | A | 3 | Zn | 168.1 | 840.5 | 0.75 | 0.158 | 0.8 | 840.5 | 953.9675 | 0.096 | 0.0000056 | 86400 | 4.572 | 41.400 |
| 16-S-A | AC-MS | MS | AC | A | 1 | Zn | 304 | 1520 | 0.75 | 0.158 | 0.8 | 1520 | 1725.2 | 0.096 | 0.0000056 | 86400 | 4.572 | 74.869 |
| 17-S-A | AC-MS | MS | AC | A | 2 | Zn | 365 | 1825 | 0.75 | 0.158 | 0.8 | 1825 | 2071.375 | 0.096 | 0.0000056 | 86400 | 4.572 | 89.892 |
| 18-S-A | AC-MS | MS | AC | A | 3 | Zn | 334.9 | 1674.5 | 0.75 | 0.158 | 0.8 | 1674.5 | 1900.558 | 0.096 | 0.0000056 | 86400 | 4.572 | 82.479 |
| 19-S-A | MC-MS | MS | MC | A | 1 | Zn | 83.5 | 417.5 | 0.75 | 0.158 | 0.8 | 417.5 | 473.8625 | 0.096 | 0.0000056 | 86400 | 4.572 | 20.564 |
| 20-S-A | MC-MS | MS | MC | A | 2 | Zn | 95.09 | 475.45 | 0.75 | 0.158 | 0.8 | 475.45 | 539.6358 | 0.096 | 0.0000056 | 86400 | 4.572 | 23.419 |
| 21-S-A | MC-MS | MS | MC | A | 3 | Zn | 101.2 | 506 | 0.75 | 0.158 | 0.8 | 506 | 574.31 | 0.096 | 0.0000056 | 86400 | 4.572 | 24.924 |
| 25-S-A | SED-CuS | CuS | SED | A | 1 | Zn | 80 | 400 | 0.75 | 0.158 | 0.8 | 400 | 454 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.702 |
| 26-S-A | SED-CuS | CuS | SED | A | 2 | Zn | 87 | 435 | 0.75 | 0.158 | 0.8 | 435 | 493.725 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.426 |
| 27-S-A | SED-CuS | CuS | SED | A | 3 | Zn | 115.9 | 579.5 | 0.75 | 0.158 | 0.8 | 579.5 | 657.7325 | 0.096 | 0.0000056 | 86400 | 4.572 | 28.544 |
| 28-S-A | MC-CuS | CuS | MC | A | 1 | Zn | 71.29 | 356.45 | 0.75 | 0.158 | 0.8 | 356.45 | 404.5708 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.557 |
| 29-S-A | MC-CuS | CuS | MC | A | 2 | Zn | 132.1 | 660.5 | 0.75 | 0.158 | 0.8 | 660.5 | 749.6675 | 0.096 | 0.0000056 | 86400 | 4.572 | 32.534 |
| 30-S-A | MC-CuS | CuS | MC | A | 3 | Zn | 95.31 | 476.55 | 0.75 | 0.158 | 0.8 | 476.55 | 540.8843 | 0.096 | 0.0000056 | 86400 | 4.572 | 23.473 |
| 7-S-B | SED-MS | MS | SED | B | 1 | Zn | 86.95 | 434.75 | 0.75 | 0.158 | 0.8 | 434.75 | 493.4413 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.414 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8-S-B | SED-MS | MS | SED | B | 2 | Zn | 87 | 434.75 | 0.75 | 0.158 | 0.8 | 434.75 | 493.4413 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.414 |
| 9-S- B | SED-MS | MS | SED | B | 3 | Zn | 91 | 455 | 0.75 | 0.158 | 0.8 | 455 | 516.425 | 0.096 | 0.0000056 | 86400 | 4.572 | 22.411 |
| 10-S-B | SC-MS | MS | SC | B | 1 | Zn | 86.4 | 432 | 0.75 | 0.158 | 0.8 | 432 | 490.32 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.279 |
| 11-S-B | SC-MS | MS | SC | B | 2 | Zn | 78.47 | 392.35 | 0.75 | 0.158 | 0.8 | 392.35 | 445.3173 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.326 |
| 12-S-B | SC-MS | MS | SC | B | 3 | Zn | 68.43 | 342.15 | 0.75 | 0.158 | 0.8 | 342.15 | 388.3403 | 0.096 | 0.0000056 | 86400 | 4.572 | 16.853 |
| 13-S-B | A-MS | MS | A | B | 1 | Zn | 76.72 | 383.6 | 0.75 | 0.158 | 0.8 | 383.6 | 435.386 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.895 |
| 14-S-B | A-MS | MS | A | B | 2 | Zn | 71.2 | 356 | 0.75 | 0.158 | 0.8 | 356 | 404.06 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.535 |
| 15-S-B | A-MS | MS | A | B | 3 | Zn | 84.96 | 424.8 | 0.75 | 0.158 | 0.8 | 424.8 | 482.148 | 0.096 | 0.0000056 | 86400 | 4.572 | 20.924 |
| 16-S-B | AC-MS | MS | AC | B | 1 | Zn | 68.84 | 344.2 | 0.75 | 0.158 | 0.8 | 344.2 | 390.667 | 0.096 | 0.0000056 | 86400 | 4.572 | 16.954 |
| 17-S-B | AC-MS | MS | AC | B | 2 | Zn | 52.43 | 262.15 | 0.75 | 0.158 | 0.8 | 262.15 | 297.5403 | 0.096 | 0.0000056 | 86400 | 4.572 | 12.912 |
| 18-S-B | AC-MS | MS | AC | B | 3 | Zn | 74.67 | 373.35 | 0.75 | 0.158 | 0.8 | 373.35 | 423.7523 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.390 |
| 19-S-B | MC-MS | MS | MC | B | 1 | Zn | 69.66 | 348.3 | 0.75 | 0.158 | 0.8 | 348.3 | 395.3205 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.156 |
| 20-S-B | MC-MS | MS | MC | B | 2 | Zn | 71.82 | 359.1 | 0.75 | 0.158 | 0.8 | 359.1 | 407.5785 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.688 |
| 21-S-B | MC-MS | MS | MC | B | 3 | Zn | 80.1 | 400.5 | 0.75 | 0.158 | 0.8 | 400.5 | 454.5675 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.727 |
| 25-S-B | SED-CuS | CuS | SED | B | 1 | Zn | 86.77 | 433.85 | 0.75 | 0.158 | 0.8 | 433.85 | 492.4198 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.370 |
| 26-S-B | SED-CuS | CuS | SED | B | 2 | Zn | 70.2 | 351 | 0.75 | 0.158 | 0.8 | 351 | 398.385 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.289 |
| 27-S-B | SED-CuS | CuS | SED | B | 3 | Zn | 98.5 | 492.5 | 0.75 | 0.158 | 0.8 | 492.5 | 558.9875 | 0.096 | 0.0000056 | 86400 | 4.572 | 24.259 |
| 28-S-B | MC-CuS | CuS | MC | B | 1 | Zn | 91.89 | 459.45 | 0.75 | 0.158 | 0.8 | 459.45 | 521.4758 | 0.096 | 0.0000056 | 86400 | 4.572 | 22.631 |
| 29-S-B | MC-CuS | CuS | MC | B | 2 | Zn | 94.77 | 473.85 | 0.75 | 0.158 | 0.8 | 473.85 | 537.8198 | 0.096 | 0.0000056 | 86400 | 4.572 | 23.340 |
| 30-S-B | MC-CuS | CuS | MC | B | 3 | Zn | 97.2 | 486 | 0.75 | 0.158 | 0.8 | 486 | 551.61 | 0.096 | 0.0000056 | 86400 | 4.572 | 23.938 |
| 7-S-C | SED-MS | MS | SED | C | 1 | Zn | 70.02 | 350.1 | 0.75 | 0.158 | 0.8 | 350.1 | 397.3635 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.245 |
| 8-S-C | SED-MS | MS | SED | C | 2 | Zn | 90.03 | 450.15 | 0.75 | 0.158 | 0.8 | 450.15 | 510.9203 | 0.096 | 0.0000056 | 86400 | 4.572 | 22.173 |
| 9-S-C | SED-MS | MS | SED | C | 3 | Zn | 77.03 | 385.15 | 0.75 | 0.158 | 0.8 | 385.15 | 437.1453 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.971 |
| 10-S-C | SC-MS | MS | SC | C | 1 | Zn | 79.09 | 395.45 | 0.75 | 0.158 | 0.8 | 395.45 | 448.8358 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.478 |
| 11-S-C | SC-MS | MS | SC | C | 2 | Zn | 84.75 | 423.75 | 0.75 | 0.158 | 0.8 | 423.75 | 480.9563 | 0.096 | 0.0000056 | 86400 | 4.572 | 20.872 |
| 12-S-C | SC-MS | MS | SC | C | 3 | Zn | 78.3 | 391.5 | 0.75 | 0.158 | 0.8 | 391.5 | 444.3525 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.284 |
| 13-S-C | A-MS | MS | A | C | 1 | Zn | 76.26 | 381.3 | 0.75 | 0.158 | 0.8 | 381.3 | 432.7755 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.781 |
| 14-S-C | A-MS | MS | A | C | 2 | Zn | 86.3 | 431.5 | 0.75 | 0.158 | 0.8 | 431.5 | 489.7525 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.254 |
| 15-S-C | A-MS | MS | A | C | 3 | Zn | 80.89 | 404.45 | 0.75 | 0.158 | 0.8 | 404.45 | 459.0508 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.922 |
| 16-S-C | AC-MS | MS | AC | C | 1 | Zn | 66.03 | 330.15 | 0.75 | 0.158 | 0.8 | 330.15 | 374.7203 | 0.096 | 0.0000056 | 86400 | 4.572 | 16.262 |
| 17-S-C | AC-MS | MS | AC | C | 2 | Zn | 75.76 | 378.8 | 0.75 | 0.158 | 0.8 | 378.8 | 429.938 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.658 |
| 18-S-C | AC-MS | MS | AC | C | 3 | Zn | 75.6 | 378 | 0.75 | 0.158 | 0.8 | 378 | 429.03 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.619 |
| 19-S-C | MC-MS | MS | MC | C | 1 | Zn | 94.3 | 471.5 | 0.75 | 0.158 | 0.8 | 471.5 | 535.1525 | 0.096 | 0.0000056 | 86400 | 4.572 | 23.224 |
| 20-S-C | MC-MS | MS | MC | C | 2 | Zn | 97.64 | 488.2 | 0.75 | 0.158 | 0.8 | 488.2 | 554.107 | 0.096 | 0.0000056 | 86400 | 4.572 | 24.047 |
| 21-S-C | MC-MS | MS | MC | C | 3 | Zn | 72.18 | 360.9 | 0.75 | 0.158 | 0.8 | 360.9 | 409.6215 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.776 |
| 25-S-C | SED-CuS | MS | SED | C | 1 | Zn | 77.5 | 387.5 | 0.75 | 0.158 | 0.8 | 387.5 | 439.8125 | 0.096 | 0.0000056 | 86400 | 4.572 | 19.087 |
| 26-S-C | SED-CuS | MS | SED | C | 2 | Zn | 69.12 | 345.6 | 0.75 | 0.158 | 0.8 | 345.6 | 392.256 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.023 |
| 27-S-C | SED-CuS | MS | SED | C | 3 | Zn | 86.6 | 433 | 0.75 | 0.158 | 0.8 | 433 | 491.455 | 0.096 | 0.0000056 | 86400 | 4.572 | 21.328 |
| 28-S-C | MC-CuS | CuS | MC | C | 1 | Zn | 75.69 | 378.45 | 0.75 | 0.158 | 0.8 | 378.45 | 429.5408 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.641 |
| 29-S-C | MC-CuS | CuS | MC | C | 2 | Zn | 73.87 | 369.35 | 0.75 | 0.158 | 0.8 | 369.35 | 419.2123 | 0.096 | 0.0000056 | 86400 | 4.572 | 18.193 |
| 30-S-C | MC-CuS | CuS | MC | C | 3 | Zn | 71.21 | 356.05 | 0.75 | 0.158 | 0.8 | 356.05 | 404.1168 | 0.096 | 0.0000056 | 86400 | 4.572 | 17.538 |
| 10-S-Cap | SC-MS | MS | SC | Cap | 1 | Cd | 21.666 | 108.33 | 0.75 | 0.158 | 0.8 | 108.33 | 122.9546 | 0.096 | 0.00000561 | 86400 | 4.572 | 5.326 |
| 11-S-Cap | SC-MS | MS | SC | Cap | 2 | Cd | 25.37 | 126.85 | 0.75 | 0.158 | 0.8 | 126.85 | 143.9748 | 0.096 | 0.00000561 | 86400 | 4.572 | 6.237 |
| 12-S-Cap | SC-MS | MS | SC | Cap | 3 | Cd | 23.09 | 115.45 | 0.75 | 0.158 | 0.8 | 115.45 | 131.0358 | 0.096 | 0.00000561 | 86400 | 4.572 | 5.676 |
| 13-S-Cap | A-MS | MS | A | Cap | 1 | Cd | 1.289 | 6.445 | 0.75 | 0.158 | 0.8 | 6.445 | 7.315075 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.317 |
| 14-S-Cap | A-MS | MS | A | Cap | 2 | Cd | 1.787 | 8.935 | 0.75 | 0.158 | 0.8 | 8.935 | 10.14123 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.439 |
| 15-S-Cap | A-MS | MS | A | Cap | 3 | Cd | 1.312 | 6.56 | 0.75 | 0.158 | 0.8 | 6.56 | 7.4456 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.323 |
| 19-S-Cap | MC-MS | MS | MC | Cap | 1 | Cd | 1.023 | 5.115 | 0.75 | 0.158 | 0.8 | 5.115 | 5.805525 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.251 |
| 20-S-Cap | MC-MS | MS | MC | Cap | 2 | Cd | 2.07 | 10.35 | 0.75 | 0.158 | 0.8 | 10.35 | 11.74725 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.509 |
| 21-S-Cap | MC-MS | MS | MC | Cap | 3 | Cd | 0.82 | 4.1 | 0.75 | 0.158 | 0.8 | 4.1 | 4.6535 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.202 |
| 28-S-Cap | MC-CuS | MS | MC | Cap | 1 | Cd | 0.94 | 4.7 | 0.75 | 0.158 | 0.8 | 4.7 | 5.3345 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.231 |
| 29-S-Cap | MC-CuS | MS | MC | Cap | 2 | Cd | 0.818 | 4.09 | 0.75 | 0.158 | 0.8 | 4.09 | 4.64215 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.201 |
| 30-S-Cap | MC-CuS | MS | MC | Cap | 3 | Cd | 0.948 | 4.74 | 0.75 | 0.158 | 0.8 | 4.74 | 5.3799 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.233 |
| 7-S-A | SED-MS | MS | SED | A | 1 | Cd | 2.533 | 12.665 | 0.75 | 0.158 | 0.8 | 12.665 | 14.37478 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.623 |
| 8-S-A | SED-MS | MS | SED | A | 2 | Cd | 2.718 | 13.59 | 0.75 | 0.158 | 0.8 | 13.59 | 15.42465 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.668 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9-S-A | SED-MS | MS | SED | A | 3 | Cd | 2.882 | 14.41 | 0.75 | 0.158 | 0.8 | 14.41 | 16.35535 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.709 |
| 10-S-A | SC-MS | MS | SC | A | 1 | Cd | 1.23 | 6.15 | 0.75 | 0.158 | 0.8 | 6.15 | 6.98025 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.302 |
| 11-S-A | SC-MS | MS | SC | A | 2 | Cd | 2.124 | 10.62 | 0.75 | 0.158 | 0.8 | 10.62 | 12.0537 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.522 |
| 12-S-A | SC-MS | MS | SC | A | 3 | Cd | 1.607 | 8.035 | 0.75 | 0.158 | 0.8 | 8.035 | 9.119725 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.395 |
| 13-S-A | A-MS | CuS | A | A | 1 | Cd | 1.115 | 5.575 | 0.75 | 0.158 | 0.8 | 5.575 | 6.327625 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.274 |
| 14-S-A | A-MS | CuS | A | A | 2 | Cd | 1.289 | 6.445 | 0.75 | 0.158 | 0.8 | 6.445 | 7.315075 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.317 |
| 15-S-A | A-MS | CuS | A | A | 3 | Cd | 1.248 | 6.24 | 0.75 | 0.158 | 0.8 | 6.24 | 7.0824 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.307 |
| 16-S-A | AC-MS | | AC | A | 1 | Cd | 0.88 | 4.41 | 0.75 | 0.158 | 0.8 | 4.41 | 5.00535 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.217 |
| 17-S-A | AC-MS | | AC | A | 2 | Cd | 0.84 | 4.19 | 0.75 | 0.158 | 0.8 | 4.19 | 4.75565 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.206 |
| 18-S-A | AC-MS | | AC | A | 3 | Cd | 0.97 | 4.86 | 0.75 | 0.158 | 0.8 | 4.86 | 5.5161 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.239 |
| 19-S-A | MC-MS | | MC | A | 1 | Cd | 1.047 | 5.235 | 0.75 | 0.158 | 0.8 | 5.235 | 5.941725 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.257 |
| 20-S-A | MC-MS | | MC | A | 2 | Cd | 1.388 | 6.94 | 0.75 | 0.158 | 0.8 | 6.94 | 7.8769 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.341 |
| 21-S-A | MC-MS | | MC | A | 3 | Cd | 0.875 | 4.375 | 0.75 | 0.158 | 0.8 | 4.375 | 4.965625 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.215 |
| 25-S-A | SED-CuS | | SED | A | 1 | Cd | 0.73 | 3.64 | 0.75 | 0.158 | 0.8 | 3.64 | 4.1314 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.179 |
| 26-S-A | SED-CuS | | SED | A | 2 | Cd | 0.67 | 3.365 | 0.75 | 0.158 | 0.8 | 3.365 | 3.819275 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.165 |
| 27-S-A | SED-CuS | | SED | A | 3 | Cd | 0.73 | 3.655 | 0.75 | 0.158 | 0.8 | 3.655 | 4.148425 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.180 |
| 28-S-A | MC-CuS | | MC | A | 1 | Cd | 1.071 | 5.355 | 0.75 | 0.158 | 0.8 | 5.355 | 6.077925 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.263 |
| 29-S-A | MC-CuS | | MC | A | 2 | Cd | 0.841 | 4.205 | 0.75 | 0.158 | 0.8 | 4.205 | 4.772675 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.207 |
| 30-S-A | MC-CuS | | MC | A | 3 | Cd | 0.862 | 4.31 | 0.75 | 0.158 | 0.8 | 4.31 | 4.89185 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.212 |
| 7-S-B | SED-MS | | SED | B | 1 | Cd | 2.825 | 14.125 | 0.75 | 0.158 | 0.8 | 14.125 | 16.03188 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.695 |
| 8-S-B | SED-MS | | SED | B | 2 | Cd | 2.83 | 14.125 | 0.75 | 0.158 | 0.8 | 14.125 | 16.03188 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.695 |
| 9-S- B | SED-MS | | SED | B | 3 | Cd | 2.37 | 11.835 | 0.75 | 0.158 | 0.8 | 11.835 | 13.43273 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.582 |
| 10-S-B | SC-MS | | SC | B | 1 | Cd | 0.927 | 4.635 | 0.75 | 0.158 | 0.8 | 4.635 | 5.260725 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.228 |
| 11-S-B | SC-MS | | SC | B | 2 | Cd | 1.666 | 8.33 | 0.75 | 0.158 | 0.8 | 8.33 | 9.45455 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.410 |
| 12-S-B | SC-MS | | SC | B | 3 | Cd | 1.298 | 6.49 | 0.75 | 0.158 | 0.8 | 6.49 | 7.36615 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.319 |
| 13-S-B | A-MS | | A | B | 1 | Cd | 1.119 | 5.595 | 0.75 | 0.158 | 0.8 | 5.595 | 6.350325 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.275 |
| 14-S-B | A-MS | | A | B | 2 | Cd | 0.991 | 4.955 | 0.75 | 0.158 | 0.8 | 4.955 | 5.623925 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.244 |
| 15-S-B | A-MS | | A | B | 3 | Cd | 0.982 | 4.91 | 0.75 | 0.158 | 0.8 | 4.91 | 5.57285 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.241 |
| 16-S-B | AC-MS | | AC | B | 1 | Cd | 0.83 | 4.15 | 0.75 | 0.158 | 0.8 | 4.15 | 4.71025 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.204 |
| 17-S-B | AC-MS | | AC | B | 2 | Cd | 0.886 | 4.43 | 0.75 | 0.158 | 0.8 | 4.43 | 5.02805 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.218 |
| 18-S-B | AC-MS | | AC | B | 3 | Cd | 0.917 | 4.585 | 0.75 | 0.158 | 0.8 | 4.585 | 5.203975 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.225 |
| 19-S-B | MC-MS | | MC | B | 1 | Cd | 1.235 | 6.175 | 0.75 | 0.158 | 0.8 | 6.175 | 7.008625 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.304 |
| 20-S-B | MC-MS | | MC | B | 2 | Cd | 1.042 | 5.21 | 0.75 | 0.158 | 0.8 | 5.21 | 5.91335 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.256 |
| 21-S-B | MC-MS | | MC | B | 3 | Cd | 0.754 | 3.77 | 0.75 | 0.158 | 0.8 | 3.77 | 4.27895 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.185 |
| 25-S-B | SED-CuS | | SED | B | 1 | Cd | 0.663 | 3.315 | 0.75 | 0.158 | 0.8 | 3.315 | 3.762525 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.163 |
| 26-S-B | SED-CuS | | SED | B | 2 | Cd | 0.751 | 3.755 | 0.75 | 0.158 | 0.8 | 3.755 | 4.261925 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.185 |
| 27-S-B | SED-CuS | | SED | B | 3 | Cd | 0.728 | 3.64 | 0.75 | 0.158 | 0.8 | 3.64 | 4.1314 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.179 |
| 28-S-B | MC-CuS | | MC | B | 1 | Cd | 0.868 | 4.34 | 0.75 | 0.158 | 0.8 | 4.34 | 4.9259 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.213 |
| 29-S-B | MC-CuS | | MC | B | 2 | Cd | 0.87 | 4.35 | 0.75 | 0.158 | 0.8 | 4.35 | 4.93725 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.214 |
| 30-S-B | MC-CuS | | MC | B | 3 | Cd | 0.715 | 3.575 | 0.75 | 0.158 | 0.8 | 3.575 | 4.057625 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.176 |
| 7-S-C | SED-MS | | SED | C | 1 | Cd | 2.485 | 12.425 | 0.75 | 0.158 | 0.8 | 12.425 | 14.10238 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.611 |
| 8-S-C | SED-MS | | SED | C | 2 | Cd | 1.827 | 9.135 | 0.75 | 0.158 | 0.8 | 9.135 | 10.36823 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.449 |
| 9-S-C | SED-MS | | SED | C | 3 | Cd | 1.912 | 9.56 | 0.75 | 0.158 | 0.8 | 9.56 | 10.8506 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.470 |
| 10-S-C | SC-MS | | SC | C | 1 | Cd | 0.885 | 4.425 | 0.75 | 0.158 | 0.8 | 4.425 | 5.022375 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.218 |
| 11-S-C | SC-MS | | SC | C | 2 | Cd | 1.361 | 6.805 | 0.75 | 0.158 | 0.8 | 6.805 | 7.723675 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.335 |
| 12-S-C | SC-MS | | SC | C | 3 | Cd | 0.757 | 3.785 | 0.75 | 0.158 | 0.8 | 3.785 | 4.295975 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.186 |
| 13-S-C | A-MS | | A | C | 1 | Cd | 0.942 | 4.71 | 0.75 | 0.158 | 0.8 | 4.71 | 5.34585 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.232 |
| 14-S-C | A-MS | | A | C | 2 | Cd | 1.489 | 7.445 | 0.75 | 0.158 | 0.8 | 7.445 | 8.450075 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.366 |
| 15-S-C | A-MS | | A | C | 3 | Cd | 1.087 | 5.435 | 0.75 | 0.158 | 0.8 | 5.435 | 6.168725 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.267 |
| 16-S-C | AC-MS | | AC | C | 1 | Cd | 0.755 | 3.775 | 0.75 | 0.158 | 0.8 | 3.775 | 4.284625 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.186 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17-S-C | AC-MS | AC | C | 2 | Cd | 0.825 | 4.125 | 0.75 | 0.158 | 0.8 | 4.125 | 4.681875 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.203 |
| 18-S-C | AC-MS | AC | C | 3 | Cd | 0.954 | 4.77 | 0.75 | 0.158 | 0.8 | 4.77 | 5.41395 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.235 |
| 19-S-C | MC-MS | MC | C | 1 | Cd | 1.185 | 5.925 | 0.75 | 0.158 | 0.8 | 5.925 | 6.724875 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.291 |
| 20-S-C | MC-MS | MC | C | 2 | Cd | 1.41 | 7.05 | 0.75 | 0.158 | 0.8 | 7.05 | 8.00175 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.347 |
| 21-S-C | MC-MS | MC | C | 3 | Cd | 0.999 | 4.995 | 0.75 | 0.158 | 0.8 | 4.995 | 5.669325 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.246 |
| 25-S-C | SED-CuS | SED | C | 1 | Cd | 0.743 | 3.715 | 0.75 | 0.158 | 0.8 | 3.715 | 4.216525 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.183 |
| 26-S-C | SED-CuS | SED | C | 2 | Cd | 0.78 | 3.9 | 0.75 | 0.158 | 0.8 | 3.9 | 4.4265 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.192 |
| 27-S-C | SED-CuS | SED | C | 3 | Cd | 0.711 | 3.555 | 0.75 | 0.158 | 0.8 | 3.555 | 4.034925 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.175 |
| 28-S-C | MC-CuS | MC | C | 1 | Cd | 0.744 | 3.72 | 0.75 | 0.158 | 0.8 | 3.72 | 4.2222 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.183 |
| 29-S-C | MC-CuS | MC | C | 2 | Cd | 1.054 | 5.27 | 0.75 | 0.158 | 0.8 | 5.27 | 5.98145 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.259 |
| 30-S-C | MC-CuS | MC | C | 3 | Cd | 0.819 | 4.095 | 0.75 | 0.158 | 0.8 | 4.095 | 4.647825 | 0.096 | 0.00000561 | 86400 | 4.572 | 0.201 |
| 10-S-Cap | SC-MS | SC | Cap | 1 | Pb | 4.973 | 24.865 | 0.75 | 0.158 | 0.8 | 24.865 | 28.22178 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.927 |
| 11-S-Cap | SC-MS | SC | Cap | 2 | Pb | 7.825 | 39.125 | 0.75 | 0.158 | 0.8 | 39.125 | 44.40688 | 0.096 | 0.0000074 | 86400 | 4.572 | 1.458 |
| 12-S-Cap | SC-MS | SC | Cap | 3 | Pb | 5.886 | 29.43 | 0.75 | 0.158 | 0.8 | 29.43 | 33.40305 | 0.096 | 0.0000074 | 86400 | 4.572 | 1.097 |
| 13-S-Cap | A-MS | A | Cap | 1 | Pb | 0.406 | 2.03 | 0.75 | 0.158 | 0.8 | 2.03 | 2.30405 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.076 |
| 14-S-Cap | A-MS | A | Cap | 2 | Pb | 0.557 | 2.785 | 0.75 | 0.158 | 0.8 | 2.785 | 3.160975 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.104 |
| 15-S-Cap | A-MS | A | Cap | 3 | Pb | 1.295 | 6.475 | 0.75 | 0.158 | 0.8 | 6.475 | 7.349125 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.241 |
| 19-S-Cap | MC-MS | MC | Cap | 1 | Pb | 0.65 | 3.25 | 0.75 | 0.158 | 0.8 | 3.25 | 3.68875 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.121 |
| 20-S-Cap | MC-MS | MC | Cap | 2 | Pb | 1.019 | 5.095 | 0.75 | 0.158 | 0.8 | 5.095 | 5.782825 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.190 |
| 21-S-Cap | MC-MS | MC | Cap | 3 | Pb | 0.575 | 2.875 | 0.75 | 0.158 | 0.8 | 2.875 | 3.263125 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.107 |
| 28-S-Cap | MC-CuS | MC | Cap | 1 | Pb | 0.421 | 2.105 | 0.75 | 0.158 | 0.8 | 2.105 | 2.389175 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.078 |
| 29-S-Cap | MC-CuS | MC | Cap | 2 | Pb | 0.979 | 4.895 | 0.75 | 0.158 | 0.8 | 4.895 | 5.555825 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.182 |
| 30-S-Cap | MC-CuS | MC | Cap | 3 | Pb | 0.232 | 1.16 | 0.75 | 0.158 | 0.8 | 1.16 | 1.3166 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.043 |
| 7-S-A | SED-MS | SED | A | 1 | Pb | 1.801 | 9.005 | 0.75 | 0.158 | 0.8 | 9.005 | 10.22068 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.336 |
| 8-S-A | SED-MS | SED | A | 2 | Pb | 1.998 | 9.99 | 0.75 | 0.158 | 0.8 | 9.99 | 11.33865 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.372 |
| 9-S-A | SED-MS | SED | A | 3 | Pb | 1.295 | 6.475 | 0.75 | 0.158 | 0.8 | 6.475 | 7.349125 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.241 |
| 10-S-A | SC-MS | SC | A | 1 | Pb | 1.441 | 7.205 | 0.75 | 0.158 | 0.8 | 7.205 | 8.177675 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.269 |
| 11-S-A | SC-MS | SC | A | 2 | Pb | 1.608 | 8.04 | 0.75 | 0.158 | 0.8 | 8.04 | 9.1254 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.300 |
| 12-S-A | SC-MS | SC | A | 3 | Pb | 1.126 | 5.63 | 0.75 | 0.158 | 0.8 | 5.63 | 6.39005 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.210 |
| 13-S-A | A-MS | A | A | 1 | Pb | 0.681 | 3.405 | 0.75 | 0.158 | 0.8 | 3.405 | 3.864675 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.127 |
| 14-S-A | A-MS | A | A | 2 | Pb | 1.194 | 5.97 | 0.75 | 0.158 | 0.8 | 5.97 | 6.77595 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.223 |
| 15-S-A | A-MS | A | A | 3 | Pb | 0.959 | 4.795 | 0.75 | 0.158 | 0.8 | 4.795 | 5.442325 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.179 |
| 16-S-A | AC-MS | AC | A | 1 | Pb | 0.577 | 2.885 | 0.75 | 0.158 | 0.8 | 2.885 | 3.274475 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.108 |
| 17-S-A | AC-MS | AC | A | 2 | Pb | 0.862 | 4.31 | 0.75 | 0.158 | 0.8 | 4.31 | 4.89185 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.161 |
| 18-S-A | AC-MS | AC | A | 3 | Pb | 0.86 | 4.31 | 0.75 | 0.158 | 0.8 | 4.31 | 4.89185 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.161 |
| 19-S-A | MC-MS | MC | A | 1 | Pb | 0.555 | 2.775 | 0.75 | 0.158 | 0.8 | 2.775 | 3.149625 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.103 |
| 20-S-A | MC-MS | MC | A | 2 | Pb | 1.095 | 5.475 | 0.75 | 0.158 | 0.8 | 5.475 | 6.214125 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.204 |
| 21-S-A | MC-MS | MC | A | 3 | Pb | 0.668 | 3.34 | 0.75 | 0.158 | 0.8 | 3.34 | 3.7909 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.124 |
| 25-S-A | SED-CuS | SED | A | 1 | Pb | 0.792 | 3.96 | 0.75 | 0.158 | 0.8 | 3.96 | 4.4946 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.148 |
| 26-S-A | SED-CuS | SED | A | 2 | Pb | 0.79 | 3.96 | 0.75 | 0.158 | 0.8 | 3.96 | 4.4946 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.148 |
| 27-S-A | SED-CuS | SED | A | 3 | Pb | 0.524 | 2.62 | 0.75 | 0.158 | 0.8 | 2.62 | 2.9737 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.098 |
| 28-S-A | MC-CuS | MC | A | 1 | Pb | 0.263 | 1.315 | 0.75 | 0.158 | 0.8 | 1.315 | 1.492525 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.049 |
| 29-S-A | MC-CuS | MC | A | 2 | Pb | 0.616 | 3.08 | 0.75 | 0.158 | 0.8 | 3.08 | 3.4958 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.115 |
| 30-S-A | MC-CuS | MC | A | 3 | Pb | 0.336 | 1.68 | 0.75 | 0.158 | 0.8 | 1.68 | 1.9068 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.063 |
| 7-S-B | SED-MS | SED | B | 1 | Pb | 0.52 | 2.62 | 0.75 | 0.158 | 0.8 | 2.62 | 2.9737 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.098 |
| 8-S-B | SED-MS | SED | B | 2 | Pb | 0.45 | 2.265 | 0.75 | 0.158 | 0.8 | 2.265 | 2.570775 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.084 |
| 9-S- B | SED-MS | SED | B | 3 | Pb | 0.67 | 3.355 | 0.75 | 0.158 | 0.8 | 3.355 | 3.807925 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.125 |
| 10-S-B | SC-MS | SC | B | 1 | Pb | 0.606 | 3.03 | 0.75 | 0.158 | 0.8 | 3.03 | 3.43905 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.113 |
| 11-S-B | SC-MS | SC | B | 2 | Pb | 0.731 | 3.655 | 0.75 | 0.158 | 0.8 | 3.655 | 4.148425 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.136 |
| 12-S-B | SC-MS | SC | B | 3 | Pb | 0.458 | 2.29 | 0.75 | 0.158 | 0.8 | 2.29 | 2.59915 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.085 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13-S-B | A-MS | A | B | 1 | Pb | 0.35 | 1.75 | 0.75 | 0.158 | 0.8 | 1.75 | 1.98625 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.065 |
| 14-S-B | A-MS | A | B | 2 | Pb | 0.379 | 1.895 | 0.75 | 0.158 | 0.8 | 1.895 | 2.150825 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.071 |
| 15-S-B | A-MS | A | B | 3 | Pb | 0.605 | 3.025 | 0.75 | 0.158 | 0.8 | 3.025 | 3.433375 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.113 |
| 16-S-B | AC-MS | AC | B | 1 | Pb | 0.354 | 1.77 | 0.75 | 0.158 | 0.8 | 1.77 | 2.00895 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.066 |
| 17-S-B | AC-MS | AC | B | 2 | Pb | 0.496 | 2.48 | 0.75 | 0.158 | 0.8 | 2.48 | 2.8148 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.092 |
| 18-S-B | AC-MS | AC | B | 3 | Pb | 0.588 | 2.94 | 0.75 | 0.158 | 0.8 | 2.94 | 3.3369 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.110 |
| 19-S-B | MC-MS | MC | B | 1 | Pb | 0.324 | 1.62 | 0.75 | 0.158 | 0.8 | 1.62 | 1.8387 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.060 |
| 20-S-B | MC-MS | MC | B | 2 | Pb | 0.44 | 2.2 | 0.75 | 0.158 | 0.8 | 2.2 | 2.497 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.082 |
| 21-S-B | MC-MS | MC | B | 3 | Pb | 0.556 | 2.78 | 0.75 | 0.158 | 0.8 | 2.78 | 3.1553 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.104 |
| 25-S-B | SED-CuS | SED | B | 1 | Pb | 0.798 | 3.99 | 0.75 | 0.158 | 0.8 | 3.99 | 4.52865 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.149 |
| 26-S-B | SED-CuS | SED | B | 2 | Pb | 0.692 | 3.46 | 0.75 | 0.158 | 0.8 | 3.46 | 3.9271 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.129 |
| 27-S-B | SED-CuS | SED | B | 3 | Pb | 0.534 | 2.67 | 0.75 | 0.158 | 0.8 | 2.67 | 3.03045 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.100 |
| 28-S-B | MC-CuS | MC | B | 1 | Pb | 0.728 | 3.64 | 0.75 | 0.158 | 0.8 | 3.64 | 4.1314 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.136 |
| 29-S-B | MC-CuS | MC | B | 2 | Pb | 0.668 | 3.34 | 0.75 | 0.158 | 0.8 | 3.34 | 3.7909 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.124 |
| 30-S-B | MC-CuS | MC | B | 3 | Pb | 0.654 | 3.27 | 0.75 | 0.158 | 0.8 | 3.27 | 3.71145 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.122 |
| 7-S-C | SED-MS | SED | C | 1 | Pb | 0.693 | 3.465 | 0.75 | 0.158 | 0.8 | 3.465 | 3.932775 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.129 |
| 8-S-C | SED-MS | SED | C | 2 | Pb | 0.416 | 2.08 | 0.75 | 0.158 | 0.8 | 2.08 | 2.3608 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.078 |
| 9-S-C | SED-MS | SED | C | 3 | Pb | 1.01 | 5.05 | 0.75 | 0.158 | 0.8 | 5.05 | 5.73175 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.188 |
| 10-S-C | SC-MS | SC | C | 1 | Pb | 0.498 | 2.49 | 0.75 | 0.158 | 0.8 | 2.49 | 2.82615 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.093 |
| 11-S-C | SC-MS | SC | C | 2 | Pb | 0.858 | 4.29 | 0.75 | 0.158 | 0.8 | 4.29 | 4.86915 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.160 |
| 12-S-C | SC-MS | SC | C | 3 | Pb | 0.366 | 1.83 | 0.75 | 0.158 | 0.8 | 1.83 | 2.07705 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.068 |
| 13-S-C | A-MS | A | C | 1 | Pb | 0.675 | 3.375 | 0.75 | 0.158 | 0.8 | 3.375 | 3.830625 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.126 |
| 14-S-C | A-MS | A | C | 2 | Pb | 0.373 | 1.865 | 0.75 | 0.158 | 0.8 | 1.865 | 2.116775 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.070 |
| 15-S-C | A-MS | A | C | 3 | Pb | 0.448 | 2.24 | 0.75 | 0.158 | 0.8 | 2.24 | 2.5424 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.083 |
| 16-S-C | AC-MS | AC | C | 1 | Pb | 0.30 | 1.475 | 0.75 | 0.158 | 0.8 | 1.475 | 1.674125 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.055 |
| 17-S-C | AC-MS | AC | C | 2 | Pb | 0.58 | 2.885 | 0.75 | 0.158 | 0.8 | 2.885 | 3.274475 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.108 |
| 18-S-C | AC-MS | AC | C | 3 | Pb | 0.86 | 4.31 | 0.75 | 0.158 | 0.8 | 4.31 | 4.89185 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.161 |
| 19-S-C | MC-MS | MC | C | 1 | Pb | 0.365 | 1.825 | 0.75 | 0.158 | 0.8 | 1.825 | 2.071375 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.068 |
| 20-S-C | MC-MS | MC | C | 2 | Pb | 0.661 | 3.305 | 0.75 | 0.158 | 0.8 | 3.305 | 3.751175 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.123 |
| 21-S-C | MC-MS | MC | C | 3 | Pb | 0.517 | 2.585 | 0.75 | 0.158 | 0.8 | 2.585 | 2.933975 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.096 |
| 25-S-C | SED-CuS | SED | C | 1 | Pb | 0.238 | 1.19 | 0.75 | 0.158 | 0.8 | 1.19 | 1.35065 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.044 |
| 26-S-C | SED-CuS | SED | C | 2 | Pb | 0.876 | 4.38 | 0.75 | 0.158 | 0.8 | 4.38 | 4.9713 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.163 |
| 27-S-C | SED-CuS | SED | C | 3 | Pb | 0.414 | 2.07 | 0.75 | 0.158 | 0.8 | 2.07 | 2.34945 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.077 |
| 28-S-C | MC-CuS | MC | C | 1 | Pb | 0.212 | 1.06 | 0.75 | 0.158 | 0.8 | 1.06 | 1.2031 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.040 |
| 29-S-C | MC-CuS | MC | C | 2 | Pb | 0.595 | 2.975 | 0.75 | 0.158 | 0.8 | 2.975 | 3.376625 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.111 |
| 30-S-C | MC-CuS | MC | C | 3 | Pb | 0.631 | 3.155 | 0.75 | 0.158 | 0.8 | 3.155 | 3.580925 | 0.096 | 0.0000074 | 86400 | 4.572 | 0.118 |

Table A1.83. Mortality and survival of *Lumbriculus variegates* measured after one and ten days of exposure in each treatment in Experiment I and II (raw data). Experiment I: no sediment (Control-C-MS), uncapped sediment (SED-MS), sediment with sand caps (SC-MS), and sediment with active caps: apatite (A-MS) and mixed cap (MC-MS), and sediment treated in situ with activated carbon (AC-MS). Experiment II: no sediment (Control-C-CuS), uncapped sediment (SED-CuS), and sediment with mixed cap (MC-CuS).

| Treatment | Replicates | Mortality | | Survival | |
|---|---|---|---|---|---|
| | | After one day | After 10 days | After one day | After 10 days |
| | | % | % | % | % |
| C-MS | 4 | 9.4 | 24.7 | 90.6 | 75.3 |
| | 5 | 17.8 | 32.4 | 82.2 | 67.6 |
| | 6 | 2.3 | 33.1 | 97.7 | 66.9 |
| SED-MS | 7 | 11.9 | 42.6 | 88.1 | 57.4 |
| | 8 | 14.4 | none | 85.6 | none |
| | 9 | 2.5 | 59.9 | 97.5 | 40.1 |
| SC-MS | 10 | 17.5 | 28.0 | 82.5 | 72.0 |
| | 11 | 4.9 | 28.3 | 95.1 | 71.7 |
| | 12 | 36.4 | 31.8 | 63.6 | 68.2 |
| A-MS | 13 | 15.5 | 20.6 | 84.5 | 79.4 |
| | 14 | 6.1 | 2.1 | 93.9 | 97.9 |
| | 15 | 6.4 | 12.0 | 93.6 | 88.0 |
| AC-MS | 16 | 5.7 | 23.9 | 94.3 | 76.1 |
| | 17 | 0.0 | 31.3 | 100.0 | 68.7 |
| | 18 | 4.5 | 28.0 | 95.5 | 72.0 |
| MC-MS | 19 | 2.8 | 20.9 | 97.2 | 79.1 |
| | 20 | 4.0 | 8.5 | 96.0 | 91.5 |
| | 21 | 8.1 | 9.3 | 91.9 | 90.7 |
| C-CuS | 22 | 1.5 | 35.3 | 98.5 | 64.7 |
| | 23 | 12.6 | 39.9 | 87.4 | 60.1 |
| | 24 | 10.2 | 25.4 | 89.8 | 74.6 |
| SED-CuS | 25 | 14.5 | 25.2 | 85.5 | 74.8 |
| | 26 | 17.9 | 49.5 | 82.1 | 50.5 |
| | 27 | 13.1 | 29.4 | 86.9 | 70.6 |
| MC-CuS | 28 | 8.5 | 16.5 | 91.5 | 83.5 |
| | 29 | 9.1 | 7.1 | 90.9 | 92.9 |
| | 30 | 9.2 | 13.9 | 90.8 | 86.1 |

Table A1.84. Whole body metal concentrations (in mg/kg) *in Lumbriculus variegates* measured after ten days of exposure in each treatment in Experiment I and II and background (BG). Experiment I: metal spike solution (4-6), uncapped sediment (7-9), sediment with sand caps (10-12), and sediment with active caps: apatite (13-15) and mixed cap (19-20), and sediment treated in situ with activated carbon (16-18). Experiment II: uncapped sediment (25-27), and sediment with mixed cap (28-30), BG 1-3 -background, Rep – replicated measurements.

| Sample Id | Mass | Cu | Zn | As | Cd | Pb |
|---|---|---|---|---|---|---|
| | g | | | mg kg$^{-1}$ | | |
| 4-10 Day Worms | 0.258 | 86.42 | 193.55 | 2.25 | 55.30 | 154.08 |
| 5-10 Day Worms | 0.259 | 115.36 | 231.02 | 1.99 | 72.42 | 309.04 |
| 6-10 Day Worms | 0.25 | 105.92 | 206.65 | 1.67 | 51.21 | 192.14 |
| 7-10 Day Worms | 0.257 | 26.82 | 133.47 | 7.65 | 9.89 | 3.50 |
| 9-10 Day Worms | 0.25 | 26.26 | 135.87 | 9.02 | 9.98 | 4.21 |
| 10-10 Day Worms | 0.256 | 36.27 | 163.80 | 7.40 | 25.39 | 20.27 |
| 11-10 Day Worms | 0.254 | 27.56 | 157.42 | 7.32 | 13.44 | 9.64 |
| 12-10 Day Worms | 0.257 | 36.61 | 155.92 | 8.13 | 21.42 | 21.69 |
| 13-10 Day Worms | 0.253 | 21.56 | 136.02 | 4.30 | 1.26 | 1.15 |
| 14-10 Day Worms | 0.254 | 20.64 | 141.23 | 5.14 | 1.32 | 1.21 |
| 15-10 Day Worms | 0.255 | 22.39 | 138.93 | 4.06 | 1.35 | 1.14 |
| 16-10 Day Worms | 0.259 | 22.62 | 139.28 | 6.88 | 3.71 | 3.02 |
| 18-10 Day Worms | 0.257 | 25.93 | 144.77 | 5.70 | 6.45 | 6.22 |
| 19-10 Day Worms | 0.25 | 20.91 | 144.59 | 4.19 | 0.67 | 0.57 |
| 20-10 Day Worms | 0.258 | 23.18 | 144.28 | 3.54 | 0.79 | 0.89 |
| 21-10 Day Worms | 0.25 | 21.22 | 128.93 | 2.75 | 0.74 | 0.80 |
| 23-10 Day Worms | 0.253 | 105.22 | 141.39 | 1.02 | 0.57 | 0.88 |
| 24-10 Day Worms | 0.255 | 112.33 | 156.00 | 0.89 | 0.49 | 0.81 |
| 25-10 Day Worms | 0.253 | 25.34 | 138.91 | 1.18 | 0.80 | 1.55 |
| BG3 10-Day | 0.258 | 17.92 | 134.63 | 0.78 | 0.11 | 0.21 |
| BG2 10-Day | 0.258 | 17.14 | 130.53 | 0.72 | 0.08 | 0.23 |
| BG1 10-Day | 0.255 | 17.63 | 133.03 | 0.80 | 0.11 | 0.21 |
| 27-10 Day Worms | 0.259 | 21.32 | 135.89 | 0.88 | 0.52 | 0.53 |
| 28-10 Day Worms | 0.259 | 21.32 | 144.00 | 0.95 | 0.46 | 0.41 |
| 29-10 Day Worms | 0.253 | 21.05 | 141.84 | 0.95 | 0.54 | 0.40 |
| 30-10 Day Worms | 0.253 | 19.34 | 131.74 | 0.74 | 0.30 | 0.37 |
| 29-10 Day Worms Rep. | 0.258 | 21.16 | 140.45 | 0.90 | 0.53 | 0.40 |
| 14-10 Day Worms Rep. | 0.256 | 20.76 | 138.25 | 5.07 | 1.24 | 1.17 |

Table A1.85. Metal concentrations in pore water (PW) experimental mesocosms with different treatments (A = apatite cap, SED = uncapped sediment) and presence (B) or absence (NB) of bioturbation.

| ID | Tank | Treatment | Bioturbation | Replicate | Element | µg $L^{-1}$ |
|---|---|---|---|---|---|---|
| 1-PW | 1 | SED | NB | 1 | Ni | 18.255 |
| 2-PW | 2 | SED | NB | 2 | Ni | 22.139 |
| 3-PW | 3 | SED | NB | 3 | Ni | 16.981 |
| 4-PW | 4 | A | NB | 1 | Ni | 5.272 |
| 5-PW | 5 | A | NB | 2 | Ni | 3.887 |
| 6-PW | 6 | A | NB | 3 | Ni | 7.095 |
| 7-PW | 7 | SED | B | 1 | Ni | 40.320 |
| 8-PW | 8 | SED | B | 2 | Ni | 14.320 |
| 9-PW | 9 | SED | B | 3 | Ni | 12.301 |
| 10-PW | 10 | A | B | 1 | Ni | 3.927 |
| 11-PW | 11 | A | B | 2 | Ni | 4.893 |
| 12-PW | 12 | A | B | 3 | Ni | 3.656 |
| 1-PW | 1 | SED | NB | 1 | Cu | 1.807 |
| 2-PW | 2 | SED | NB | 2 | Cu | 4.172 |
| 3-PW | 3 | SED | NB | 3 | Cu | 1.794 |
| 4-PW | 4 | A | NB | 1 | Cu | 1.471 |
| 5-PW | 5 | A | NB | 2 | Cu | 0.835 |
| 6-PW | 6 | A | NB | 3 | Cu | 1.317 |
| 7-PW | 7 | SED | B | 1 | Cu | 4.941 |
| 8-PW | 8 | SED | B | 2 | Cu | 6.854 |
| 9-PW | 9 | SED | B | 3 | Cu | 9.500 |
| 10-PW | 10 | A | B | 1 | Cu | 0.651 |
| 11-PW | 11 | A | B | 2 | Cu | 1.258 |
| 12-PW | 12 | A | B | 3 | Cu | 1.982 |
| 1-PW | 1 | SED | NB | 1 | Zn | 58.232 |
| 2-PW | 2 | SED | NB | 2 | Zn | 65.589 |
| 3-PW | 3 | SED | NB | 3 | Zn | 71.999 |
| 4-PW | 4 | A | NB | 1 | Zn | 51.779 |
| 5-PW | 5 | A | NB | 2 | Zn | 36.764 |
| 6-PW | 6 | A | NB | 3 | Zn | 35.633 |
| 7-PW | 7 | SED | B | 1 | Zn | 91.256 |
| 8-PW | 8 | SED | B | 2 | Zn | 62.086 |
| 9-PW | 9 | SED | B | 3 | Zn | 62.086 |
| 10-PW | 10 | A | B | 1 | Zn | 41.496 |
| 11-PW | 11 | A | B | 2 | Zn | 39.345 |
| 12-PW | 12 | A | B | 3 | Zn | 43.583 |

Table A1.85 (continued).

| ID | Tank | Treatment | Bioturbation | Replicate | Element | µg $L^{-1}$ |
|---|---|---|---|---|---|---|
| 1-PW | 1 | SED | NB | 1 | Cd | 3.038 |
| 2-PW | 2 | SED | NB | 2 | Cd | 7.547 |
| 3-PW | 3 | SED | NB | 3 | Cd | 2.264 |
| 4-PW | 4 | A | NB | 1 | Cd | 0.769 |
| 5-PW | 5 | A | NB | 2 | Cd | 0.598 |
| 6-PW | 6 | A | NB | 3 | Cd | 1.140 |
| 7-PW | 7 | SED | B | 1 | Cd | 6.193 |
| 8-PW | 8 | SED | B | 2 | Cd | 2.275 |
| 9-PW | 9 | SED | B | 3 | Cd | 3.520 |
| 10-PW | 10 | A | B | 1 | Cd | 0.614 |
| 11-PW | 11 | A | B | 2 | Cd | 0.742 |
| 12-PW | 12 | A | B | 3 | Cd | 1.108 |
| 1-PW | 1 | SED | NB | 1 | Pb | 1.428 |
| 2-PW | 2 | SED | NB | 2 | Pb | 2.281 |
| 3-PW | 3 | SED | NB | 3 | Pb | 1.551 |
| 4-PW | 4 | A | NB | 1 | Pb | 0.908 |
| 5-PW | 5 | A | NB | 2 | Pb | 0.503 |
| 6-PW | 6 | A | NB | 3 | Pb | 1.155 |
| 7-PW | 7 | SED | B | 1 | Pb | 3.522 |
| 8-PW | 8 | SED | B | 2 | Pb | 4.413 |
| 9-PW | 9 | SED | B | 3 | Pb | 5.945 |
| 10-PW | 10 | A | B | 1 | Pb | 0.355 |
| 11-PW | 11 | A | B | 2 | Pb | 0.736 |
| 12-PW | 12 | A | B | 3 | Pb | 0.957 |
| 1-PW | 1 | SED | NB | 1 | As | 0.758 |
| 2-PW | 2 | SED | NB | 2 | As | 1.031 |
| 3-PW | 3 | SED | NB | 3 | As | 0.705 |
| 4-PW | 4 | A | NB | 1 | As | 2.145 |
| 5-PW | 5 | A | NB | 2 | As | 2.019 |
| 6-PW | 6 | A | NB | 3 | As | 2.397 |
| 7-PW | 7 | SED | B | 1 | As | 3.238 |
| 8-PW | 8 | SED | B | 2 | As | 1.573 |
| 9-PW | 9 | SED | B | 3 | As | 2.033 |
| 10-PW | 10 | A | B | 1 | As | 2.225 |
| 11-PW | 11 | A | B | 2 | As | 2.384 |
| 12-PW | 12 | A | B | 3 | As | 2.726 |

Table A1.86. Total and filtered metal concentrations in the surface water (SW) of experimental mesocosms with different treatments (A = apatite cap, SED = uncapped sediment) and presence (B) or absence (NB) of bioturbation (raw data).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 10-2SW | 10 | A | B | 1 | As | 4.18 | 17.85 |
| 10-3SW | 10 | A | B | 24 | As | 3.83 | 28.72 |
| 10-5SW | 10 | A | B | 264 | As | 12.76 | 5.08 |
| 10-6SW | 10 | A | B | 432 | As | 5.83 | 5.81 |
| 10-7SW | 10 | A | B | 600 | As | 6.43 | 6.57 |
| 10-8SW | 10 | A | B | 696 | As | 6.13 | 6.54 |
| 10-4SW | 10 | A | B | 96 | As | 4.65 | 4.34 |
| 11-2SW | 11 | A | B | 1 | As | 3.04 | 28.84 |
| 11-3SW | 11 | A | B | 24 | As | 3.52 | 12.04 |
| 11-5SW | 11 | A | B | 264 | As | 9.72 | 5.89 |
| 11-6SW | 11 | A | B | 432 | As | 6.57 | 7.04 |
| 11-7SW | 11 | A | B | 600 | As | 7.35 | 7.74 |
| 11-8SW | 11 | A | B | 696 | As | 6.88 | 7.31 |
| 11-4SW | 11 | A | B | 96 | As | 3.72 | 4.33 |
| 12-2SW | 12 | A | B | 1 | As | 9.12 | 15.37 |
| 12-3SW | 12 | A | B | 24 | As | 4.77 | 13.69 |
| 12-5SW | 12 | A | B | 264 | As | 5.56 | 6.30 |
| 12-6SW | 12 | A | B | 432 | As | 7.30 | 7.83 |
| 12-7SW | 12 | A | B | 600 | As | 8.74 | 9.14 |
| 12-8SW | 12 | A | B | 696 | As | 7.92 | 8.65 |
| 12-4SW | 12 | A | B | 96 | As | 5.29 | 5.57 |
| 4-2SW | 4 | A | NB | 1 | As | 3.53 | 40.66 |
| 4-3SW | 4 | A | NB | 24 | As | 3.71 | 10.97 |
| 4-5SW | 4 | A | NB | 264 | As | 9.84 | 3.58 |
| 4-6SW | 4 | A | NB | 432 | As | 3.20 | 4.29 |
| 4-7SW | 4 | A | NB | 600 | As | 3.99 | 4.07 |
| 4-8SW | 4 | A | NB | 696 | As | 3.95 | 4.36 |
| 4-4SW | 4 | A | NB | 96 | As | 3.62 | 3.91 |
| 5-2SW | 5 | A | NB | 1 | As | 3.98 | 12.11 |
| 5-3SW | 5 | A | NB | 24 | As | 3.68 | 41.19 |
| 5-5SW | 5 | A | NB | 264 | As | 9.95 | 3.78 |
| 5-6SW | 5 | A | NB | 432 | As | 3.73 | 4.02 |
| 5-7SW | 5 | A | NB | 600 | As | 5.27 | 4.96 |
| 5-8SW | 5 | A | NB | 696 | As | 5.21 | 5.43 |
| 5-4SW | 5 | A | NB | 96 | As | 3.79 | 4.11 |
| 6-2SW | 6 | A | NB | 1 | As | 3.28 | 15.10 |
| 6-3SW | 6 | A | NB | 24 | As | 4.17 | 23.19 |
| 6-5SW | 6 | A | NB | 264 | As | 8.50 | 4.00 |
| 6-6SW | 6 | A | NB | 432 | As | 3.33 | 3.64 |
| 6-7SW | 6 | A | NB | 600 | As | 4.17 | 4.03 |
| 6-8SW | 6 | A | NB | 696 | As | 4.12 | 4.63 |
| 6-4SW | 6 | A | NB | 96 | As | 3.92 | 3.78 |
| 7-2SW | 7 | SED | B | 1 | As | 2.96 | 12.10 |
| 7-3SW | 7 | SED | B | 24 | As | 2.28 | 17.18 |
| 7-5SW | 7 | SED | B | 264 | As | 13.87 | 8.89 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 7-6SW | 7 | SED | B | 432 | As | 8.35 | 8.73 |
| 7-7SW | 7 | SED | B | 600 | As | 7.38 | 7.94 |
| 7-8SW | 7 | SED | B | 696 | As | 7.06 | 7.15 |
| 7-4SW | 7 | SED | B | 96 | As | 2.39 | 1.93 |
| 8-2SW | 8 | SED | B | 1 | As | 2.16 | 8.01 |
| 8-3SW | 8 | SED | B | 24 | As | 1.81 | 17.67 |
| 8-5SW | 8 | SED | B | 264 | As | 10.04 | 8.49 |
| 8-6SW | 8 | SED | B | 432 | As | 8.75 | 10.83 |
| 8-7SW | 8 | SED | B | 600 | As | 9.48 | 9.25 |
| 8-8SW | 8 | SED | B | 696 | As | 8.11 | 8.60 |
| 8-4SW | 8 | SED | B | 96 | As | 2.32 | 2.25 |
| 9-2SW | 9 | SED | B | 1 | As | 2.19 | 9.02 |
| 9-3SW | 9 | SED | B | 24 | As | 2.00 | 7.52 |
| 9-5SW | 9 | SED | B | 264 | As | 9.47 | 6.37 |
| 9-6SW | 9 | SED | B | 432 | As | 7.06 | 7.88 |
| 9-7SW | 9 | SED | B | 600 | As | 8.10 | 8.20 |
| 9-8SW | 9 | SED | B | 696 | As | 7.49 | 8.31 |
| 9-4SW | 9 | SED | B | 96 | As | 1.76 | 2.23 |
| 1-2SW | 1 | SED | NB | 1 | As | 2.42 | 10.67 |
| 1-3SW | 1 | SED | NB | 24 | As | 2.05 | 25.15 |
| 1-5SW | 1 | SED | NB | 264 | As | 7.33 | 1.69 |
| 1-6SW | 1 | SED | NB | 432 | As | 1.80 | 1.79 |
| 1-7SW | 1 | SED | NB | 600 | As | 2.47 | 2.81 |
| 1-8SW | 1 | SED | NB | 696 | As | 2.50 | 2.51 |
| 1-4SW | 1 | SED | NB | 96 | As | 2.14 | 1.63 |
| 2-2SW | 2 | SED | NB | 1 | As | 1.66 | 9.81 |
| 2-3SW | 2 | SED | NB | 24 | As | 2.01 | 7.30 |
| 2-5SW | 2 | SED | NB | 264 | As | 8.35 | 2.02 |
| 2-6SW | 2 | SED | NB | 432 | As | 1.54 | 1.86 |
| 2-7SW | 2 | SED | NB | 600 | As | 2.68 | 2.94 |
| 2-8SW | 2 | SED | NB | 696 | As | 2.67 | 3.23 |
| 2-4SW | 2 | SED | NB | 96 | As | 1.61 | 1.81 |
| 3-2SW | 3 | SED | NB | 1 | As | 2.04 | 7.44 |
| 3-3SW | 3 | SED | NB | 24 | As | 3.20 | 12.75 |
| 3-5SW | 3 | SED | NB | 264 | As | 7.38 | 1.69 |
| 3-6SW | 3 | SED | NB | 432 | As | 1.73 | 1.93 |
| 3-7SW | 3 | SED | NB | 600 | As | 2.62 | 2.78 |
| 3-8SW | 3 | SED | NB | 696 | As | 2.84 | 3.09 |
| 3-4SW | 3 | SED | NB | 96 | As | 1.57 | 2.20 |
| 10-2SW | 10 | A | B | 1 | Ca | 121.46 | 122.78 |
| 10-3SW | 10 | A | B | 24 | Ca | 125.47 | 127.69 |
| 10-5SW | 10 | A | B | 264 | Ca | 97.14 | 96.17 |
| 10-6SW | 10 | A | B | 432 | Ca | 80.95 | 83.89 |
| 10-7SW | 10 | A | B | 600 | Ca | 74.40 | 75.84 |
| 10-8SW | 10 | A | B | 696 | Ca | 70.79 | 69.29 |
| 10-4SW | 10 | A | B | 96 | Ca | 105.97 | 108.30 |
| 11-2SW | 11 | A | B | 1 | Ca | 117.22 | 116.84 |
| 11-3SW | 11 | A | B | 24 | Ca | 117.92 | 120.90 |
| 11-5SW | 11 | A | B | 264 | Ca | 105.29 | 102.93 |
| 11-6SW | 11 | A | B | 432 | Ca | 88.10 | 88.37 |

Table A1.86. (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 11-7SW | 11 | A | B | 600 | Ca | 78.33 | 78.96 |
| 11-8SW | 11 | A | B | 696 | Ca | 73.66 | 73.87 |
| 11-4SW | 11 | A | B | 96 | Ca | 104.96 | 106.14 |
| 12-2SW | 12 | A | B | 1 | Ca | 118.58 | 118.71 |
| 12-3SW | 12 | A | B | 24 | Ca | 126.76 | 129.23 |
| 12-5SW | 12 | A | B | 264 | Ca | 98.97 | 96.11 |
| 12-6SW | 12 | A | B | 432 | Ca | 83.19 | 84.03 |
| 12-7SW | 12 | A | B | 600 | Ca | 75.78 | 75.43 |
| 12-8SW | 12 | A | B | 696 | Ca | 67.07 | 67.85 |
| 12-4SW | 12 | A | B | 96 | Ca | 113.80 | 115.52 |
| 4-2SW | 4 | A | NB | 1 | Ca | 119.99 | 123.35 |
| 4-3SW | 4 | A | NB | 24 | Ca | 127.34 | 131.15 |
| 4-5SW | 4 | A | NB | 264 | Ca | 82.61 | 79.29 |
| 4-6SW | 4 | A | NB | 432 | Ca | 58.23 | 58.98 |
| 4-7SW | 4 | A | NB | 600 | Ca | 47.13 | 46.69 |
| 4-8SW | 4 | A | NB | 696 | Ca | 42.54 | 42.66 |
| 4-4SW | 4 | A | NB | 96 | Ca | 105.51 | 109.44 |
| 5-2SW | 5 | A | NB | 1 | Ca | 109.99 | 112.64 |
| 5-3SW | 5 | A | NB | 24 | Ca | 116.04 | 120.41 |
| 5-5SW | 5 | A | NB | 264 | Ca | 74.14 | 71.35 |
| 5-6SW | 5 | A | NB | 432 | Ca | 52.76 | 53.12 |
| 5-7SW | 5 | A | NB | 600 | Ca | 42.30 | 40.91 |
| 5-8SW | 5 | A | NB | 696 | Ca | 37.82 | 38.44 |
| 5-4SW | 5 | A | NB | 96 | Ca | 100.93 | 101.90 |
| 6-2SW | 6 | A | NB | 1 | Ca | 110.14 | 112.10 |
| 6-3SW | 6 | A | NB | 24 | Ca | 118.41 | 118.52 |
| 6-5SW | 6 | A | NB | 264 | Ca | 77.97 | 75.50 |
| 6-6SW | 6 | A | NB | 432 | Ca | 55.69 | 56.34 |
| 6-7SW | 6 | A | NB | 600 | Ca | 47.25 | 45.13 |
| 6-8SW | 6 | A | NB | 696 | Ca | 41.82 | 42.97 |
| 6-4SW | 6 | A | NB | 96 | Ca | 102.57 | 101.91 |
| 7-2SW | 7 | SED | B | 1 | Ca | 28.02 | 28.13 |
| 7-3SW | 7 | SED | B | 24 | Ca | 30.40 | 31.59 |
| 7-5SW | 7 | SED | B | 264 | Ca | 27.62 | 29.47 |
| 7-6SW | 7 | SED | B | 432 | Ca | 26.26 | 27.35 |
| 7-7SW | 7 | SED | B | 600 | Ca | 26.11 | 27.11 |
| 7-8SW | 7 | SED | B | 696 | Ca | 25.09 | 25.70 |
| 7-4SW | 7 | SED | B | 96 | Ca | 25.65 | 29.44 |
| 8-2SW | 8 | SED | B | 1 | Ca | 33.53 | 32.60 |
| 8-3SW | 8 | SED | B | 24 | Ca | 36.19 | 36.92 |
| 8-5SW | 8 | SED | B | 264 | Ca | 32.80 | 34.08 |
| 8-6SW | 8 | SED | B | 432 | Ca | 30.38 | 30.72 |
| 8-7SW | 8 | SED | B | 600 | Ca | 29.42 | 30.04 |
| 8-8SW | 8 | SED | B | 696 | Ca | 28.94 | 29.12 |
| 8-4SW | 8 | SED | B | 96 | Ca | 33.35 | 34.61 |
| 9-2SW | 9 | SED | B | 1 | Ca | 28.75 | 27.92 |
| 9-3SW | 9 | SED | B | 24 | Ca | 31.30 | 33.10 |
| 9-5SW | 9 | SED | B | 264 | Ca | 30.44 | 30.79 |
| 9-6SW | 9 | SED | B | 432 | Ca | 29.77 | 30.52 |
| 9-7SW | 9 | SED | B | 600 | Ca | 29.83 | 31.06 |

Table A1.86. (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 9-8SW | 9 | SED | B | 696 | Ca | 29.46 | 30.42 |
| 9-4SW | 9 | SED | B | 96 | Ca | 29.74 | 30.14 |
| 1-2SW | 1 | SED | NB | 1 | Ca | 27.29 | 28.35 |
| 1-3SW | 1 | SED | NB | 24 | Ca | 31.52 | 33.76 |
| 1-5SW | 1 | SED | NB | 264 | Ca | 20.26 | 20.95 |
| 1-6SW | 1 | SED | NB | 432 | Ca | 16.56 | 16.63 |
| 1-7SW | 1 | SED | NB | 600 | Ca | 13.63 | 13.27 |
| 1-8SW | 1 | SED | NB | 696 | Ca | 12.36 | 12.59 |
| 1-4SW | 1 | SED | NB | 96 | Ca | 25.07 | 28.21 |
| 2-2SW | 2 | SED | NB | 1 | Ca | 26.41 | 27.39 |
| 2-3SW | 2 | SED | NB | 24 | Ca | 29.87 | 30.50 |
| 2-5SW | 2 | SED | NB | 264 | Ca | 19.47 | 19.65 |
| 2-6SW | 2 | SED | NB | 432 | Ca | 15.03 | 15.68 |
| 2-7SW | 2 | SED | NB | 600 | Ca | 12.54 | 12.71 |
| 2-8SW | 2 | SED | NB | 696 | Ca | 11.67 | 11.84 |
| 2-4SW | 2 | SED | NB | 96 | Ca | 26.82 | 26.78 |
| 3-2SW | 3 | SED | NB | 1 | Ca | 28.32 | 28.48 |
| 3-3SW | 3 | SED | NB | 24 | Ca | 32.32 | 32.95 |
| 3-5SW | 3 | SED | NB | 264 | Ca | 21.79 | 21.63 |
| 3-6SW | 3 | SED | NB | 432 | Ca | 16.62 | 17.39 |
| 3-7SW | 3 | SED | NB | 600 | Ca | 13.47 | 13.67 |
| 3-8SW | 3 | SED | NB | 696 | Ca | 12.61 | 12.67 |
| 3-4SW | 3 | SED | NB | 96 | Ca | 28.52 | 28.77 |
| 10-2SW | 10 | A | B | 1 | Cd | 68.25 | 117.82 |
| 10-3SW | 10 | A | B | 24 | Cd | 31.35 | 56.54 |
| 10-5SW | 10 | A | B | 264 | Cd | 3.63 | 2.65 |
| 10-6SW | 10 | A | B | 432 | Cd | 1.79 | 3.14 |
| 10-7SW | 10 | A | B | 600 | Cd | 1.06 | 1.48 |
| 10-8SW | 10 | A | B | 696 | Cd | 0.99 | 1.24 |
| 10-4SW | 10 | A | B | 96 | Cd | 12.83 | 17.69 |
| 11-2SW | 11 | A | B | 1 | Cd | 81.41 | 117.37 |
| 11-3SW | 11 | A | B | 24 | Cd | 42.24 | 54.76 |
| 11-5SW | 11 | A | B | 264 | Cd | 5.03 | 3.91 |
| 11-6SW | 11 | A | B | 432 | Cd | 2.00 | 2.85 |
| 11-7SW | 11 | A | B | 600 | Cd | 1.14 | 1.49 |
| 11-8SW | 11 | A | B | 696 | Cd | 1.23 | 1.52 |
| 11-4SW | 11 | A | B | 96 | Cd | 22.16 | 27.23 |
| 12-2SW | 12 | A | B | 1 | Cd | 53.21 | 78.84 |
| 12-3SW | 12 | A | B | 24 | Cd | 12.04 | 21.07 |
| 12-5SW | 12 | A | B | 264 | Cd | 2.81 | 2.27 |
| 12-6SW | 12 | A | B | 432 | Cd | 1.53 | 2.13 |
| 12-7SW | 12 | A | B | 600 | Cd | 1.56 | 2.03 |
| 12-8SW | 12 | A | B | 696 | Cd | 1.25 | 1.57 |
| 12-4SW | 12 | A | B | 96 | Cd | 8.89 | 6.84 |
| 4-2SW | 4 | A | NB | 1 | Cd | 70.48 | 126.21 |
| 4-3SW | 4 | A | NB | 24 | Cd | 37.79 | 46.31 |
| 4-5SW | 4 | A | NB | 264 | Cd | 18.08 | 26.65 |
| 4-6SW | 4 | A | NB | 432 | Cd | 13.03 | 18.67 |
| 4-7SW | 4 | A | NB | 600 | Cd | 7.39 | 9.24 |
| 4-8SW | 4 | A | NB | 696 | Cd | 6.33 | 7.50 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 4-4SW | 4 | A | NB | 96 | Cd | 28.42 | 39.80 |
| 5-2SW | 5 | A | NB | 1 | Cd | 61.13 | 107.70 |
| 5-3SW | 5 | A | NB | 24 | Cd | 30.62 | 79.49 |
| 5-5SW | 5 | A | NB | 264 | Cd | 8.92 | 15.73 |
| 5-6SW | 5 | A | NB | 432 | Cd | 5.56 | 8.33 |
| 5-7SW | 5 | A | NB | 600 | Cd | 2.40 | 3.07 |
| 5-8SW | 5 | A | NB | 696 | Cd | 2.03 | 2.53 |
| 5-4SW | 5 | A | NB | 96 | Cd | 25.06 | 28.29 |
| 6-2SW | 6 | A | NB | 1 | Cd | 76.72 | 101.42 |
| 6-3SW | 6 | A | NB | 24 | Cd | 36.57 | 63.04 |
| 6-5SW | 6 | A | NB | 264 | Cd | 16.33 | 23.35 |
| 6-6SW | 6 | A | NB | 432 | Cd | 11.19 | 15.03 |
| 6-7SW | 6 | A | NB | 600 | Cd | 5.79 | 7.40 |
| 6-8SW | 6 | A | NB | 696 | Cd | 4.17 | 4.87 |
| 6-4SW | 6 | A | NB | 96 | Cd | 31.10 | 36.00 |
| 7-2SW | 7 | SED | B | 1 | Cd | 84.99 | 166.56 |
| 7-3SW | 7 | SED | B | 24 | Cd | 131.82 | 202.40 |
| 7-5SW | 7 | SED | B | 264 | Cd | 7.97 | 4.75 |
| 7-6SW | 7 | SED | B | 432 | Cd | 1.45 | 2.94 |
| 7-7SW | 7 | SED | B | 600 | Cd | 1.72 | 2.86 |
| 7-8SW | 7 | SED | B | 696 | Cd | 1.71 | 2.22 |
| 7-4SW | 7 | SED | B | 96 | Cd | 46.73 | 86.60 |
| 8-2SW | 8 | SED | B | 1 | Cd | 110.27 | 199.16 |
| 8-3SW | 8 | SED | B | 24 | Cd | 176.48 | 240.57 |
| 8-5SW | 8 | SED | B | 264 | Cd | 8.11 | 4.30 |
| 8-6SW | 8 | SED | B | 432 | Cd | 2.01 | 4.02 |
| 8-7SW | 8 | SED | B | 600 | Cd | 1.66 | 2.59 |
| 8-8SW | 8 | SED | B | 696 | Cd | 2.20 | 2.46 |
| 8-4SW | 8 | SED | B | 96 | Cd | 91.45 | 113.07 |
| 9-2SW | 9 | SED | B | 1 | Cd | 106.24 | 157.33 |
| 9-3SW | 9 | SED | B | 24 | Cd | 128.66 | 187.64 |
| 9-5SW | 9 | SED | B | 264 | Cd | 11.05 | 9.63 |
| 9-6SW | 9 | SED | B | 432 | Cd | 1.48 | 2.94 |
| 9-7SW | 9 | SED | B | 600 | Cd | 1.28 | 2.20 |
| 9-8SW | 9 | SED | B | 696 | Cd | 1.48 | 1.74 |
| 9-4SW | 9 | SED | B | 96 | Cd | 90.28 | 96.42 |
| 1-2SW | 1 | SED | NB | 1 | Cd | 106.18 | 163.44 |
| 1-3SW | 1 | SED | NB | 24 | Cd | 146.58 | 203.25 |
| 1-5SW | 1 | SED | NB | 264 | Cd | 47.21 | 102.40 |
| 1-6SW | 1 | SED | NB | 432 | Cd | 24.94 | 64.25 |
| 1-7SW | 1 | SED | NB | 600 | Cd | 24.68 | 37.23 |
| 1-8SW | 1 | SED | NB | 696 | Cd | 22.84 | 29.72 |
| 1-4SW | 1 | SED | NB | 96 | Cd | 105.53 | 163.12 |
| 2-2SW | 2 | SED | NB | 1 | Cd | 112.89 | 159.10 |
| 2-3SW | 2 | SED | NB | 24 | Cd | 132.04 | 183.48 |
| 2-5SW | 2 | SED | NB | 264 | Cd | 47.73 | 90.56 |
| 2-6SW | 2 | SED | NB | 432 | Cd | 11.10 | 56.73 |
| 2-7SW | 2 | SED | NB | 600 | Cd | 16.51 | 29.03 |
| 2-8SW | 2 | SED | NB | 696 | Cd | 17.14 | 23.35 |
| 2-4SW | 2 | SED | NB | 96 | Cd | 134.15 | 152.95 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 3-2SW | 3 | SED | NB | 1 | Cd | 130.23 | 168.78 |
| 3-3SW | 3 | SED | NB | 24 | Cd | 141.83 | 205.80 |
| 3-5SW | 3 | SED | NB | 264 | Cd | 58.87 | 104.68 |
| 3-6SW | 3 | SED | NB | 432 | Cd | 23.40 | 67.38 |
| 3-7SW | 3 | SED | NB | 600 | Cd | 26.11 | 36.69 |
| 3-8SW | 3 | SED | NB | 696 | Cd | 23.12 | 29.67 |
| 3-4SW | 3 | SED | NB | 96 | Cd | 155.13 | 167.62 |
| 10-2SW | 10 | A | B | 1 | Cr | 0.56 | 9.52 |
| 10-3SW | 10 | A | B | 24 | Cr | 0.49 | 13.67 |
| 10-5SW | 10 | A | B | 264 | Cr | 0.76 | 1.78 |
| 10-6SW | 10 | A | B | 432 | Cr | <MDL | 0.03 |
| 10-7SW | 10 | A | B | 600 | Cr | <MDL | <MDL |
| 10-8SW | 10 | A | B | 696 | Cr | <MDL | 0.03 |
| 10-4SW | 10 | A | B | 96 | Cr | 0.98 | 0.67 |
| 11-2SW | 11 | A | B | 1 | Cr | 0.50 | 13.54 |
| 11-3SW | 11 | A | B | 24 | Cr | 0.34 | 3.73 |
| 11-5SW | 11 | A | B | 264 | Cr | 0.70 | 0.65 |
| 11-6SW | 11 | A | B | 432 | Cr | <MDL | 0.07 |
| 11-7SW | 11 | A | B | 600 | Cr | <MDL | <MDL |
| 11-8SW | 11 | A | B | 696 | Cr | <MDL | 0.03 |
| 11-4SW | 11 | A | B | 96 | Cr | 0.46 | 0.48 |
| 12-2SW | 12 | A | B | 1 | Cr | 0.68 | 6.88 |
| 12-3SW | 12 | A | B | 24 | Cr | 0.47 | 5.25 |
| 12-5SW | 12 | A | B | 264 | Cr | 0.78 | 1.04 |
| 12-6SW | 12 | A | B | 432 | Cr | <MDL | 0.09 |
| 12-7SW | 12 | A | B | 600 | Cr | <MDL | 0.03 |
| 12-8SW | 12 | A | B | 696 | Cr | <MDL | 0.03 |
| 12-4SW | 12 | A | B | 96 | Cr | 0.70 | 0.97 |
| 4-2SW | 4 | A | NB | 1 | Cr | 0.54 | 22.65 |
| 4-3SW | 4 | A | NB | 24 | Cr | 0.40 | 3.45 |
| 4-5SW | 4 | A | NB | 264 | Cr | 0.66 | 1.15 |
| 4-6SW | 4 | A | NB | 432 | Cr | <MDL | 0.13 |
| 4-7SW | 4 | A | NB | 600 | Cr | <MDL | 0.02 |
| 4-8SW | 4 | A | NB | 696 | Cr | <MDL | <MDL |
| 4-4SW | 4 | A | NB | 96 | Cr | 2.15 | 4.30 |
| 5-2SW | 5 | A | NB | 1 | Cr | 0.52 | 4.49 |
| 5-3SW | 5 | A | NB | 24 | Cr | 0.39 | 23.39 |
| 5-5SW | 5 | A | NB | 264 | Cr | 0.63 | 0.72 |
| 5-6SW | 5 | A | NB | 432 | Cr | <MDL | <MDL |
| 5-7SW | 5 | A | NB | 600 | Cr | <MDL | 0.03 |
| 5-8SW | 5 | A | NB | 696 | Cr | <MDL | <MDL |
| 5-4SW | 5 | A | NB | 96 | Cr | 2.41 | 1.41 |
| 6-2SW | 6 | A | NB | 1 | Cr | 0.46 | 6.60 |
| 6-3SW | 6 | A | NB | 24 | Cr | 0.39 | 11.34 |
| 6-5SW | 6 | A | NB | 264 | Cr | 0.81 | 0.77 |
| 6-6SW | 6 | A | NB | 432 | Cr | <MDL | <MDL |
| 6-7SW | 6 | A | NB | 600 | Cr | <MDL | <MDL |
| 6-8SW | 6 | A | NB | 696 | Cr | <MDL | <MDL |
| 6-4SW | 6 | A | NB | 96 | Cr | 2.79 | 0.55 |
| 7-2SW | 7 | SED | B | 1 | Cr | 0.19 | 7.71 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 7-3SW | 7 | SED | B | 24 | Cr | 0.22 | 11.29 |
| 7-5SW | 7 | SED | B | 264 | Cr | 0.74 | 0.97 |
| 7-6SW | 7 | SED | B | 432 | Cr | <MDL | 0.05 |
| 7-7SW | 7 | SED | B | 600 | Cr | <MDL | 0.03 |
| 7-8SW | 7 | SED | B | 696 | Cr | <MDL | <MDL |
| 7-4SW | 7 | SED | B | 96 | Cr | 0.66 | 0.36 |
| 8-2SW | 8 | SED | B | 1 | Cr | 0.16 | 5.04 |
| 8-3SW | 8 | SED | B | 24 | Cr | 0.25 | 12.90 |
| 8-5SW | 8 | SED | B | 264 | Cr | 0.40 | 0.75 |
| 8-6SW | 8 | SED | B | 432 | Cr | <MDL | 0.20 |
| 8-7SW | 8 | SED | B | 600 | Cr | <MDL | 0.06 |
| 8-8SW | 8 | SED | B | 696 | Cr | <MDL | <MDL |
| 8-4SW | 8 | SED | B | 96 | Cr | 2.23 | 0.58 |
| 9-2SW | 9 | SED | B | 1 | Cr | 0.73 | 5.49 |
| 9-3SW | 9 | SED | B | 24 | Cr | 0.22 | 3.67 |
| 9-5SW | 9 | SED | B | 264 | Cr | 0.34 | 0.83 |
| 9-6SW | 9 | SED | B | 432 | Cr | <MDL | 0.06 |
| 9-7SW | 9 | SED | B | 600 | Cr | <MDL | 0.05 |
| 9-8SW | 9 | SED | B | 696 | Cr | <MDL | 0.02 |
| 9-4SW | 9 | SED | B | 96 | Cr | 1.09 | 0.32 |
| 1-2SW | 1 | SED | NB | 1 | Cr | 0.17 | 8.65 |
| 1-3SW | 1 | SED | NB | 24 | Cr | 0.25 | 20.84 |
| 1-5SW | 1 | SED | NB | 264 | Cr | 0.81 | 0.45 |
| 1-6SW | 1 | SED | NB | 432 | Cr | <MDL | <MDL |
| 1-7SW | 1 | SED | NB | 600 | Cr | <MDL | <MDL |
| 1-8SW | 1 | SED | NB | 696 | Cr | <MDL | <MDL |
| 1-4SW | 1 | SED | NB | 96 | Cr | 0.50 | 0.61 |
| 2-2SW | 2 | SED | NB | 1 | Cr | 0.13 | 6.02 |
| 2-3SW | 2 | SED | NB | 24 | Cr | 0.27 | 3.43 |
| 2-5SW | 2 | SED | NB | 264 | Cr | 0.34 | 0.50 |
| 2-6SW | 2 | SED | NB | 432 | Cr | <MDL | <MDL |
| 2-7SW | 2 | SED | NB | 600 | Cr | <MDL | 0.02 |
| 2-8SW | 2 | SED | NB | 696 | Cr | <MDL | 0.02 |
| 2-4SW | 2 | SED | NB | 96 | Cr | 0.42 | 15.67 |
| 3-2SW | 3 | SED | NB | 1 | Cr | 0.15 | 3.57 |
| 3-3SW | 3 | SED | NB | 24 | Cr | 0.21 | 7.44 |
| 3-5SW | 3 | SED | NB | 264 | Cr | 0.84 | 13.89 |
| 3-6SW | 3 | SED | NB | 432 | Cr | <MDL | <MDL |
| 3-7SW | 3 | SED | NB | 600 | Cr | <MDL | 0.02 |
| 3-8SW | 3 | SED | NB | 696 | Cr | <MDL | <MDL |
| 3-4SW | 3 | SED | NB | 96 | Cr | 0.52 | 2.06 |
| 10-2SW | 10 | A | B | 1 | Cu | 2.25 | 24.39 |
| 10-3SW | 10 | A | B | 24 | Cu | 2.57 | 40.71 |
| 10-5SW | 10 | A | B | 264 | Cu | 2.34 | 2.10 |
| 10-6SW | 10 | A | B | 432 | Cu | 2.04 | 2.11 |
| 10-7SW | 10 | A | B | 600 | Cu | 2.08 | 1.69 |
| 10-8SW | 10 | A | B | 696 | Cu | 2.35 | 1.71 |
| 10-4SW | 10 | A | B | 96 | Cu | 1.78 | 2.16 |
| 11-2SW | 11 | A | B | 1 | Cu | 2.31 | 38.72 |
| 11-3SW | 11 | A | B | 24 | Cu | 2.89 | 12.12 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 11-5SW | 11 | A | B | 264 | Cu | 2.47 | 1.89 |
| 11-6SW | 11 | A | B | 432 | Cu | 2.26 | 2.76 |
| 11-7SW | 11 | A | B | 600 | Cu | 2.08 | 1.91 |
| 11-8SW | 11 | A | B | 696 | Cu | 1.93 | 2.04 |
| 11-4SW | 11 | A | B | 96 | Cu | 1.78 | 2.49 |
| 12-2SW | 12 | A | B | 1 | Cu | 2.32 | 17.91 |
| 12-3SW | 12 | A | B | 24 | Cu | 2.15 | 17.37 |
| 12-5SW | 12 | A | B | 264 | Cu | 1.47 | 2.02 |
| 12-6SW | 12 | A | B | 432 | Cu | 2.22 | 3.14 |
| 12-7SW | 12 | A | B | 600 | Cu | 2.74 | 2.60 |
| 12-8SW | 12 | A | B | 696 | Cu | 1.95 | 1.97 |
| 12-4SW | 12 | A | B | 96 | Cu | 1.45 | 2.53 |
| 4-2SW | 4 | A | NB | 1 | Cu | 2.24 | 71.84 |
| 4-3SW | 4 | A | NB | 24 | Cu | 2.86 | 13.57 |
| 4-5SW | 4 | A | NB | 264 | Cu | 2.18 | 1.65 |
| 4-6SW | 4 | A | NB | 432 | Cu | 1.61 | 2.39 |
| 4-7SW | 4 | A | NB | 600 | Cu | 1.49 | 1.54 |
| 4-8SW | 4 | A | NB | 696 | Cu | 1.39 | 1.36 |
| 4-4SW | 4 | A | NB | 96 | Cu | 1.90 | 3.49 |
| 5-2SW | 5 | A | NB | 1 | Cu | 1.98 | 13.24 |
| 5-3SW | 5 | A | NB | 24 | Cu | 2.55 | 82.88 |
| 5-5SW | 5 | A | NB | 264 | Cu | 2.08 | 1.63 |
| 5-6SW | 5 | A | NB | 432 | Cu | 1.44 | 1.43 |
| 5-7SW | 5 | A | NB | 600 | Cu | 1.44 | 1.54 |
| 5-8SW | 5 | A | NB | 696 | Cu | 1.29 | 1.24 |
| 5-4SW | 5 | A | NB | 96 | Cu | 1.88 | 2.12 |
| 6-2SW | 6 | A | NB | 1 | Cu | 2.21 | 17.33 |
| 6-3SW | 6 | A | NB | 24 | Cu | 2.61 | 36.94 |
| 6-5SW | 6 | A | NB | 264 | Cu | 2.10 | 3.15 |
| 6-6SW | 6 | A | NB | 432 | Cu | 1.44 | 1.36 |
| 6-7SW | 6 | A | NB | 600 | Cu | 1.33 | 1.57 |
| 6-8SW | 6 | A | NB | 696 | Cu | 1.41 | 2.00 |
| 6-4SW | 6 | A | NB | 96 | Cu | 1.88 | 2.09 |
| 7-2SW | 7 | SED | B | 1 | Cu | 2.74 | 37.97 |
| 7-3SW | 7 | SED | B | 24 | Cu | 4.79 | 53.86 |
| 7-5SW | 7 | SED | B | 264 | Cu | 4.51 | 5.48 |
| 7-6SW | 7 | SED | B | 432 | Cu | 3.99 | 4.58 |
| 7-7SW | 7 | SED | B | 600 | Cu | 4.30 | 3.54 |
| 7-8SW | 7 | SED | B | 696 | Cu | 3.62 | 3.18 |
| 7-4SW | 7 | SED | B | 96 | Cu | 1.47 | 2.82 |
| 8-2SW | 8 | SED | B | 1 | Cu | 2.86 | 30.36 |
| 8-3SW | 8 | SED | B | 24 | Cu | 6.20 | 58.47 |
| 8-5SW | 8 | SED | B | 264 | Cu | 3.90 | 4.12 |
| 8-6SW | 8 | SED | B | 432 | Cu | 4.62 | 6.68 |
| 8-7SW | 8 | SED | B | 600 | Cu | 4.35 | 4.76 |
| 8-8SW | 8 | SED | B | 696 | Cu | 4.05 | 3.95 |
| 8-4SW | 8 | SED | B | 96 | Cu | 1.81 | 2.14 |
| 9-2SW | 9 | SED | B | 1 | Cu | 2.92 | 26.26 |
| 9-3SW | 9 | SED | B | 24 | Cu | 5.46 | 33.02 |
| 9-5SW | 9 | SED | B | 264 | Cu | 3.84 | 2.94 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 9-6SW | 9 | SED | B | 432 | Cu | 3.23 | 3.76 |
| 9-7SW | 9 | SED | B | 600 | Cu | 3.72 | 3.53 |
| 9-8SW | 9 | SED | B | 696 | Cu | 3.14 | 3.27 |
| 9-4SW | 9 | SED | B | 96 | Cu | 1.95 | 2.50 |
| 1-2SW | 1 | SED | NB | 1 | Cu | 2.63 | 35.47 |
| 1-3SW | 1 | SED | NB | 24 | Cu | 4.68 | 74.87 |
| 1-5SW | 1 | SED | NB | 264 | Cu | 2.51 | 2.78 |
| 1-6SW | 1 | SED | NB | 432 | Cu | 1.35 | 1.69 |
| 1-7SW | 1 | SED | NB | 600 | Cu | 1.32 | 1.34 |
| 1-8SW | 1 | SED | NB | 696 | Cu | 1.15 | 1.20 |
| 1-4SW | 1 | SED | NB | 96 | Cu | 3.47 | 11.64 |
| 2-2SW | 2 | SED | NB | 1 | Cu | 2.91 | 31.30 |
| 2-3SW | 2 | SED | NB | 24 | Cu | 5.06 | 28.84 |
| 2-5SW | 2 | SED | NB | 264 | Cu | 2.30 | 2.53 |
| 2-6SW | 2 | SED | NB | 432 | Cu | 1.14 | 1.70 |
| 2-7SW | 2 | SED | NB | 600 | Cu | 1.64 | 1.51 |
| 2-8SW | 2 | SED | NB | 696 | Cu | 1.17 | 1.31 |
| 2-4SW | 2 | SED | NB | 96 | Cu | 4.82 | 21.42 |
| 3-2SW | 3 | SED | NB | 1 | Cu | 3.05 | 25.03 |
| 3-3SW | 3 | SED | NB | 24 | Cu | 6.97 | 37.90 |
| 3-5SW | 3 | SED | NB | 264 | Cu | 3.14 | 3.78 |
| 3-6SW | 3 | SED | NB | 432 | Cu | 1.48 | 1.75 |
| 3-7SW | 3 | SED | NB | 600 | Cu | 1.32 | 1.50 |
| 3-8SW | 3 | SED | NB | 696 | Cu | 1.23 | 1.29 |
| 3-4SW | 3 | SED | NB | 96 | Cu | 5.16 | 11.24 |
| 10-2SW | 10 | A | B | 1 | Fe | 0.01 | 2.11 |
| 10-3SW | 10 | A | B | 24 | Fe | 0.01 | 4.12 |
| 10-5SW | 10 | A | B | 264 | Fe | 0.01 | 0.02 |
| 10-6SW | 10 | A | B | 432 | Fe | 1.15 | 14.26 |
| 10-7SW | 10 | A | B | 600 | Fe | 0.66 | 1.79 |
| 10-8SW | 10 | A | B | 696 | Fe | <MDL | 1.35 |
| 10-4SW | 10 | A | B | 96 | Fe | <MDL | 0.03 |
| 11-2SW | 11 | A | B | 1 | Fe | <MDL | 3.56 |
| 11-3SW | 11 | A | B | 24 | Fe | <MDL | 0.93 |
| 11-5SW | 11 | A | B | 264 | Fe | <MDL | 0.01 |
| 11-6SW | 11 | A | B | 432 | Fe | 0.92 | 6.44 |
| 11-7SW | 11 | A | B | 600 | Fe | 1.01 | 2.04 |
| 11-8SW | 11 | A | B | 696 | Fe | 1.15 | 2.94 |
| 11-4SW | 11 | A | B | 96 | Fe | <MDL | 0.02 |
| 12-2SW | 12 | A | B | 1 | Fe | <MDL | 1.59 |
| 12-3SW | 12 | A | B | 24 | Fe | <MDL | 1.40 |
| 12-5SW | 12 | A | B | 264 | Fe | <MDL | 0.05 |
| 12-6SW | 12 | A | B | 432 | Fe | 2.28 | 6.02 |
| 12-7SW | 12 | A | B | 600 | Fe | 0.58 | 2.62 |
| 12-8SW | 12 | A | B | 696 | Fe | <MDL | 1.02 |
| 12-4SW | 12 | A | B | 96 | Fe | <MDL | 0.09 |
| 4-2SW | 4 | A | NB | 1 | Fe | <MDL | 6.36 |
| 4-3SW | 4 | A | NB | 24 | Fe | <MDL | 0.91 |
| 4-5SW | 4 | A | NB | 264 | Fe | <MDL | 0.01 |
| 4-6SW | 4 | A | NB | 432 | Fe | 171.60 | 193.51 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 4-7SW | 4 | A | NB | 600 | Fe | 59.43 | 65.56 |
| 4-8SW | 4 | A | NB | 696 | Fe | 32.04 | 33.53 |
| 4-4SW | 4 | A | NB | 96 | Fe | 0.01 | 0.18 |
| 5-2SW | 5 | A | NB | 1 | Fe | 0.01 | 1.07 |
| 5-3SW | 5 | A | NB | 24 | Fe | <MDL | 5.78 |
| 5-5SW | 5 | A | NB | 264 | Fe | 0.01 | 0.02 |
| 5-6SW | 5 | A | NB | 432 | Fe | 17.66 | 22.56 |
| 5-7SW | 5 | A | NB | 600 | Fe | 1.28 | 1.96 |
| 5-8SW | 5 | A | NB | 696 | Fe | 0.56 | 0.94 |
| 5-4SW | 5 | A | NB | 96 | Fe | 0.01 | 0.04 |
| 6-2SW | 6 | A | NB | 1 | Fe | <MDL | 1.48 |
| 6-3SW | 6 | A | NB | 24 | Fe | <MDL | 3.14 |
| 6-5SW | 6 | A | NB | 264 | Fe | <MDL | 0.01 |
| 6-6SW | 6 | A | NB | 432 | Fe | 105.64 | 118.22 |
| 6-7SW | 6 | A | NB | 600 | Fe | 16.49 | 16.61 |
| 6-8SW | 6 | A | NB | 696 | Fe | 3.88 | 4.09 |
| 6-4SW | 6 | A | NB | 96 | Fe | 0.01 | 0.39 |
| 7-2SW | 7 | SED | B | 1 | Fe | 0.01 | 1.89 |
| 7-3SW | 7 | SED | B | 24 | Fe | <MDL | 2.77 |
| 7-5SW | 7 | SED | B | 264 | Fe | 0.04 | 0.49 |
| 7-6SW | 7 | SED | B | 432 | Fe | 2.80 | 11.42 |
| 7-7SW | 7 | SED | B | 600 | Fe | 3.83 | 8.28 |
| 7-8SW | 7 | SED | B | 696 | Fe | 3.71 | 5.82 |
| 7-4SW | 7 | SED | B | 96 | Fe | 0.01 | 0.20 |
| 8-2SW | 8 | SED | B | 1 | Fe | 0.01 | 1.08 |
| 8-3SW | 8 | SED | B | 24 | Fe | <MDL | 2.97 |
| 8-5SW | 8 | SED | B | 264 | Fe | 0.03 | 0.10 |
| 8-6SW | 8 | SED | B | 432 | Fe | 2.65 | 19.25 |
| 8-7SW | 8 | SED | B | 600 | Fe | 2.26 | 7.25 |
| 8-8SW | 8 | SED | B | 696 | Fe | 1.58 | 2.44 |
| 8-4SW | 8 | SED | B | 96 | Fe | 0.01 | 0.01 |
| 9-2SW | 9 | SED | B | 1 | Fe | 0.01 | 1.23 |
| 9-3SW | 9 | SED | B | 24 | Fe | <MDL | 0.88 |
| 9-5SW | 9 | SED | B | 264 | Fe | <MDL | 0.03 |
| 9-6SW | 9 | SED | B | 432 | Fe | 5.34 | 14.89 |
| 9-7SW | 9 | SED | B | 600 | Fe | 1.64 | 4.22 |
| 9-8SW | 9 | SED | B | 696 | Fe | 2.22 | 4.04 |
| 9-4SW | 9 | SED | B | 96 | Fe | 0.01 | 0.25 |
| 1-2SW | 1 | SED | NB | 1 | Fe | 0.01 | 1.90 |
| 1-3SW | 1 | SED | NB | 24 | Fe | <MDL | 5.39 |
| 1-5SW | 1 | SED | NB | 264 | Fe | 0.02 | <MDL |
| 1-6SW | 1 | SED | NB | 432 | Fe | 448.82 | 510.67 |
| 1-7SW | 1 | SED | NB | 600 | Fe | 314.80 | 356.40 |
| 1-8SW | 1 | SED | NB | 696 | Fe | 284.66 | 318.15 |
| 1-4SW | 1 | SED | NB | 96 | Fe | 0.01 | 0.09 |
| 2-2SW | 2 | SED | NB | 1 | Fe | 0.01 | 1.51 |
| 2-3SW | 2 | SED | NB | 24 | Fe | <MDL | 1.05 |
| 2-5SW | 2 | SED | NB | 264 | Fe | 0.01 | 0.05 |
| 2-6SW | 2 | SED | NB | 432 | Fe | 366.46 | 455.41 |
| 2-7SW | 2 | SED | NB | 600 | Fe | 264.12 | 319.61 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 2-8SW | 2 | SED | NB | 696 | Fe | 239.76 | 273.24 |
| 2-4SW | 2 | SED | NB | 96 | Fe | <MDL | 0.27 |
| 3-2SW | 3 | SED | NB | 1 | Fe | 0.01 | 0.78 |
| 3-3SW | 3 | SED | NB | 24 | Fe | <MDL | 1.67 |
| 3-5SW | 3 | SED | NB | 264 | Fe | 0.01 | 0.08 |
| 3-6SW | 3 | SED | NB | 432 | Fe | 450.09 | 533.10 |
| 3-7SW | 3 | SED | NB | 600 | Fe | 318.33 | 370.92 |
| 3-8SW | 3 | SED | NB | 696 | Fe | 294.96 | 323.16 |
| 3-4SW | 3 | SED | NB | 96 | Fe | <MDL | 0.07 |
| 10-2SW | 10 | A | B | 1 | Mg | 12.39 | 12.85 |
| 10-3SW | 10 | A | B | 24 | Mg | 12.83 | 12.94 |
| 10-5SW | 10 | A | B | 264 | Mg | 9.45 | 9.05 |
| 10-6SW | 10 | A | B | 432 | Mg | 7.03 | 7.35 |
| 10-7SW | 10 | A | B | 600 | Mg | 6.47 | 6.38 |
| 10-8SW | 10 | A | B | 696 | Mg | 6.14 | 5.90 |
| 10-4SW | 10 | A | B | 96 | Mg | 10.97 | 10.82 |
| 11-2SW | 11 | A | B | 1 | Mg | 12.74 | 13.29 |
| 11-3SW | 11 | A | B | 24 | Mg | 12.95 | 12.99 |
| 11-5SW | 11 | A | B | 264 | Mg | 10.95 | 10.32 |
| 11-6SW | 11 | A | B | 432 | Mg | 8.40 | 8.09 |
| 11-7SW | 11 | A | B | 600 | Mg | 7.09 | 7.00 |
| 11-8SW | 11 | A | B | 696 | Mg | 6.56 | 6.68 |
| 11-4SW | 11 | A | B | 96 | Mg | 11.48 | 11.37 |
| 12-2SW | 12 | A | B | 1 | Mg | 12.63 | 12.92 |
| 12-3SW | 12 | A | B | 24 | Mg | 12.99 | 12.92 |
| 12-5SW | 12 | A | B | 264 | Mg | 9.60 | 9.24 |
| 12-6SW | 12 | A | B | 432 | Mg | 7.65 | 7.53 |
| 12-7SW | 12 | A | B | 600 | Mg | 6.78 | 6.55 |
| 12-8SW | 12 | A | B | 696 | Mg | 5.90 | 6.01 |
| 12-4SW | 12 | A | B | 96 | Mg | 11.54 | 11.30 |
| 4-2SW | 4 | A | NB | 1 | Mg | 13.03 | 13.93 |
| 4-3SW | 4 | A | NB | 24 | Mg | 13.69 | 13.81 |
| 4-5SW | 4 | A | NB | 264 | Mg | 9.67 | 9.05 |
| 4-6SW | 4 | A | NB | 432 | Mg | 6.81 | 6.97 |
| 4-7SW | 4 | A | NB | 600 | Mg | 5.73 | 5.53 |
| 4-8SW | 4 | A | NB | 696 | Mg | 5.21 | 5.40 |
| 4-4SW | 4 | A | NB | 96 | Mg | 11.65 | 11.85 |
| 5-2SW | 5 | A | NB | 1 | Mg | 11.49 | 11.92 |
| 5-3SW | 5 | A | NB | 24 | Mg | 11.85 | 12.52 |
| 5-5SW | 5 | A | NB | 264 | Mg | 8.15 | 7.75 |
| 5-6SW | 5 | A | NB | 432 | Mg | 5.98 | 5.93 |
| 5-7SW | 5 | A | NB | 600 | Mg | 5.19 | 4.69 |
| 5-8SW | 5 | A | NB | 696 | Mg | 4.38 | 4.64 |
| 5-4SW | 5 | A | NB | 96 | Mg | 10.57 | 10.45 |
| 6-2SW | 6 | A | NB | 1 | Mg | 12.66 | 13.15 |
| 6-3SW | 6 | A | NB | 24 | Mg | 13.44 | 13.38 |
| 6-5SW | 6 | A | NB | 264 | Mg | 9.61 | 9.17 |
| 6-6SW | 6 | A | NB | 432 | Mg | 6.82 | 6.78 |
| 6-7SW | 6 | A | NB | 600 | Mg | 6.20 | 5.56 |
| 6-8SW | 6 | A | NB | 696 | Mg | 5.18 | 5.59 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 6-4SW | 6 | A | NB | 96 | Mg | 11.68 | 11.63 |
| 7-2SW | 7 | SED | B | 1 | Mg | 4.15 | 4.48 |
| 7-3SW | 7 | SED | B | 24 | Mg | 4.57 | 5.03 |
| 7-5SW | 7 | SED | B | 264 | Mg | 3.81 | 3.78 |
| 7-6SW | 7 | SED | B | 432 | Mg | 3.27 | 3.34 |
| 7-7SW | 7 | SED | B | 600 | Mg | 3.28 | 3.34 |
| 7-8SW | 7 | SED | B | 696 | Mg | 2.95 | 3.11 |
| 7-4SW | 7 | SED | B | 96 | Mg | 4.11 | 4.26 |
| 8-2SW | 8 | SED | B | 1 | Mg | 4.82 | 4.98 |
| 8-3SW | 8 | SED | B | 24 | Mg | 5.37 | 5.77 |
| 8-5SW | 8 | SED | B | 264 | Mg | 4.34 | 4.19 |
| 8-6SW | 8 | SED | B | 432 | Mg | 3.48 | 3.52 |
| 8-7SW | 8 | SED | B | 600 | Mg | 3.44 | 3.44 |
| 8-8SW | 8 | SED | B | 696 | Mg | 3.19 | 3.31 |
| 8-4SW | 8 | SED | B | 96 | Mg | 4.95 | 4.92 |
| 9-2SW | 9 | SED | B | 1 | Mg | 4.30 | 4.46 |
| 9-3SW | 9 | SED | B | 24 | Mg | 4.67 | 4.88 |
| 9-5SW | 9 | SED | B | 264 | Mg | 4.11 | 3.97 |
| 9-6SW | 9 | SED | B | 432 | Mg | 3.42 | 3.52 |
| 9-7SW | 9 | SED | B | 600 | Mg | 3.45 | 3.46 |
| 9-8SW | 9 | SED | B | 696 | Mg | 3.43 | 3.38 |
| 9-4SW | 9 | SED | B | 96 | Mg | 4.50 | 4.42 |
| 1-2SW | 1 | SED | NB | 1 | Mg | 4.19 | 4.50 |
| 1-3SW | 1 | SED | NB | 24 | Mg | 4.69 | 5.66 |
| 1-5SW | 1 | SED | NB | 264 | Mg | 3.61 | 3.59 |
| 1-6SW | 1 | SED | NB | 432 | Mg | 3.07 | 2.92 |
| 1-7SW | 1 | SED | NB | 600 | Mg | 2.71 | 2.49 |
| 1-8SW | 1 | SED | NB | 696 | Mg | 2.51 | 2.63 |
| 1-4SW | 1 | SED | NB | 96 | Mg | 4.18 | 4.29 |
| 2-2SW | 2 | SED | NB | 1 | Mg | 4.09 | 4.32 |
| 2-3SW | 2 | SED | NB | 24 | Mg | 4.52 | 4.59 |
| 2-5SW | 2 | SED | NB | 264 | Mg | 3.54 | 3.44 |
| 2-6SW | 2 | SED | NB | 432 | Mg | 2.88 | 2.89 |
| 2-7SW | 2 | SED | NB | 600 | Mg | 2.60 | 2.52 |
| 2-8SW | 2 | SED | NB | 696 | Mg | 2.45 | 2.55 |
| 2-4SW | 2 | SED | NB | 96 | Mg | 4.26 | 4.15 |
| 3-2SW | 3 | SED | NB | 1 | Mg | 4.39 | 4.49 |
| 3-3SW | 3 | SED | NB | 24 | Mg | 4.83 | 5.06 |
| 3-5SW | 3 | SED | NB | 264 | Mg | 3.83 | 3.63 |
| 3-6SW | 3 | SED | NB | 432 | Mg | 3.06 | 3.17 |
| 3-7SW | 3 | SED | NB | 600 | Mg | 2.68 | 2.62 |
| 3-8SW | 3 | SED | NB | 696 | Mg | 2.57 | 2.63 |
| 3-4SW | 3 | SED | NB | 96 | Mg | 4.44 | 4.41 |
| 10-2SW | 10 | A | B | 1 | Mn | 910.41 | 1162.33 |
| 10-3SW | 10 | A | B | 24 | Mn | 878.15 | 989.84 |
| 10-5SW | 10 | A | B | 264 | Mn | 27.03 | 4.20 |
| 10-6SW | 10 | A | B | 432 | Mn | 0.52 | 0.59 |
| 10-7SW | 10 | A | B | 600 | Mn | 0.59 | 0.61 |
| 10-8SW | 10 | A | B | 696 | Mn | 0.58 | 0.74 |
| 10-4SW | 10 | A | B | 96 | Mn | 311.92 | 350.90 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 11-2SW | 11 | A | B | 1 | Mn | 959.62 | 1235.78 |
| 11-3SW | 11 | A | B | 24 | Mn | 978.70 | 1006.67 |
| 11-5SW | 11 | A | B | 264 | Mn | 33.07 | 9.65 |
| 11-6SW | 11 | A | B | 432 | Mn | 0.52 | 0.73 |
| 11-7SW | 11 | A | B | 600 | Mn | 0.55 | 0.56 |
| 11-8SW | 11 | A | B | 696 | Mn | 0.54 | 0.67 |
| 11-4SW | 11 | A | B | 96 | Mn | 507.01 | 530.76 |
| 12-2SW | 12 | A | B | 1 | Mn | 803.15 | 954.38 |
| 12-3SW | 12 | A | B | 24 | Mn | 424.90 | 462.86 |
| 12-5SW | 12 | A | B | 264 | Mn | 8.09 | 2.86 |
| 12-6SW | 12 | A | B | 432 | Mn | 0.63 | 0.92 |
| 12-7SW | 12 | A | B | 600 | Mn | 0.51 | 0.54 |
| 12-8SW | 12 | A | B | 696 | Mn | 0.48 | 0.66 |
| 12-4SW | 12 | A | B | 96 | Mn | 184.98 | 142.19 |
| 4-2SW | 4 | A | NB | 1 | Mn | 969.86 | 1336.08 |
| 4-3SW | 4 | A | NB | 24 | Mn | 969.32 | 983.75 |
| 4-5SW | 4 | A | NB | 264 | Mn | 366.07 | 423.23 |
| 4-6SW | 4 | A | NB | 432 | Mn | 0.37 | 0.78 |
| 4-7SW | 4 | A | NB | 600 | Mn | 0.35 | 0.38 |
| 4-8SW | 4 | A | NB | 696 | Mn | 0.36 | 0.45 |
| 4-4SW | 4 | A | NB | 96 | Mn | 694.19 | 789.13 |
| 5-2SW | 5 | A | NB | 1 | Mn | 886.41 | 1066.91 |
| 5-3SW | 5 | A | NB | 24 | Mn | 827.95 | 1153.80 |
| 5-5SW | 5 | A | NB | 264 | Mn | 195.61 | 234.56 |
| 5-6SW | 5 | A | NB | 432 | Mn | 0.46 | 0.48 |
| 5-7SW | 5 | A | NB | 600 | Mn | 0.52 | 0.56 |
| 5-8SW | 5 | A | NB | 696 | Mn | 0.46 | 0.48 |
| 5-4SW | 5 | A | NB | 96 | Mn | 640.04 | 641.34 |
| 6-2SW | 6 | A | NB | 1 | Mn | 930.16 | 1061.55 |
| 6-3SW | 6 | A | NB | 24 | Mn | 919.20 | 1076.63 |
| 6-5SW | 6 | A | NB | 264 | Mn | 322.48 | 374.14 |
| 6-6SW | 6 | A | NB | 432 | Mn | 0.42 | 0.38 |
| 6-7SW | 6 | A | NB | 600 | Mn | 0.53 | 0.51 |
| 6-8SW | 6 | A | NB | 696 | Mn | 0.51 | 0.56 |
| 6-4SW | 6 | A | NB | 96 | Mn | 732.18 | 746.39 |
| 7-2SW | 7 | SED | B | 1 | Mn | 678.76 | 951.61 |
| 7-3SW | 7 | SED | B | 24 | Mn | 1002.65 | 1205.99 |
| 7-5SW | 7 | SED | B | 264 | Mn | 43.48 | 8.25 |
| 7-6SW | 7 | SED | B | 432 | Mn | 0.31 | 0.49 |
| 7-7SW | 7 | SED | B | 600 | Mn | 0.37 | 0.45 |
| 7-8SW | 7 | SED | B | 696 | Mn | 0.33 | 0.38 |
| 7-4SW | 7 | SED | B | 96 | Mn | 468.45 | 613.74 |
| 8-2SW | 8 | SED | B | 1 | Mn | 851.28 | 1097.79 |
| 8-3SW | 8 | SED | B | 24 | Mn | 1246.38 | 1464.41 |
| 8-5SW | 8 | SED | B | 264 | Mn | 70.45 | 10.75 |
| 8-6SW | 8 | SED | B | 432 | Mn | 0.32 | 0.97 |
| 8-7SW | 8 | SED | B | 600 | Mn | 0.46 | 0.60 |
| 8-8SW | 8 | SED | B | 696 | Mn | 0.37 | 0.43 |
| 8-4SW | 8 | SED | B | 96 | Mn | 730.77 | 778.16 |
| 9-2SW | 9 | SED | B | 1 | Mn | 750.20 | 917.62 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 9-3SW | 9 | SED | B | 24 | Mn | 1022.90 | 1134.73 |
| 9-5SW | 9 | SED | B | 264 | Mn | 149.78 | 120.94 |
| 9-6SW | 9 | SED | B | 432 | Mn | 0.22 | 0.45 |
| 9-7SW | 9 | SED | B | 600 | Mn | 0.33 | 0.47 |
| 9-8SW | 9 | SED | B | 696 | Mn | 0.43 | 0.36 |
| 9-4SW | 9 | SED | B | 96 | Mn | 666.69 | 671.51 |
| 1-2SW | 1 | SED | NB | 1 | Mn | 785.77 | 962.10 |
| 1-3SW | 1 | SED | NB | 24 | Mn | 1065.86 | 1380.75 |
| 1-5SW | 1 | SED | NB | 264 | Mn | 534.72 | 715.93 |
| 1-6SW | 1 | SED | NB | 432 | Mn | <MDL | <MDL |
| 1-7SW | 1 | SED | NB | 600 | Mn | <MDL | <MDL |
| 1-8SW | 1 | SED | NB | 696 | Mn | <MDL | <MDL |
| 1-4SW | 1 | SED | NB | 96 | Mn | 806.81 | 978.65 |
| 2-2SW | 2 | SED | NB | 1 | Mn | 785.62 | 910.07 |
| 2-3SW | 2 | SED | NB | 24 | Mn | 988.44 | 1064.78 |
| 2-5SW | 2 | SED | NB | 264 | Mn | 510.02 | 635.57 |
| 2-6SW | 2 | SED | NB | 432 | Mn | <MDL | <MDL |
| 2-7SW | 2 | SED | NB | 600 | Mn | <MDL | <MDL |
| 2-8SW | 2 | SED | NB | 696 | Mn | <MDL | <MDL |
| 2-4SW | 2 | SED | NB | 96 | Mn | 899.75 | 903.98 |
| 3-2SW | 3 | SED | NB | 1 | Mn | 866.42 | 934.27 |
| 3-3SW | 3 | SED | NB | 24 | Mn | 1073.91 | 1215.52 |
| 3-5SW | 3 | SED | NB | 264 | Mn | 600.16 | 724.96 |
| 3-6SW | 3 | SED | NB | 432 | Mn | <MDL | <MDL |
| 3-7SW | 3 | SED | NB | 600 | Mn | <MDL | <MDL |
| 3-8SW | 3 | SED | NB | 696 | Mn | <MDL | <MDL |
| 3-4SW | 3 | SED | NB | 96 | Mn | 994.93 | 993.44 |
| 10-2SW | 10 | A | B | 1 | Ni | 46.18 | 55.14 |
| 10-3SW | 10 | A | B | 24 | Ni | 17.64 | 27.09 |
| 10-5SW | 10 | A | B | 264 | Ni | 1.98 | 2.89 |
| 10-6SW | 10 | A | B | 432 | Ni | 1.28 | 1.74 |
| 10-7SW | 10 | A | B | 600 | Ni | 1.07 | 1.00 |
| 10-8SW | 10 | A | B | 696 | Ni | 0.85 | 0.90 |
| 10-4SW | 10 | A | B | 96 | Ni | 6.26 | 6.60 |
| 11-2SW | 11 | A | B | 1 | Ni | 46.59 | 57.70 |
| 11-3SW | 11 | A | B | 24 | Ni | 24.00 | 26.47 |
| 11-5SW | 11 | A | B | 264 | Ni | 3.32 | 2.29 |
| 11-6SW | 11 | A | B | 432 | Ni | 1.64 | 1.73 |
| 11-7SW | 11 | A | B | 600 | Ni | 1.32 | 1.06 |
| 11-8SW | 11 | A | B | 696 | Ni | 1.10 | 1.08 |
| 11-4SW | 11 | A | B | 96 | Ni | 10.63 | 10.95 |
| 12-2SW | 12 | A | B | 1 | Ni | 30.83 | 33.45 |
| 12-3SW | 12 | A | B | 24 | Ni | 5.77 | 10.20 |
| 12-5SW | 12 | A | B | 264 | Ni | 1.32 | 1.25 |
| 12-6SW | 12 | A | B | 432 | Ni | 1.16 | 1.28 |
| 12-7SW | 12 | A | B | 600 | Ni | 1.32 | 1.25 |
| 12-8SW | 12 | A | B | 696 | Ni | 0.89 | 0.98 |
| 12-4SW | 12 | A | B | 96 | Ni | 3.60 | 2.94 |
| 4-2SW | 4 | A | NB | 1 | Ni | 39.93 | 66.04 |
| 4-3SW | 4 | A | NB | 24 | Ni | 19.05 | 17.87 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 4-5SW | 4 | A | NB | 264 | Ni | 6.92 | 7.96 |
| 4-6SW | 4 | A | NB | 432 | Ni | 4.38 | 4.98 |
| 4-7SW | 4 | A | NB | 600 | Ni | 2.28 | 2.22 |
| 4-8SW | 4 | A | NB | 696 | Ni | 1.94 | 2.02 |
| 4-4SW | 4 | A | NB | 96 | Ni | 13.57 | 16.19 |
| 5-2SW | 5 | A | NB | 1 | Ni | 44.37 | 50.92 |
| 5-3SW | 5 | A | NB | 24 | Ni | 17.92 | 43.38 |
| 5-5SW | 5 | A | NB | 264 | Ni | 4.10 | 4.68 |
| 5-6SW | 5 | A | NB | 432 | Ni | 2.40 | 2.43 |
| 5-7SW | 5 | A | NB | 600 | Ni | 1.50 | 1.20 |
| 5-8SW | 5 | A | NB | 696 | Ni | 1.00 | 0.97 |
| 5-4SW | 5 | A | NB | 96 | Ni | 11.37 | 10.94 |
| 6-2SW | 6 | A | NB | 1 | Ni | 44.01 | 47.99 |
| 6-3SW | 6 | A | NB | 24 | Ni | 20.29 | 33.10 |
| 6-5SW | 6 | A | NB | 264 | Ni | 6.64 | 7.34 |
| 6-6SW | 6 | A | NB | 432 | Ni | 3.81 | 3.96 |
| 6-7SW | 6 | A | NB | 600 | Ni | 2.51 | 2.08 |
| 6-8SW | 6 | A | NB | 696 | Ni | 1.71 | 1.89 |
| 6-4SW | 6 | A | NB | 96 | Ni | 14.43 | 13.89 |
| 7-2SW | 7 | SED | B | 1 | Ni | 42.57 | 60.63 |
| 7-3SW | 7 | SED | B | 24 | Ni | 75.32 | 86.95 |
| 7-5SW | 7 | SED | B | 264 | Ni | 5.91 | 6.54 |
| 7-6SW | 7 | SED | B | 432 | Ni | 1.92 | 2.22 |
| 7-7SW | 7 | SED | B | 600 | Ni | 1.57 | 1.65 |
| 7-8SW | 7 | SED | B | 696 | Ni | 1.20 | 1.16 |
| 7-4SW | 7 | SED | B | 96 | Ni | 35.09 | 44.58 |
| 8-2SW | 8 | SED | B | 1 | Ni | 52.92 | 70.57 |
| 8-3SW | 8 | SED | B | 24 | Ni | 92.81 | 103.05 |
| 8-5SW | 8 | SED | B | 264 | Ni | 5.67 | 5.95 |
| 8-6SW | 8 | SED | B | 432 | Ni | 2.13 | 2.91 |
| 8-7SW | 8 | SED | B | 600 | Ni | 1.66 | 1.72 |
| 8-8SW | 8 | SED | B | 696 | Ni | 1.75 | 1.59 |
| 8-4SW | 8 | SED | B | 96 | Ni | 52.75 | 56.16 |
| 9-2SW | 9 | SED | B | 1 | Ni | 46.67 | 58.77 |
| 9-3SW | 9 | SED | B | 24 | Ni | 74.84 | 81.12 |
| 9-5SW | 9 | SED | B | 264 | Ni | 6.40 | 7.27 |
| 9-6SW | 9 | SED | B | 432 | Ni | 1.85 | 2.30 |
| 9-7SW | 9 | SED | B | 600 | Ni | 1.56 | 1.51 |
| 9-8SW | 9 | SED | B | 696 | Ni | 1.32 | 1.26 |
| 9-4SW | 9 | SED | B | 96 | Ni | 47.20 | 48.41 |
| 1-2SW | 1 | SED | NB | 1 | Ni | 44.45 | 58.98 |
| 1-3SW | 1 | SED | NB | 24 | Ni | 77.36 | 94.63 |
| 1-5SW | 1 | SED | NB | 264 | Ni | 33.74 | 48.07 |
| 1-6SW | 1 | SED | NB | 432 | Ni | 29.63 | 30.96 |
| 1-7SW | 1 | SED | NB | 600 | Ni | 17.53 | 17.55 |
| 1-8SW | 1 | SED | NB | 696 | Ni | 14.34 | 14.46 |
| 1-4SW | 1 | SED | NB | 96 | Ni | 58.62 | 71.12 |
| 2-2SW | 2 | SED | NB | 1 | Ni | 45.94 | 56.78 |
| 2-3SW | 2 | SED | NB | 24 | Ni | 72.78 | 77.85 |
| 2-5SW | 2 | SED | NB | 264 | Ni | 32.65 | 42.37 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 2-6SW | 2 | SED | NB | 432 | Ni | 23.33 | 26.72 |
| 2-7SW | 2 | SED | NB | 600 | Ni | 13.56 | 14.06 |
| 2-8SW | 2 | SED | NB | 696 | Ni | 10.78 | 11.11 |
| 2-4SW | 2 | SED | NB | 96 | Ni | 63.75 | 73.40 |
| 3-2SW | 3 | SED | NB | 1 | Ni | 53.51 | 62.17 |
| 3-3SW | 3 | SED | NB | 24 | Ni | 80.53 | 88.08 |
| 3-5SW | 3 | SED | NB | 264 | Ni | 40.82 | 56.83 |
| 3-6SW | 3 | SED | NB | 432 | Ni | 30.09 | 32.44 |
| 3-7SW | 3 | SED | NB | 600 | Ni | 17.48 | 17.84 |
| 3-8SW | 3 | SED | NB | 696 | Ni | 14.13 | 14.71 |
| 3-4SW | 3 | SED | NB | 96 | Ni | 71.51 | 73.36 |
| 10-2SW | 10 | A | B | 1 | Pb | <MDL | 10.78 |
| 10-3SW | 10 | A | B | 24 | Pb | <MDL | 19.43 |
| 10-5SW | 10 | A | B | 264 | Pb | <MDL | 0.08 |
| 10-6SW | 10 | A | B | 432 | Pb | <MDL | <MDL |
| 10-7SW | 10 | A | B | 600 | Pb | <MDL | <MDL |
| 10-8SW | 10 | A | B | 696 | Pb | <MDL | 0.19 |
| 10-4SW | 10 | A | B | 96 | Pb | <MDL | 0.13 |
| 11-2SW | 11 | A | B | 1 | Pb | <MDL | 18.54 |
| 11-3SW | 11 | A | B | 24 | Pb | <MDL | 4.95 |
| 11-5SW | 11 | A | B | 264 | Pb | <MDL | <MDL |
| 11-6SW | 11 | A | B | 432 | Pb | <MDL | 0.39 |
| 11-7SW | 11 | A | B | 600 | Pb | <MDL | <MDL |
| 11-8SW | 11 | A | B | 696 | Pb | <MDL | <MDL |
| 11-4SW | 11 | A | B | 96 | Pb | <MDL | <MDL |
| 12-2SW | 12 | A | B | 1 | Pb | <MDL | 7.85 |
| 12-3SW | 12 | A | B | 24 | Pb | <MDL | 6.53 |
| 12-5SW | 12 | A | B | 264 | Pb | <MDL | 0.29 |
| 12-6SW | 12 | A | B | 432 | Pb | <MDL | 0.47 |
| 12-7SW | 12 | A | B | 600 | Pb | <MDL | <MDL |
| 12-8SW | 12 | A | B | 696 | Pb | <MDL | <MDL |
| 12-4SW | 12 | A | B | 96 | Pb | <MDL | 0.37 |
| 4-2SW | 4 | A | NB | 1 | Pb | <MDL | 33.37 |
| 4-3SW | 4 | A | NB | 24 | Pb | <MDL | 4.18 |
| 4-5SW | 4 | A | NB | 264 | Pb | <MDL | <MDL |
| 4-6SW | 4 | A | NB | 432 | Pb | <MDL | 0.64 |
| 4-7SW | 4 | A | NB | 600 | Pb | <MDL | <MDL |
| 4-8SW | 4 | A | NB | 696 | Pb | <MDL | <MDL |
| 4-4SW | 4 | A | NB | 96 | Pb | <MDL | 0.20 |
| 5-2SW | 5 | A | NB | 1 | Pb | <MDL | 5.29 |
| 5-3SW | 5 | A | NB | 24 | Pb | <MDL | 40.11 |
| 5-5SW | 5 | A | NB | 264 | Pb | <MDL | <MDL |
| 5-6SW | 5 | A | NB | 432 | Pb | <MDL | <MDL |
| 5-7SW | 5 | A | NB | 600 | Pb | <MDL | 0.22 |
| 5-8SW | 5 | A | NB | 696 | Pb | <MDL | <MDL |
| 5-4SW | 5 | A | NB | 96 | Pb | <MDL | <MDL |
| 6-2SW | 6 | A | NB | 1 | Pb | <MDL | 7.46 |
| 6-3SW | 6 | A | NB | 24 | Pb | <MDL | 15.92 |
| 6-5SW | 6 | A | NB | 264 | Pb | <MDL | 0.24 |
| 6-6SW | 6 | A | NB | 432 | Pb | <MDL | <MDL |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 6-7SW | 6 | A | NB | 600 | Pb | <MDL | <MDL |
| 6-8SW | 6 | A | NB | 696 | Pb | <MDL | 0.20 |
| 6-4SW | 6 | A | NB | 96 | Pb | <MDL | <MDL |
| 7-2SW | 7 | SED | B | 1 | Pb | 0.08 | 12.77 |
| 7-3SW | 7 | SED | B | 24 | Pb | <MDL | 18.99 |
| 7-5SW | 7 | SED | B | 264 | Pb | 0.11 | 0.22 |
| 7-6SW | 7 | SED | B | 432 | Pb | <MDL | 0.34 |
| 7-7SW | 7 | SED | B | 600 | Pb | <MDL | 0.20 |
| 7-8SW | 7 | SED | B | 696 | Pb | <MDL | <MDL |
| 7-4SW | 7 | SED | B | 96 | Pb | <MDL | 0.14 |
| 8-2SW | 8 | SED | B | 1 | Pb | <MDL | 7.98 |
| 8-3SW | 8 | SED | B | 24 | Pb | <MDL | 21.41 |
| 8-5SW | 8 | SED | B | 264 | Pb | 0.08 | 0.59 |
| 8-6SW | 8 | SED | B | 432 | Pb | <MDL | 1.09 |
| 8-7SW | 8 | SED | B | 600 | Pb | <MDL | 0.40 |
| 8-8SW | 8 | SED | B | 696 | Pb | <MDL | <MDL |
| 8-4SW | 8 | SED | B | 96 | Pb | <MDL | <MDL |
| 9-2SW | 9 | SED | B | 1 | Pb | <MDL | 8.18 |
| 9-3SW | 9 | SED | B | 24 | Pb | 0.09 | 6.02 |
| 9-5SW | 9 | SED | B | 264 | Pb | <MDL | 0.19 |
| 9-6SW | 9 | SED | B | 432 | Pb | <MDL | 0.38 |
| 9-7SW | 9 | SED | B | 600 | Pb | <MDL | 0.30 |
| 9-8SW | 9 | SED | B | 696 | Pb | <MDL | <MDL |
| 9-4SW | 9 | SED | B | 96 | Pb | <MDL | <MDL |
| 1-2SW | 1 | SED | NB | 1 | Pb | 0.13 | 11.58 |
| 1-3SW | 1 | SED | NB | 24 | Pb | <MDL | 34.31 |
| 1-5SW | 1 | SED | NB | 264 | Pb | 0.16 | 0.08 |
| 1-6SW | 1 | SED | NB | 432 | Pb | <MDL | <MDL |
| 1-7SW | 1 | SED | NB | 600 | Pb | <MDL | <MDL |
| 1-8SW | 1 | SED | NB | 696 | Pb | <MDL | <MDL |
| 1-4SW | 1 | SED | NB | 96 | Pb | <MDL | 0.42 |
| 2-2SW | 2 | SED | NB | 1 | Pb | 0.07 | 9.60 |
| 2-3SW | 2 | SED | NB | 24 | Pb | 0.08 | 5.93 |
| 2-5SW | 2 | SED | NB | 264 | Pb | <MDL | <MDL |
| 2-6SW | 2 | SED | NB | 432 | Pb | <MDL | <MDL |
| 2-7SW | 2 | SED | NB | 600 | Pb | <MDL | <MDL |
| 2-8SW | 2 | SED | NB | 696 | Pb | <MDL | <MDL |
| 2-4SW | 2 | SED | NB | 96 | Pb | <MDL | 0.40 |
| 3-2SW | 3 | SED | NB | 1 | Pb | <MDL | 6.19 |
| 3-3SW | 3 | SED | NB | 24 | Pb | <MDL | 12.67 |
| 3-5SW | 3 | SED | NB | 264 | Pb | <MDL | 0.10 |
| 3-6SW | 3 | SED | NB | 432 | Pb | <MDL | <MDL |
| 3-7SW | 3 | SED | NB | 600 | Pb | <MDL | <MDL |
| 3-8SW | 3 | SED | NB | 696 | Pb | <MDL | <MDL |
| 3-4SW | 3 | SED | NB | 96 | Pb | <MDL | 0.47 |
| 10-2SW | 10 | A | B | 1 | Zn | 96.77 | 45.40 |
| 10-3SW | 10 | A | B | 24 | Zn | 124.72 | 40.99 |
| 10-5SW | 10 | A | B | 264 | Zn | 22.60 | 31.52 |
| 10-6SW | 10 | A | B | 432 | Zn | 29.88 | 35.68 |
| 10-7SW | 10 | A | B | 600 | Zn | 98.05 | 67.21 |

Table A1.86 (continued).

| ID number | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 10-8SW | 10 | A | B | 696 | Zn | 121.83 | 55.32 |
| 10-4SW | 10 | A | B | 96 | Zn | 63.19 | 53.02 |
| 11-2SW | 11 | A | B | 1 | Zn | 122.45 | 61.23 |
| 11-3SW | 11 | A | B | 24 | Zn | 108.06 | 22.13 |
| 11-5SW | 11 | A | B | 264 | Zn | 20.30 | 24.44 |
| 11-6SW | 11 | A | B | 432 | Zn | 30.12 | 33.68 |
| 11-7SW | 11 | A | B | 600 | Zn | 112.03 | 81.74 |
| 11-8SW | 11 | A | B | 696 | Zn | 141.67 | 101.69 |
| 11-4SW | 11 | A | B | 96 | Zn | 87.68 | 65.55 |
| 12-2SW | 12 | A | B | 1 | Zn | 106.81 | 23.07 |
| 12-3SW | 12 | A | B | 24 | Zn | 134.56 | 20.81 |
| 12-5SW | 12 | A | B | 264 | Zn | 21.70 | 25.93 |
| 12-6SW | 12 | A | B | 432 | Zn | 30.54 | 34.88 |
| 12-7SW | 12 | A | B | 600 | Zn | 100.50 | 51.11 |
| 12-8SW | 12 | A | B | 696 | Zn | 123.80 | 69.25 |
| 12-4SW | 12 | A | B | 96 | Zn | 61.27 | 33.37 |
| 4-2SW | 4 | A | NB | 1 | Zn | 117.65 | 80.26 |
| 4-3SW | 4 | A | NB | 24 | Zn | 126.96 | 18.73 |
| 4-5SW | 4 | A | NB | 264 | Zn | 21.08 | 35.08 |
| 4-6SW | 4 | A | NB | 432 | Zn | 35.23 | 48.90 |
| 4-7SW | 4 | A | NB | 600 | Zn | 115.21 | 68.23 |
| 4-8SW | 4 | A | NB | 696 | Zn | 141.62 | 94.37 |
| 4-4SW | 4 | A | NB | 96 | Zn | 58.59 | 33.68 |
| 5-2SW | 5 | A | NB | 1 | Zn | 101.25 | 39.89 |
| 5-3SW | 5 | A | NB | 24 | Zn | 120.45 | 61.57 |
| 5-5SW | 5 | A | NB | 264 | Zn | 20.96 | 29.85 |
| 5-6SW | 5 | A | NB | 432 | Zn | 36.99 | 41.97 |
| 5-7SW | 5 | A | NB | 600 | Zn | 100.81 | 55.41 |
| 5-8SW | 5 | A | NB | 696 | Zn | 129.64 | 58.36 |
| 5-4SW | 5 | A | NB | 96 | Zn | 78.33 | 83.14 |
| 6-2SW | 6 | A | NB | 1 | Zn | 131.82 | 36.45 |
| 6-3SW | 6 | A | NB | 24 | Zn | 108.86 | 53.30 |
| 6-5SW | 6 | A | NB | 264 | Zn | 26.29 | 38.79 |
| 6-6SW | 6 | A | NB | 432 | Zn | 41.23 | 57.50 |
| 6-7SW | 6 | A | NB | 600 | Zn | 110.42 | 80.42 |
| 6-8SW | 6 | A | NB | 696 | Zn | 136.39 | 58.50 |
| 6-4SW | 6 | A | NB | 96 | Zn | 71.08 | 57.60 |
| 7-2SW | 7 | SED | B | 1 | Zn | 117.96 | 141.46 |
| 7-3SW | 7 | SED | B | 24 | Zn | 78.29 | 173.02 |
| 7-5SW | 7 | SED | B | 264 | Zn | 34.97 | 49.27 |
| 7-6SW | 7 | SED | B | 432 | Zn | 72.93 | 90.30 |
| 7-7SW | 7 | SED | B | 600 | Zn | 91.41 | 78.54 |
| 7-8SW | 7 | SED | B | 696 | Zn | 156.28 | 94.45 |
| 7-4SW | 7 | SED | B | 96 | Zn | 87.77 | 104.01 |
| 8-2SW | 8 | SED | B | 1 | Zn | 116.46 | 157.48 |
| 8-3SW | 8 | SED | B | 24 | Zn | 117.80 | 219.58 |
| 8-5SW | 8 | SED | B | 264 | Zn | 30.28 | 46.51 |
| 8-6SW | 8 | SED | B | 432 | Zn | 72.80 | 98.59 |
| 8-7SW | 8 | SED | B | 600 | Zn | 114.01 | 75.19 |
| 8-8SW | 8 | SED | B | 696 | Zn | 265.66 | 83.60 |

Table A1.86 (continued).

| | Tank | Treatment | Bioturbation | Time (h) | Metal | Filtered (μg $L^{-1}$) | Total (μg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| 8-4SW | 8 | SED | B | 96 | Zn | 127.38 | 97.00 |
| 9-2SW | 9 | SED | B | 1 | Zn | 122.08 | 136.98 |
| 9-3SW | 9 | SED | B | 24 | Zn | 70.40 | 163.18 |
| 9-5SW | 9 | SED | B | 264 | Zn | 33.27 | 48.28 |
| 9-6SW | 9 | SED | B | 432 | Zn | 102.65 | 116.31 |
| 9-7SW | 9 | SED | B | 600 | Zn | 102.63 | 93.76 |
| 9-8SW | 9 | SED | B | 696 | Zn | 127.29 | 56.76 |
| 9-4SW | 9 | SED | B | 96 | Zn | 117.94 | 77.25 |
| 1-2SW | 1 | SED | NB | 1 | Zn | 163.94 | 159.45 |
| 1-3SW | 1 | SED | NB | 24 | Zn | 108.03 | 175.78 |
| 1-5SW | 1 | SED | NB | 264 | Zn | 65.88 | 88.90 |
| 1-6SW | 1 | SED | NB | 432 | Zn | 42.93 | 76.46 |
| 1-7SW | 1 | SED | NB | 600 | Zn | 78.78 | 101.58 |
| 1-8SW | 1 | SED | NB | 696 | Zn | 154.51 | 114.94 |
| 1-4SW | 1 | SED | NB | 96 | Zn | 103.59 | 139.41 |
| 2-2SW | 2 | SED | NB | 1 | Zn | 164.25 | 128.94 |
| 2-3SW | 2 | SED | NB | 24 | Zn | 94.60 | 141.72 |
| 2-5SW | 2 | SED | NB | 264 | Zn | 67.97 | 93.57 |
| 2-6SW | 2 | SED | NB | 432 | Zn | 58.08 | 89.35 |
| 2-7SW | 2 | SED | NB | 600 | Zn | 67.83 | 51.54 |
| 2-8SW | 2 | SED | NB | 696 | Zn | 117.65 | 139.27 |
| 2-4SW | 2 | SED | NB | 96 | Zn | 222.59 | 246.34 |
| 3-2SW | 3 | SED | NB | 1 | Zn | 173.50 | 139.50 |
| 3-3SW | 3 | SED | NB | 24 | Zn | 106.29 | 196.04 |
| 3-5SW | 3 | SED | NB | 264 | Zn | 65.22 | 99.28 |
| 3-6SW | 3 | SED | NB | 432 | Zn | 59.75 | 94.26 |
| 3-7SW | 3 | SED | NB | 600 | Zn | 75.96 | 94.56 |
| 3-8SW | 3 | SED | NB | 696 | Zn | 138.97 | 84.57 |
| 3-4SW | 3 | SED | NB | 96 | Zn | 219.93 | 167.82 |

Table A1.87. Metal concentrations in Asian clam (*Corbicula fluminea*) and California blackworm (*Lumbriculus variegatus*) soft tissue (whole body) with different treatments (A = apatite cap, SED = uncapped sediment, B = presence of bioturbation, NB = absence of bioturbation, BG = background concentration represented by organisms before placement in experimental facilities).

| Tank | Treatment | Bioturbation | Organism | Element | mg kg$^{-1}$ |
|---|---|---|---|---|---|
| 10 | A | B | Clam | As | 8.90 |
| 11 | A | B | Clam | As | 7.98 |
| 12 | A | B | Clam | As | 8.32 |
| | BG | BG | Clam | As | 6.59 |
| | BG | BG | Clam | As | 6.06 |
| | BG | BG | Clam | As | 4.89 |
| | BG | BG | Clam | As | 10.13 |
| | BG | BG | Clam | As | 8.28 |
| | BG | BG | Clam | As | 8.27 |
| 7 | SED | B | Clam | As | 10.34 |
| 8 | SED | B | Clam | As | 8.42 |
| 9 | SED | B | Clam | As | 9.84 |
| 10 | A | B | Clam | Cd | 14.58 |
| 11 | A | B | Clam | Cd | 20.38 |
| 12 | A | B | Clam | Cd | 11.76 |
| | BG | BG | Clam | Cd | 1.24 |
| | BG | BG | Clam | Cd | 1.31 |
| | BG | BG | Clam | Cd | 1.00 |
| | BG | BG | Clam | Cd | 1.96 |
| | BG | BG | Clam | Cd | 1.62 |
| | BG | BG | Clam | Cd | 1.50 |
| 7 | SED | B | Clam | Cd | 43.39 |
| 8 | SED | B | Clam | Cd | 39.64 |
| 9 | SED | B | Clam | Cd | 45.81 |
| 10 | A | B | Clam | Cu | 121.37 |
| 11 | A | B | Clam | Cu | 108.83 |
| 12 | A | B | Clam | Cu | 109.40 |
| | BG | BG | Clam | Cu | 82.94 |
| | BG | BG | Clam | Cu | 70.45 |
| | BG | BG | Clam | Cu | 61.10 |
| | BG | BG | Clam | Cu | 144.65 |
| | BG | BG | Clam | Cu | 102.24 |
| | BG | BG | Clam | Cu | 112.41 |
| 7 | SED | B | Clam | Cu | 127.52 |
| 8 | SED | B | Clam | Cu | 90.22 |
| 9 | SED | B | Clam | Cu | 132.63 |
| 10 | A | B | Clam | Ni | 1.16 |
| 11 | A | B | Clam | Ni | 1.30 |
| 12 | A | B | Clam | Ni | 0.78 |
| | BG | BG | Clam | Ni | 0.80 |
| | BG | BG | Clam | Ni | 0.71 |
| | BG | BG | Clam | Ni | 0.68 |
| | BG | BG | Clam | Ni | 0.71 |
| | BG | BG | Clam | Ni | 0.59 |
| | BG | BG | Clam | Ni | 0.55 |

Table A1.87 (continued).

| Tank | Treatment | Bioturbation | Organism | Element | mg kg$^{-1}$ |
|---|---|---|---|---|---|
| 7 | SED | B | Clam | Ni | 2.31 |
| 8 | SED | B | Clam | Ni | 2.14 |
| 9 | SED | B | Clam | Ni | 2.42 |
| 10 | A | B | Clam | Pb | 0.61 |
| 11 | A | B | Clam | Pb | 0.55 |
| 12 | A | B | Clam | Pb | 0.33 |
| BG | NA | NA | Clam | Pb | 0.27 |
| BG | NA | NA | Clam | Pb | 0.30 |
| BG | NA | NA | Clam | Pb | 0.42 |
| BG | NA | NA | Clam | Pb | 0.17 |
| BG | NA | NA | Clam | Pb | 0.15 |
| BG | NA | NA | Clam | Pb | 0.18 |
| 7 | SED | B | Clam | Pb | 0.66 |
| 8 | SED | B | Clam | Pb | 0.51 |
| 9 | SED | B | Clam | Pb | 0.70 |
| 10 | A | B | Clam | Zn | 135.07 |
| 11 | A | B | Clam | Zn | 147.34 |
| 12 | A | B | Clam | Zn | 134.52 |
| BG | NA | NA | Clam | Zn | 157.28 |
| BG | NA | NA | Clam | Zn | 159.07 |
| BG | NA | NA | Clam | Zn | 165.37 |
| BG | NA | NA | Clam | Zn | 162.33 |
| BG | NA | NA | Clam | Zn | 156.71 |
| BG | NA | NA | Clam | Zn | 144.55 |
| 7 | SED | B | Clam | Zn | 157.18 |
| 8 | SED | B | Clam | Zn | 128.04 |
| 9 | SED | B | Clam | Zn | 137.29 |
| 10 | A | B | Worm | As | 3.91 |
| 11 | A | B | Worm | As | 3.42 |
| 12 | A | B | Worm | As | 4.13 |
| 4 | A | NB | Worm | As | 5.31 |
| 6 | A | NB | Worm | As | 6.28 |
| BG | NA | NA | Worm | As | 2.16 |
| BG | NA | NA | Worm | As | 1.76 |
| BG | NA | NA | Worm | As | 1.81 |
| BG | NA | NA | Worm | As | 1.93 |
| BG | NA | NA | Worm | As | 1.69 |
| 7 | SED | B | Worm | As | 5.27 |
| 8 | SED | B | Worm | As | 5.62 |
| 9 | SED | B | Worm | As | 4.49 |
| 1 | SED | NB | Worm | As | 5.44 |
| 2 | SED | NB | Worm | As | 6.18 |
| 3 | SED | NB | Worm | As | 5.75 |
| 10 | A | B | Worm | C | 8.51 |
| 11 | A | B | Worm | Cd | 7.85 |
| 12 | A | B | Worm | Cd | 12.61 |
| 4 | A | NB | Worm | Cd | 50.94 |
| 6 | A | NB | Worm | Cd | 49.74 |

Table A1.87 (continued).

| Tank | Treatment | Bioturbation | Organism | Element | mg kg$^{-1}$ |
|---|---|---|---|---|---|
| BG | NA | NA | Worm | Cd | 0.23 |
| BG | NA | NA | Worm | Cd | 0.14 |
| BG | NA | NA | Worm | Cd | 0.17 |
| BG | NA | NA | Worm | Cd | 0.14 |
| BG | NA | NA | Worm | Cd | 0.12 |
| 7 | SED | B | Worm | Cd | 25.46 |
| 8 | SED | B | Worm | Cd | 31.83 |
| 9 | SED | B | Worm | Cd | 29.67 |
| 1 | SED | NB | Worm | Cd | 120.79 |
| 2 | SED | NB | Worm | Cd | 86.06 |
| 3 | SED | NB | Worm | Cd | 87.95 |
| 10 | A | B | Worm | Cu | 31.57 |
| 11 | A | B | Worm | Cu | 26.31 |
| 12 | A | B | Worm | Cu | 28.93 |
| 4 | A | NB | Worm | Cu | 35.97 |
| 6 | A | NB | Worm | Cu | 44.18 |
| BG | NA | NA | Worm | Cu | 25.22 |
| BG | NA | NA | Worm | Cu | 19.75 |
| BG | NA | NA | Worm | Cu | 20.50 |
| BG | NA | NA | Worm | Cu | 19.88 |
| BG | NA | NA | Worm | Cu | 19.81 |
| 7 | SED | B | Worm | Cu | 32.58 |
| 8 | SED | B | Worm | Cu | 38.07 |
| 9 | SED | B | Worm | Cu | 32.30 |
| 1 | SED | NB | Worm | Cu | 39.32 |
| 2 | SED | NB | Worm | Cu | 35.92 |
| 3 | SED | NB | Worm | Cu | 32.18 |
| 10 | A | B | Worm | Ni | 2.19 |
| 11 | A | B | Worm | Ni | 2.02 |
| 12 | A | B | Worm | Ni | 2.16 |
| 4 | A | NB | Worm | Ni | 3.14 |
| 6 | A | NB | Worm | Ni | 4.19 |
| BG | NA | NA | Worm | Ni | 1.01 |
| BG | NA | NA | Worm | Ni | 0.76 |
| BG | NA | NA | Worm | Ni | 0.72 |
| BG | NA | NA | Worm | Ni | 0.80 |
| BG | NA | NA | Worm | Ni | 0.77 |
| 7 | SED | B | Worm | Ni | 3.25 |
| 8 | SED | B | Worm | Ni | 3.86 |
| 9 | SED | B | Worm | Ni | 2.28 |
| 1 | SED | NB | Worm | Ni | 4.94 |
| 2 | SED | NB | Worm | Ni | 4.64 |
| 3 | SED | NB | Worm | Ni | 4.49 |
| 10 | A | B | Worm | Pb | 2.30 |
| 11 | A | B | Worm | Pb | 1.60 |
| 12 | A | B | Worm | Pb | 2.01 |
| 4 | A | NB | Worm | Pb | 3.24 |
| 6 | A | NB | Worm | Pb | 4.55 |

Table A1.87 (continued).

| Tank | Treatment | Bioturbation | Organism | Element | mg kg$^{-1}$ |
|---|---|---|---|---|---|
| BG | NA | NA | Worm | Pb | 0.41 |
| BG | NA | NA | Worm | Pb | 0.28 |
| BG | NA | NA | Worm | Pb | 0.28 |
| BG | NA | NA | Worm | Pb | 0.34 |
| BG | NA | NA | Worm | Pb | 0.29 |
| 7 | SED | B | Worm | Pb | 3.68 |
| 8 | SED | B | Worm | Pb | 4.63 |
| 9 | SED | B | Worm | Pb | 2.77 |
| 1 | SED | NB | Worm | Pb | 5.05 |
| 2 | SED | NB | Worm | Pb | 4.77 |
| 3 | SED | NB | Worm | Pb | 4.32 |
| 10 | A | B | Worm | Zn | 228.78 |
| 11 | A | B | Worm | Zn | 201.99 |
| 12 | A | B | Worm | Zn | 213.68 |
| 4 | A | NB | Worm | Zn | 218.66 |
| 6 | A | NB | Worm | Zn | 234.91 |
| BG | NA | NA | Worm | Zn | 229.26 |
| BG | NA | NA | Worm | Zn | 187.36 |
| BG | NA | NA | Worm | Zn | 193.75 |
| BG | NA | NA | Worm | Zn | 190.32 |
| BG | NA | NA | Worm | Zn | 185.30 |
| 7 | SED | B | Worm | Zn | 208.91 |
| 8 | SED | B | Worm | Zn | 207.92 |
| 9 | SED | B | Worm | Zn | 191.40 |
| 1 | SED | NB | Worm | Zn | 248.38 |
| 2 | SED | NB | Worm | Zn | 215.37 |
| 3 | SED | NB | Worm | Zn | 202.42 |

Table A1.88. Raw data for element concentrations measured by water DGT probes ($C_{DGT}$) in surface water and calculation of $C_{DGT}$: VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; Δg is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit; BG= blank.

| Sample ID | Element | Tank | Treatment | Element con. | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt | C dgt - BG | C dgt final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 DGT water-24 H | Cu | 1 | SED-NB | 2.590333 | 1.000 | 0.158 | 0.8 | 12.95167 | 18.74754 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.223976 | -0.216 | 0 |
| 1 DGT water-24 H | Zn | 1 | SED-NB | 906.3846 | 1.0 | 0.158 | 0.8 | 4531.923 | 6559.958 | 0.096 | 5.29E-06 | 86400 | 3.14 | 438.8067 | 398.503 | 398.503 |
| 1 DGT water-24 H | Cd | 1 | SED-NB | 87.91 | 1.00 | 0.158 | 0.8 | 439.55 | 636.2486 | 0.096 | 5.3E-06 | 86400 | 3.14 | 42.47944 | 42.460 | 42.460 |
| 1 DGT water-24 H | Pb | 1 | SED-NB | 0.288333 | 1.000 | 0.158 | 0.8 | 1.441667 | 2.086813 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.105641 | 0.059 | 0.059 |
| 1 DGT water-24 H | As | 1 | SED-NB | 0.261333 | 1.000 | 0.158 | 0.8 | 1.306667 | 1.8914 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.139726 | | 0.140 |
| 1 DGT water-24 H | Ni | 1 | SED-NB | 40.64333 | 1.00 | 0.158 | 0.8 | 203.2167 | 294.1561 | 0.096 | 5.42E-06 | 86400 | 4.572 | 13.18955 | 12.784 | 12.784 |
| 2 DGT water-24 H | Cu | 2 | SED-NB | 2.423333 | 1.000 | 0.158 | 0.8 | 12.11667 | 17.53888 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.145065 | 0.156 | 0.156 |
| 2 DGT water-24 H | Zn | 2 | SED-NB | 396.3667 | 1.0 | 0.158 | 0.8 | 1981.833 | 2868.704 | 0.096 | 5.29E-06 | 86400 | 3.14 | 191.8924 | 151.588 | 151.588 |
| 2 DGT water-24 H | Cd | 2 | SED-NB | 64.17333 | 1.00 | 0.158 | 0.8 | 320.8667 | 464.4545 | 0.096 | 5.3E-06 | 86400 | 3.14 | 31.00953 | 30.990 | 30.990 |
| 2 DGT water-24 H | Pb | 2 | SED-NB | 0.310333 | 1.000 | 0.158 | 0.8 | 1.551667 | 2.246038 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.113702 | 0.067 | 0.067 |
| 2 DGT water-24 H | As | 2 | SED-NB | 0.266 | 1.000 | 0.158 | 0.8 | 1.33 | 1.925175 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.142221 | | 0.142 |
| 2 DGT water-24 H | Ni | 2 | SED-NB | 27.86333 | 1.00 | 0.158 | 0.8 | 139.3167 | 201.6609 | 0.096 | 5.42E-06 | 86400 | 3.14 | 13.16589 | 12.183 | 12.183 |
| 3 DGT water-24 H | Cu | 3 | SED-NB | 8.072667 | 1.000 | 0.158 | 0.8 | 40.36333 | 58.42593 | 0.096 | 5.42E-06 | 86400 | 3.14 | 3.81447 | 2.825 | 2.825 |
| 3 DGT water-24 H | Zn | 3 | SED-NB | 260.7667 | 1.0 | 0.158 | 0.8 | 1303.833 | 1887.299 | 0.096 | 5.29E-06 | 86400 | 3.14 | 126.2446 | 85.941 | 85.941 |
| 3 DGT water-24 H | Cd | 3 | SED-NB | 81.91667 | 1.00 | 0.158 | 0.8 | 409.5833 | 592.8719 | 0.096 | 5.3E-06 | 86400 | 3.14 | 39.58338 | 39.564 | 39.564 |
| 3 DGT water-24 H | Pb | 3 | SED-NB | 0.224 | 1.000 | 0.158 | 0.8 | 1.12 | 1.6212 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.082071 | 0.035 | 0.035 |
| 3 DGT water-24 H | As | 3 | SED-NB | 0.293 | 1.000 | 0.158 | 0.8 | 1.465 | 2.120588 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.156657 | | 0.157 |
| 3 DGT water-24 H | Ni | 3 | SED-NB | 36.85333 | 1.00 | 0.158 | 0.8 | 184.2667 | 266.726 | 0.096 | 5.42E-06 | 86400 | 3.14 | 17.41381 | 16.431 | 16.431 |
| 4 DGT water-24 H | Cu | 4 | A-NB | 3.14 | 1.000 | 0.158 | 0.8 | 15.7 | 22.72575 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.483702 | 0.495 | 0.495 |
| 4 DGT water-24 H | Zn | 4 | A-NB | 155.6333 | 1.0 | 0.158 | 0.8 | 778.1667 | 1126.396 | 0.096 | 5.29E-06 | 86400 | 3.14 | 75.34655 | 35.043 | 35.043 |
| 4 DGT water-24 H | Cd | 4 | A-NB | 16.90333 | 1.00 | 0.158 | 0.8 | 84.51667 | 122.3379 | 0.096 | 5.3E-06 | 86400 | 3.14 | 8.167947 | 8.148 | 8.148 |
| 4 DGT water-24 H | Pb | 4 | A-NB | 0.357 | 1.000 | 0.158 | 0.8 | 1.785 | 2.583788 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.1308 | 0.084 | 0.084 |
| 4 DGT water-24 H | As | 4 | A-NB | 0.3 | 1.000 | 0.158 | 0.8 | 1.5 | 2.17125 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.160399 | | 0.160 |
| 4 DGT water-24 H | Ni | 4 | A-NB | 4.757333 | 1.000 | 0.158 | 0.8 | 23.78667 | 34.4312 | 0.096 | 5.42E-06 | 86400 | 3.14 | 2.247919 | 1.265 | 1.265 |
| 5 DGT water-24 H | Cu | 5 | A-NB | 1.716667 | 1.000 | 0.158 | 0.8 | 8.583333 | 12.42438 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.811154 | -0.178 | 0 |
| 5 DGT water-24 H | Zn | 5 | A-NB | 175.6667 | 1.0 | 0.158 | 0.8 | 878.3333 | 1271.388 | 0.096 | 5.29E-06 | 86400 | 3.14 | 85.04526 | 44.741 | 44.741 |
| 5 DGT water-24 H | Cd | 5 | A-NB | 6.27 | 1.000 | 0.158 | 0.8 | 31.35 | 45.37913 | 0.096 | 5.3E-06 | 86400 | 3.14 | 3.029759 | 3.010 | 3.010 |
| 5 DGT water-24 H | Pb | 5 | A-NB | 0.151667 | 1.000 | 0.158 | 0.8 | 0.758333 | 1.097688 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.055569 | 0.009 | 0.009 |
| 5 DGT water-24 H | As | 5 | A-NB | 0.306 | 1.000 | 0.158 | 0.8 | 1.53 | 2.214675 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.163607 | | 0.164 |
| 5 DGT water-24 H | Ni | 5 | A-NB | 2.5 | 1.000 | 0.158 | 0.8 | 12.5 | 18.09375 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.181292 | 0.198 | 0.198 |

Table A1.88 (continued).

| Sample ID | Element | Tank | Treatment | Element con. | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt | C dgt - BG | C dgt final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 DGT water-24 H | Cu | 6 | A-NB | 1.93 | 1.000 | 0.158 | 0.8 | 9.65 | 13.96838 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.911957 | -0.077 | 0 |
| 6 DGT water-24 H | Zn | 6 | A-NB | 174.5333 | 1.0 | 0.158 | 0.8 | 872.6667 | 1263.185 | 0.096 | 5.29E-06 | 86400 | 3.14 | 84.49658 | 44.193 | 44.193 |
| 6 DGT water-24 H | Cd | 6 | A-NB | 11.81 | 1.00 | 0.158 | 0.8 | 59.05 | 85.47488 | 0.096 | 5.3E-06 | 86400 | 3.14 | 5.706771 | 5.687 | 5.687 |
| 6 DGT water-24 H | Pb | 6 | A-NB | 0.288 | 1.000 | 0.158 | 0.8 | 1.44 | 2.0844 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.105519 | 0.059 | 0.059 |
| 6 DGT water-24 H | As | 6 | A-NB | 0.292333 | 1.000 | 0.158 | 0.8 | 1.461667 | 2.115763 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.1563 | | 0.156 |
| 6 DGT water-24 H | Ni | 6 | A-NB | 4.006667 | 1.000 | 0.158 | 0.8 | 20.03333 | 28.99825 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.893217 | 0.910 | 0.910 |
| 7 DGT water-24 H | Cu | 7 | SED-B | 2.747667 | 1.000 | 0.158 | 0.8 | 13.73833 | 19.88624 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.298318 | 0.309 | 0.309 |
| 7 DGT water-24 H | Zn | 7 | SED-B | 145.1667 | 1.0 | 0.158 | 0.8 | 725.8333 | 1050.644 | 0.096 | 5.29E-06 | 86400 | 3.14 | 70.27934 | 29.975 | 29.975 |
| 7 DGT water-24 H | Cd | 7 | SED-B | 3.806 | 1.000 | 0.158 | 0.8 | 19.03 | 27.54593 | 0.096 | 5.3E-06 | 86400 | 3.14 | 1.839117 | 1.819 | 1.819 |
| 7 DGT water-24 H | Pb | 7 | SED-B | 0.221333 | 1.000 | 0.158 | 0.8 | 1.106667 | 1.6019 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.081094 | 0.034 | 0.034 |
| 7 DGT water-24 H | As | 7 | SED-B | 0.277667 | 1.000 | 0.158 | 0.8 | 1.388333 | 2.009613 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.148458 | | 0.148 |
| 7 DGT water-24 H | Ni | 7 | SED-B | 1.897667 | 1.000 | 0.158 | 0.8 | 9.488333 | 13.73436 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.896679 | -0.086 | 0 |
| 8 DGT water-24 H | Cu | 8 | SED-B | 3.405333 | 1.000 | 0.158 | 0.8 | 17.02667 | 24.6461 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.609077 | 0.620 | 0.620 |
| 8 DGT water-24 H | Zn | 8 | SED-B | 227.7 | 1.0 | 0.158 | 0.8 | 1138.5 | 1647.979 | 0.096 | 5.29E-06 | 86400 | 3.14 | 110.2361 | 69.932 | 69.932 |
| 8 DGT water-24 H | Cd | 8 | SED-B | 4.109667 | 1.000 | 0.158 | 0.8 | 20.54833 | 29.74371 | 0.096 | 5.3E-06 | 86400 | 3.14 | 1.985853 | 1.966 | 1.966 |
| 8 DGT water-24 H | Pb | 8 | SED-B | 0.192 | 1.000 | 0.158 | 0.8 | 0.96 | 1.3896 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.070346 | 0.024 | 0.024 |
| 8 DGT water-24 H | As | 8 | SED-B | 0.325 | 1.000 | 0.158 | 0.8 | 1.625 | 2.352188 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.173766 | | 0.174 |
| 8 DGT water-24 H | Ni | 8 | SED-B | 3.464667 | 1.000 | 0.158 | 0.8 | 17.32333 | 25.07553 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.637113 | 0.654 | 0.654 |
| 9 DGT water-24 H | Cu | 9 | SED-B | 2.861667 | 1.000 | 0.158 | 0.8 | 14.30833 | 20.71131 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.352185 | 0.363 | 0.363 |
| 9 DGT water-24 H | Zn | 9 | SED-B | 261.3333 | 1.0 | 0.158 | 0.8 | 1306.667 | 1891.4 | 0.096 | 5.29E-06 | 86400 | 3.14 | 126.5189 | 86.215 | 86.215 |
| 9 DGT water-24 H | Cd | 9 | SED-B | 3.245667 | 1.000 | 0.158 | 0.8 | 16.22833 | 23.49051 | 0.096 | 5.3E-06 | 86400 | 3.14 | 1.568355 | 1.549 | 1.549 |
| 9 DGT water-24 H | Pb | 9 | SED-B | 0.395 | 1.000 | 0.158 | 0.8 | 1.975 | 2.858813 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.144723 | 0.098 | 0.098 |
| 9 DGT water-24 H | As | 9 | SED-B | 0.322333 | 1.000 | 0.158 | 0.8 | 1.611667 | 2.332888 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.17234 | | 0.172 |
| 9 DGT water-24 H | Ni | 9 | SED-B | 2.129333 | 1.000 | 0.158 | 0.8 | 10.64667 | 15.41105 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.006145 | 0.023 | 0.023 |
| 10 DGT water-24 H | Cu | 10 | A-B | 2.155667 | 1.000 | 0.158 | 0.8 | 10.77833 | 15.60164 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.018588 | 0.030 | 0.030 |
| 10 DGT water-24 H | Zn | 10 | A-B | 114.5667 | 1.0 | 0.158 | 0.8 | 572.8333 | 829.1763 | 0.096 | 5.29E-06 | 86400 | 3.14 | 55.465 | 15.161 | 15.161 |
| 10 DGT water-24 H | Cd | 10 | A-B | 2.449333 | 1.000 | 0.158 | 0.8 | 12.24667 | 17.72705 | 0.096 | 5.3E-06 | 86400 | 3.14 | 1.183555 | 1.164 | 1.164 |
| 10 DGT water-24 H | Pb | 10 | A-B | 0.220333 | 1.000 | 0.158 | 0.8 | 1.101667 | 1.594663 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.080727 | 0.034 | 0.034 |
| 10 DGT water-24 H | As | 10 | A-B | 0.314 | 1.000 | 0.158 | 0.8 | 1.57 | 2.272575 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.167884 | | 0.168 |
| 10 DGT water-24 H | Ni | 10 | A-B | 1.738333 | 1.000 | 0.158 | 0.8 | 8.691667 | 12.58119 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.821391 | -0.162 | 0 |
| 11 DGT water-24 H | Cu | 11 | A-B | 1.995 | 1.000 | 0.158 | 0.8 | 9.975 | 14.43881 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.942671 | -0.046 | 0 |
| 11 DGT water-24 H | Zn | 11 | A-B | 129.7667 | 1.0 | 0.158 | 0.8 | 648.8333 | 939.1863 | 0.096 | 5.29E-06 | 86400 | 3.14 | 62.82376 | 22.520 | 22.520 |

Table A1.88 (continued).

| Sample ID | Element | Tank | Treatment | Element con. | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt | C dgt - BG | C dgt final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 DGT water-24 H | Cd | 11 | A-B | 2.741333 | 1.000 | 0.158 | 0.8 | 13.70667 | 19.8404 | 0.096 | 5.3E-06 | 86400 | 3.14 | 1.324654 | 1.305 | 1.305 |
| 11 DGT water-24 H | Pb | 11 | A-B | 0.245333 | 1.000 | 0.158 | 0.8 | 1.226667 | 1.7756 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.089887 | 0.043 | 0.043 |
| 11 DGT water-24 H | As | 11 | A-B | 0.375 | 1.000 | 0.158 | 0.8 | 1.875 | 2.714063 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.200499 | | 0.200 |
| 11 DGT water-24 H | Ni | 11 | A-B | 1.669 | 1.000 | 0.158 | 0.8 | 8.345 | 12.07939 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.78863 | -0.195 | 0 |
| 12 DGT water-24 H | Cu | 12 | A-B | 2.510667 | 1.000 | 0.158 | 0.8 | 12.55333 | 18.17095 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.186332 | 0.197 | 0.197 |
| 12 DGT water-24 H | Zn | 12 | A-B | 284.6 | 1.0 | 0.158 | 0.8 | 1423 | 2059.793 | 0.096 | 5.29E-06 | 86400 | 3.14 | 137.783 | 97.479 | 97.479 |
| 12 DGT water-24 H | Cd | 12 | A-B | 3.025 | 1.000 | 0.158 | 0.8 | 15.125 | 21.89344 | 0.096 | 5.3E-06 | 86400 | 3.14 | 1.461726 | 1.442 | 1.442 |
| 12 DGT water-24 H | Pb | 12 | A-B | 0.31 | 1.000 | 0.158 | 0.8 | 1.55 | 2.243625 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.11358 | 0.067 | 0.067 |
| 12 DGT water-24 H | As | 12 | A-B | 0.403 | 1.000 | 0.158 | 0.8 | 2.015 | 2.916713 | 0.096 | 4.79E-06 | 86400 | 3.14 | 0.21547 | | 0.215 |
| 12 DGT water-24 H | Ni | 12 | A-B | 1.739 | 1.000 | 0.158 | 0.8 | 8.695 | 12.58601 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.821706 | -0.161 | 0 |
| 13 blank 1 | Cu | blank | water blank | 0.954333 | 1.000 | 0.158 | 0.8 | 4.771667 | 6.906988 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.450938 | | 0.310 |
| 14 blank 2 | Cu | blank | water blank | 5.140667 | 1.000 | 0.158 | 0.8 | 25.70333 | 37.20558 | 0.096 | 5.42E-06 | 86400 | 3.14 | 2.429051 | | 1.668 |
| 13 blank 1 | Zn | blank | water blank | 108.5 | 1.0 | 0.158 | 0.8 | 542.5 | 785.2688 | 0.096 | 5.29E-06 | 86400 | 4.572 | 36.07563 | | 36.076 |
| 14 blank 2 | Zn | blank | water blank | 133.9333 | 1.0 | 0.158 | 0.8 | 669.6667 | 969.3425 | 0.096 | 5.29E-06 | 86400 | 4.572 | 44.53207 | | 44.532 |
| 13 blank 1 | Cd | blank | water blank | 0.041333 | 1.000 | 0.158 | 0.8 | 0.206667 | 0.29915 | 0.096 | 5.3E-06 | 86400 | 3.14 | 0.019973 | | 0.014 |
| 14 blank 2 | Cd | blank | water blank | 0.040667 | 1.000 | 0.158 | 0.8 | 0.203333 | 0.294325 | 0.096 | 5.3E-06 | 86400 | 3.14 | 0.019651 | | 0.013 |
| 13 blank 1 | Pb | blank | water blank | 0.127667 | 1.000 | 0.158 | 0.8 | 0.638333 | 0.923988 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.046775 | | 0.032 |
| 14 blank 2 | Pb | blank | water blank | 0.127667 | 1.000 | 0.158 | 0.8 | 0.638333 | 0.923988 | 0.096 | 6.99E-06 | 86400 | 3.14 | 0.046775 | | 0.032 |
| 13 blank 1 | As | blank | water blank | 0.197 | 1.000 | 0.158 | 0.8 | 0.985 | 1.425788 | 0.096 | 4.79E-06 | 86400 | 4.572 | 0.072339 | | 0.072 |
| 14 blank 2 | As | blank | water blank | 0.186 | 1.000 | 0.158 | 0.8 | 0.93 | 1.346175 | 0.096 | 4.79E-06 | 86400 | 4.572 | 0.068299 | | 0.068 |
| 13 blank 1 | Ni | blank | water blank | 2.352667 | 1.000 | 0.158 | 0.8 | 11.76333 | 17.02743 | 0.096 | 5.42E-06 | 86400 | 3.14 | 1.111674 | | 0.310 |
| 14 blank 2 | Ni | blank | water blank | 1.808667 | 1.000 | 0.158 | 0.8 | 9.043333 | 13.09023 | 0.096 | 5.42E-06 | 86400 | 3.14 | 0.854625 | | 1.668 |

Table A1.89. Raw data for As concentrations (µg $kg^{-1}$) measured by DGT probes ($C_{DGT}$) in cap and sediment and calculation of $C_{DGT}$. See Table A1.4 for additional details. VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; delta G is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit.

| Sample ID | Tank | Treatment | Layers | rep | As (ppb) | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 1-1s CL/DGT sediment | 1 | SED-NB | 1CL | 1 | 0.408 | 1 | 0.158 | 0.8 | 2.04 | 2.9529 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.150 |
| 2 1-1s A/DGT sediment | 1 | SED-NB | 3A | 1 | 0.466 | 1 | 0.158 | 0.8 | 2.33 | 3.372675 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.171 |
| 3 1-1s B/DGT sediment | 1 | SED-NB | 4B | 1 | 0.662 | 1 | 0.158 | 0.8 | 3.308333333 | 4.7888125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.243 |
| 4 1-2s CL/DGT sediment | 1 | SED-NB | 1CL | 2 | 0.537 | 1 | 0.158 | 0.8 | 2.685 | 3.8865375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.197 |
| 5 1-2s A/DGT sediment | 1 | SED-NB | 3A | 2 | 0.353 | 1 | 0.158 | 0.8 | 1.763333333 | 2.552425 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.129 |
| 6 1-2s B/DGT sediment | 1 | SED-NB | 4B | 2 | 0.584 | 1 | 0.158 | 0.8 | 2.921666667 | 4.2291125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.215 |
| 10 2-2s CL/DGT sediment | 2 | SED-NB | 1CL | 2 | 0.440 | 1 | 0.158 | 0.8 | 2.2 | 3.1845 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.162 |
| 11 2-2s A/DGT sediment | 2 | SED-NB | 3A | 2 | 0.845 | 1 | 0.158 | 0.8 | 4.226666667 | 6.1181 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.310 |
| 12 2-2s B/DGT sediment | 2 | SED-NB | 4B | 2 | 0.466 | 1 | 0.158 | 0.8 | 2.328333333 | 3.3702625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.171 |
| 7 2-1s CL/DGT sediment | 2 | SED-NB | 1CL | 1 | 0.645 | 1 | 0.158 | 0.8 | 3.225 | 4.6681875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.237 |
| 8 2-1s A/DGT sediment | 2 | SED-NB | 3A | 1 | 0.706 | 1 | 0.158 | 0.8 | 3.528333333 | 5.1072625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.259 |
| 9 2-1s B/DGT sediment | 2 | SED-NB | 4B | 1 | 1.922 | 1 | 0.158 | 0.8 | 9.61 | 13.910475 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.706 |
| 13 3-1s CL/DGT sediment | 3 | SED-NB | 1CL | 1 | 0.742 | 1 | 0.158 | 0.8 | 3.708333333 | 5.3678125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.272 |
| 14 3-1s A/DGT sediment | 3 | SED-NB | 3A | 1 | 0.500 | 1 | 0.158 | 0.8 | 2.5 | 3.61875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.184 |
| 15 3-1s B/DGT sediment | 3 | SED-NB | 4B | 1 | 0.601 | 1 | 0.158 | 0.8 | 3.003333333 | 4.347325 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.221 |
| 16 3-2s CL/DGT sediment | 3 | SED-NB | 1CL | 2 | 0.552 | 1 | 0.158 | 0.8 | 2.758333333 | 3.9926875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.203 |
| 17 3-2s A/DGT sediment | 3 | SED-NB | 3A | 2 | 0.647 | 1 | 0.158 | 0.8 | 3.236666667 | 4.685075 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.238 |
| 18 3-2s B/DGT sediment | 3 | SED-NB | 4B | 2 | 0.805 | 1 | 0.158 | 0.8 | 4.025 | 5.8261875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.296 |
| 19 4-1s CL/DGT sediment | 4 | A-NB | 1CL | 1 | 0.466 | 1 | 0.158 | 0.8 | 2.331666667 | 3.3750875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.171 |
| 20 4-1 s A cap/DGT sediment | 4 | A-NB | 2cap | 1 | 0.560 | 1 | 0.158 | 0.8 | 2.8 | 4.053 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.206 |
| 21 4-1s A/DGT sediment | 4 | A-NB | 3A | 1 | 0.502 | 1 | 0.158 | 0.8 | 2.51 | 3.633225 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.184 |
| 22 4-1s B/DGT sediment | 4 | A-NB | 4B | 1 | 0.533 | 1 | 0.158 | 0.8 | 2.665 | 3.8575875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.196 |
| 23 4-2s CL/DGT sediment | 4 | A-NB | 1CL | 2 | 0.349 | 1 | 0.158 | 0.8 | 1.745 | 2.5258875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.128 |
| 24 4-2 s A cap/DGT sediment | 4 | A-NB | 2cap | 2 | 0.798 | 1 | 0.158 | 0.8 | 3.99 | 5.775525 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.293 |
| 25 4-2s A/DGT sediment | 4 | A-NB | 3A | 2 | 0.742 | 1 | 0.158 | 0.8 | 3.708333333 | 5.3678125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.272 |
| 26 4-2s B/DGT sediment | 4 | A-NB | 4B | 2 | 0.558 | 1 | 0.158 | 0.8 | 2.788333333 | 4.0361125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.205 |
| 27 5-1s CL/DGT sediment | 5 | A-NB | 1CL | 1 | 0.625 | 1 | 0.158 | 0.8 | 3.125 | 4.5234375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.230 |
| 28 5-1 s A cap/DGT sediment | 5 | A-NB | 2cap | 1 | 0.603 | 1 | 0.158 | 0.8 | 3.015 | 4.3642125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.221 |
| 29 5-1s A/DGT sediment | 5 | A-NB | 3A | 1 | 0.598 | 1 | 0.158 | 0.8 | 2.991666667 | 4.3304375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.220 |
| 30 5-1s B/DGT sediment | 5 | A-NB | 4B | 1 | 1.021 | 1 | 0.158 | 0.8 | 5.103333333 | 7.387075 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.375 |
| 31 5-2s CL/DGT sediment | 5 | A-NB | 1CL | 2 | 0.650 | 1 | 0.158 | 0.8 | 3.251666667 | 4.7067875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.239 |
| 32 5-2 s A cap/DGT sediment | 5 | A-NB | 2cap | 2 | 0.724 | 1 | 0.158 | 0.8 | 3.621666667 | 5.2423625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.266 |
| 33 5-2s A/DGT sediment | 5 | A-NB | 3A | 2 | 0.410 | 1 | 0.158 | 0.8 | 2.051666667 | 2.9697875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.151 |
| 34 5-2s B/DGT sediment | 5 | A-NB | 4B | 2 | 0.777 | 1 | 0.158 | 0.8 | 3.886666667 | 5.62595 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.285 |
| 35 6-1s CL/DGT sediment | 6 | A-NB | 1CL | 1 | 0.490 | 1 | 0.158 | 0.8 | 2.448333333 | 3.5439625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.180 |
| 36 6-1 s A cap/DGT sediment | 6 | A-NB | 2cap | 1 | 0.760 | 1 | 0.158 | 0.8 | 3.801666667 | 5.5029125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.279 |
| 37 6-1s A/DGT sediment | 6 | A-NB | 3A | 1 | 0.507 | 1 | 0.158 | 0.8 | 2.536666667 | 3.671825 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.186 |
| 38 6-1s B/DGT sediment | 6 | A-NB | 4B | 1 | 0.820 | 1 | 0.158 | 0.8 | 4.101666667 | 5.9371625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.301 |
| 39 6-2s CL/DGT sediment | 6 | A-NB | 1CL | 2 | 0.542 | 1 | 0.158 | 0.8 | 2.711666667 | 3.9251375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.199 |

Table A1.89 (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 6-2 s A cap/DGT sediment | 6 | A-NB | 2cap | 2 | 0.803 | 1 | 0.158 | 0.8 | 4.015 | 5.8117125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.295 |
| 41 6-2s A/DGT sediment | 6 | A-NB | 3A | 2 | 0.457 | 1 | 0.158 | 0.8 | 2.283333333 | 3.305125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.168 |
| 42 6-2s B/DGT sediment | 6 | A-NB | 4B | 2 | 0.506 | 1 | 0.158 | 0.8 | 2.528333333 | 3.6597625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.186 |
| 43 7-1s CL/DGT sediment | 7 | SED-B | 1CL | 1 | 0.282 | 1 | 0.158 | 0.8 | 1.408333333 | 2.0385625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.103 |
| 44 7-1s A/DGT sediment | 7 | SED-B | 3A | 1 | 0.754 | 1 | 0.158 | 0.8 | 3.768333333 | 5.4546625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.277 |
| 45 7-1s B/DGT sediment | 7 | SED-B | 4B | 1 | 0.546 | 1 | 0.158 | 0.8 | 2.73 | 3.951675 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.200 |
| 46 7-2s CL/DGT sediment | 7 | SED-B | 1CL | 2 | 0.379 | 1 | 0.158 | 0.8 | 1.895 | 2.7430125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.139 |
| 47 7-2s A/DGT sediment | 7 | SED-B | 3A | 2 | 0.357 | 1 | 0.158 | 0.8 | 1.783333333 | 2.581375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.131 |
| 48 7-2s B/DGT sediment | 7 | SED-B | 4B | 2 | 0.354 | 1 | 0.158 | 0.8 | 1.768333333 | 2.5596625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.130 |
| 49 8-1s CL/DGT sediment | 8 | SED-B | 1CL | 1 | 0.441 | 1 | 0.158 | 0.8 | 2.205 | 3.1917375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.162 |
| 50 8-1s A/DGT sediment | 8 | SED-B | 3A | 1 | 0.398 | 1 | 0.158 | 0.8 | 1.988333333 | 2.8781125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.146 |
| 51 8-1s B/DGT sediment | 8 | SED-B | 4B | 1 | 0.332 | 1 | 0.158 | 0.8 | 1.661666667 | 2.4052625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.122 |
| 52 8-2s CL/DGT sediment | 8 | SED-B | 1CL | 2 | 0.568 | 1 | 0.158 | 0.8 | 2.838333333 | 4.1084875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.208 |
| 53 8-2s A/DGT sediment | 8 | SED-B | 3A | 2 | 0.529 | 1 | 0.158 | 0.8 | 2.643333333 | 3.826225 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.194 |
| 54 8-2s B/DGT sediment | 8 | SED-B | 4B | 2 | 0.548 | 1 | 0.158 | 0.8 | 2.738333333 | 3.9637375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.201 |
| 55 9-1s CL/DGT sediment | 9 | SED-B | 1CL | 1 | 0.697 | 1 | 0.158 | 0.8 | 3.485 | 5.0445375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.256 |
| 56 9-1s A/DGT sediment | 9 | SED-B | 3A | 1 | 0.457 | 1 | 0.158 | 0.8 | 2.283333333 | 3.305125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.168 |
| 57 9-1s B/DGT sediment | 9 | SED-B | 4B | 1 | 0.715 | 1 | 0.158 | 0.8 | 3.575 | 5.1748125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.263 |
| 58 9-2s CL/DGT sediment | 9 | SED-B | 1CL | 2 | 0.384 | 1 | 0.158 | 0.8 | 1.92 | 2.7792 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.141 |
| 60 9-2s A/DGT sediment | 9 | SED-B | 3A | 2 | 0.423 | 1 | 0.158 | 0.8 | 2.113333333 | 3.05905 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.155 |
| 61 9-2s B/DGT sediment | 9 | SED-B | 4B | 2 | 2.373 | 1 | 0.158 | 0.8 | 11.86666667 | 17.177 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.871 |
| 62 10-1s CL/DGT sediment | 10 | A-B | 1CL | 1 | 0.346 | 1 | 0.158 | 0.8 | 1.731666667 | 2.5065875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.127 |
| 63 10-1 s A cap/DGT sediment | 10 | A-B | 2cap | 1 | 0.466 | 1 | 0.158 | 0.8 | 2.33 | 3.372675 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.171 |
| 64 10-1s A/DGT sediment | 10 | A-B | 3A | 1 | 0.275 | 1 | 0.158 | 0.8 | 1.376666667 | 1.992725 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.101 |
| 65 10-1s B/DGT sediment | 10 | A-B | 4B | 1 | 0.685 | 1 | 0.158 | 0.8 | 3.426666667 | 4.9601 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.252 |
| 66 10-2s CL/DGT sediment | 10 | A-B | 1CL | 2 | 0.399 | 1 | 0.158 | 0.8 | 1.993333333 | 2.88535 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.146 |
| 67 10-2 s A cap/DGT sediment | 10 | A-B | 2cap | 2 | 0.499 | 1 | 0.158 | 0.8 | 2.495 | 3.6115125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.183 |
| 68 10-2s A/DGT sediment | 10 | A-B | 3A | 2 | 0.410 | 1 | 0.158 | 0.8 | 2.051666667 | 2.9697875 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.151 |
| 69 10-2s B/DGT sediment | 10 | A-B | 4B | 2 | 0.400 | 1 | 0.158 | 0.8 | 2.001666667 | 2.8974125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.147 |
| 70 11-1s CL/DGT sediment | 11 | A-B | 1CL | 1 | 0.357 | 1 | 0.158 | 0.8 | 1.783333333 | 2.581375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.131 |
| 71 11-1 s A cap/DGT sediment | 11 | A-B | 2cap | 1 | 0.459 | 1 | 0.158 | 0.8 | 2.295 | 3.3220125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.169 |
| 72 11-1s A/DGT sediment | 11 | A-B | 3A | 1 | 0.414 | 1 | 0.158 | 0.8 | 2.071666667 | 2.9987375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.152 |
| 73 11-1s B/DGT sediment | 11 | A-B | 4B | 1 | 0.542 | 1 | 0.158 | 0.8 | 2.71 | 3.922725 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.199 |
| 74 11-2s CL/DGT sediment | 11 | A-B | 1CL | 2 | 0.474 | 1 | 0.158 | 0.8 | 2.368333333 | 3.4281625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.174 |
| 75 11-2 s A cap/DGT sediment | 11 | A-B | 2cap | 2 | 0.879 | 1 | 0.158 | 0.8 | 4.395 | 6.3617625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.323 |
| 76 11-2s A/DGT sediment | 11 | A-B | 3A | 2 | 0.514 | 1 | 0.158 | 0.8 | 2.568333333 | 3.7176625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.189 |
| 77 11-2s B/DGT sediment | 11 | A-B | 4B | 2 | 0.662 | 1 | 0.158 | 0.8 | 3.308333333 | 4.7888125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.243 |
| 78 12-1s CL/DGT sediment | 12 | A-B | 1CL | 1 | 1.163 | 1 | 0.158 | 0.8 | 5.816666667 | 8.419625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.427 |
| 79 12-1 s A cap/DGT sediment | 12 | A-B | 2cap | 1 | 1.665 | 1 | 0.158 | 0.8 | 8.323333333 | 12.048025 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.611 |
| 80 12-1s A/DGT sediment | 12 | A-B | 3A | 1 | 0.841 | 1 | 0.158 | 0.8 | 4.205 | 6.0867375 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.309 |

Table A1.89 (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 12-1s B/DGT sediment | 12 | A-B | 4B | 1 | 1.111 | 1 | 0.158 | 0.8 | 5.553333333 | 8.03845 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.408 |
| 82 12-2s CL/DGT sediment | 12 | A-B | 1CL | 2 | 0.784 | 1 | 0.158 | 0.8 | 3.92 | 5.6742 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.288 |
| 83 12-2 s A cap/DGT sediment | 12 | A-B | 2cap | 2 | 0.991 | 1 | 0.158 | 0.8 | 4.955 | 7.1723625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.364 |
| 84 12-2s A/DGT sediment | 12 | A-B | 3A | 2 | 0.927 | 1 | 0.158 | 0.8 | 4.633333333 | 6.70675 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.340 |
| 85 12-2s B/DGT sediment | 12 | A-B | 4B | 2 | 1.182 | 1 | 0.158 | 0.8 | 5.91 | 8.554725 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.434 |
| 86 Blank 1 A/DGT sediment | blank | sed blank | sed blank | 1 | 0.408 | 1 | 0.158 | 0.8 | 2.04 | 2.9529 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.150 |
| 87 Blank 1 B/DGT sediment | blank | sed blank | sed blank | 1 | 0.323 | 1 | 0.158 | 0.8 | 1.616666667 | 2.340125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.119 |
| 88 Blank 2 A/DGT sediment | blank | sed blank | sed blank | 2 | 0.396 | 1 | 0.158 | 0.8 | 1.981666667 | 2.8684625 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.146 |
| 89 Blank 2 B/DGT sediment | blank | sed blank | sed blank | 2 | 0.411 | 1 | 0.158 | 0.8 | 2.055 | 2.9746125 | 0.096 | 0.00000479 | 86400 | 4.572 | 0.151 |

Table A1.90. Raw data for Cd concentrations (µg $kg^{-1}$) measured by DGT probes ($C_{DGT}$) in cap and sediment and calculation of $C_{DGT}$. See Table A1.4 for additional details. VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; delta G is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit.

| Sample ID | Tank | treatment | layers | rep | Cd | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C dgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 4-1s CL/DGT sediment | 4 | A-NB | 1CL | 1 | 30.28 | 1 | 0.158 | 0.8 | 151.4166667 | 219.175625 | 0.096 | 0.0000053 | 86400 | 4.572 | 10.050 |
| 27 5-1s CL/DGT sediment | 5 | A-NB | 1CL | 1 | 12.95 | 1 | 0.158 | 0.8 | 64.75 | 93.725625 | 0.096 | 0.0000053 | 86400 | 4.572 | 4.298 |
| 35 6-1s CL/DGT sediment | 6 | A-NB | 1CL | 1 | 17.97 | 1 | 0.158 | 0.8 | 89.85 | 130.057875 | 0.096 | 0.0000053 | 86400 | 4.572 | 5.964 |
| 62 10-1s CL/DGT sediment | 10 | A-B | 1CL | 1 | 3.161 | 1 | 0.158 | 0.8 | 15.80333333 | 22.875325 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.049 |
| 70 11-1s CL/DGT sediment | 11 | A-B | 1CL | 1 | 4.334 | 1 | 0.158 | 0.8 | 21.67166667 | 31.3697375 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.438 |
| 78 12-1s CL/DGT sediment | 12 | A-B | 1CL | 1 | 6.391 | 1 | 0.158 | 0.8 | 31.955 | 46.2548625 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.121 |
| 20 4-1 s A cap/DGT sediment | 4 | A-NB | 2cap | 1 | 30.40 | 1 | 0.158 | 0.8 | 152 | 220.02 | 0.096 | 0.0000053 | 86400 | 9.144 | 5.044 |
| 28 5-1 s A cap/DGT sediment | 5 | A-NB | 2cap | 1 | 18.07 | 1 | 0.158 | 0.8 | 90.36666667 | 130.80575 | 0.096 | 0.0000053 | 86400 | 9.144 | 2.999 |
| 36 6-1 s A cap/DGT sediment | 6 | A-NB | 2cap | 1 | 19.77 | 1 | 0.158 | 0.8 | 98.83333333 | 143.06125 | 0.096 | 0.0000053 | 86400 | 9.144 | 3.280 |
| 63 10-1 s A cap/DGT sediment | 10 | A-B | 2cap | 1 | 4.852 | 1 | 0.158 | 0.8 | 24.25833333 | 35.1139375 | 0.096 | 0.0000053 | 86400 | 9.144 | 0.805 |
| 71 11-1 s A cap/DGT sediment | 11 | A-B | 2cap | 1 | 6.584 | 1 | 0.158 | 0.8 | 32.91833333 | 47.6492875 | 0.096 | 0.0000053 | 86400 | 9.144 | 1.092 |
| 79 12-1 s A cap/DGT sediment | 12 | A-B | 2cap | 1 | 4.675 | 1 | 0.158 | 0.8 | 23.375 | 33.8353125 | 0.096 | 0.0000053 | 86400 | 9.144 | 0.776 |
| 21 4-1s A/DGT sediment | 4 | A-NB | 3A | 1 | 7.749 | 1 | 0.158 | 0.8 | 38.74666667 | 56.0858 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.572 |
| 29 5-1s A/DGT sediment | 5 | A-NB | 3A | 1 | 6.007 | 1 | 0.158 | 0.8 | 30.035 | 43.4756625 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.994 |
| 37 6-1s A/DGT sediment | 6 | A-NB | 3A | 1 | 4.591 | 1 | 0.158 | 0.8 | 22.95333333 | 33.22495 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.523 |
| 64 10-1s A/DGT sediment | 10 | A-B | 3A | 1 | 0.159 | 1 | 0.158 | 0.8 | 0.793333333 | 1.14835 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.053 |
| 72 11-1s A/DGT sediment | 11 | A-B | 3A | 1 | 3.239 | 1 | 0.158 | 0.8 | 16.19333333 | 23.43985 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.075 |
| 80 12-1s A/DGT sediment | 12 | A-B | 3A | 1 | 2.633 | 1 | 0.158 | 0.8 | 13.165 | 19.0563375 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.874 |
| 22 4-1s B/DGT sediment | 4 | A-NB | 4B | 1 | 5.122 | 1 | 0.158 | 0.8 | 25.61 | 37.070475 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.700 |
| 30 5-1s B/DGT sediment | 5 | A-NB | 4B | 1 | 6.807 | 1 | 0.158 | 0.8 | 34.035 | 49.2656625 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.259 |
| 38 6-1s B/DGT sediment | 6 | A-NB | 4B | 1 | 4.873 | 1 | 0.158 | 0.8 | 24.36333333 | 35.265925 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.617 |
| 65 10-1s B/DGT sediment | 10 | A-B | 4B | 1 | 2.387 | 1 | 0.158 | 0.8 | 11.93666667 | 17.278325 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.792 |
| 73 11-1s B/DGT sediment | 11 | A-B | 4B | 1 | 3.358 | 1 | 0.158 | 0.8 | 16.78833333 | 24.3011125 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.114 |
| 81 12-1s B/DGT sediment | 12 | A-B | 4B | 1 | 2.163 | 1 | 0.158 | 0.8 | 10.81333333 | 15.6523 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.718 |
| 23 4-2s CL/DGT sediment | 4 | A-NB | 1CL | 2 | 27.67 | 1 | 0.158 | 0.8 | 138.3333333 | 200.2375 | 0.096 | 0.0000053 | 86400 | 4.572 | 9.182 |
| 31 5-2s CL/DGT sediment | 5 | A-NB | 1CL | 2 | 8.741 | 1 | 0.158 | 0.8 | 43.70333333 | 63.260575 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.901 |
| 39 6-2s CL/DGT sediment | 6 | A-NB | 1CL | 2 | 24.39 | 1 | 0.158 | 0.8 | 121.9666667 | 176.54675 | 0.096 | 0.0000053 | 86400 | 4.572 | 8.095 |
| 66 10-2s CL/DGT sediment | 10 | A-B | 1CL | 2 | 3.356 | 1 | 0.158 | 0.8 | 16.78 | 24.28905 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.114 |
| 74 11-2s CL/DGT sediment | 11 | A-B | 1CL | 2 | 3.155 | 1 | 0.158 | 0.8 | 15.77333333 | 22.8319 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.047 |
| 82 12-2s CL/DGT sediment | 12 | A-B | 1CL | 2 | 3.978 | 1 | 0.158 | 0.8 | 19.88833333 | 28.7883625 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.320 |
| 24 4-2 s A cap/DGT sediment | 4 | A-NB | 2cap | 2 | 33.69 | 1 | 0.158 | 0.8 | 168.4666667 | 243.8555 | 0.096 | 0.0000053 | 86400 | 9.144 | 5.591 |
| 32 5-2 s A cap/DGT sediment | 5 | A-NB | 2cap | 2 | 15.95 | 1 | 0.158 | 0.8 | 79.76666667 | 115.46225 | 0.096 | 0.0000053 | 86400 | 9.144 | 2.647 |
| 40 6-2 s A cap/DGT sediment | 6 | A-NB | 2cap | 2 | 29.36 | 1 | 0.158 | 0.8 | 146.8 | 212.493 | 0.096 | 0.0000053 | 86400 | 9.144 | 4.872 |
| 67 10-2 s A cap/DGT sediment | 10 | A-B | 2cap | 2 | 3.327 | 1 | 0.158 | 0.8 | 16.635 | 24.0791625 | 0.096 | 0.0000053 | 86400 | 9.144 | 0.552 |
| 75 11-2 s A cap/DGT sediment | 11 | A-B | 2cap | 2 | 4.334 | 1 | 0.158 | 0.8 | 21.67166667 | 31.3697375 | 0.096 | 0.0000053 | 86400 | 9.144 | 0.719 |
| 83 12-2 s A cap/DGT sediment | 12 | A-B | 2cap | 2 | 3.723 | 1 | 0.158 | 0.8 | 18.61333333 | 26.9428 | 0.096 | 0.0000053 | 86400 | 9.144 | 0.618 |
| 25 4-2s A/DGT sediment | 4 | A-NB | 3A | 2 | 13.74 | 1 | 0.158 | 0.8 | 68.71666667 | 99.467375 | 0.096 | 0.0000053 | 86400 | 4.572 | 4.561 |
| 33 5-2s A/DGT sediment | 5 | A-NB | 3A | 2 | 3.725 | 1 | 0.158 | 0.8 | 18.625 | 26.9596875 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.236 |
| 41 6-2s A/DGT sediment | 6 | A-NB | 3A | 2 | 10.09 | 1 | 0.158 | 0.8 | 50.45 | 73.026375 | 0.096 | 0.0000053 | 86400 | 4.572 | 3.349 |

Table A1.90. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 10-2s A/DGT sediment | 10 | A-B | 3A | 2 | 1.722 | 1 | 0.158 | 0.8 | 8.611666667 | 12.4653875 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.572 |
| 76 11-2s A/DGT sediment | 11 | A-B | 3A | 2 | 2.754 | 1 | 0.158 | 0.8 | 13.76833333 | 19.9296625 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.914 |
| 84 12-2s A/DGT sediment | 12 | A-B | 3A | 2 | 2.580 | 1 | 0.158 | 0.8 | 12.9 | 18.67275 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.856 |
| 26 4-2s B/DGT sediment | 4 | A-NB | 4B | 2 | 6.853 | 1 | 0.158 | 0.8 | 34.265 | 49.5985875 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.274 |
| 34 5-2s B/DGT sediment | 5 | A-NB | 4B | 2 | 3.855 | 1 | 0.158 | 0.8 | 19.27666667 | 27.902975 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.279 |
| 42 6-2s B/DGT sediment | 6 | A-NB | 4B | 2 | 6.770 | 1 | 0.158 | 0.8 | 33.84833333 | 48.9954625 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.247 |
| 69 10-2s B/DGT sediment | 10 | A-B | 4B | 2 | 1.478 | 1 | 0.158 | 0.8 | 7.39 | 10.697025 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.490 |
| 77 11-2s B/DGT sediment | 11 | A-B | 4B | 2 | 2.379 | 1 | 0.158 | 0.8 | 11.89666667 | 17.220425 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.790 |
| 85 12-2s B/DGT sediment | 12 | A-B | 4B | 2 | 2.588 | 1 | 0.158 | 0.8 | 12.94 | 18.73065 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.859 |
| 1 1-1s CL/DGT sediment | 1 | SED-NB | 1CL | 1 | 28.87 | 1 | 0.158 | 0.8 | 144.3333333 | 208.9225 | 0.096 | 0.0000053 | 86400 | 4.572 | 9.580 |
| 7 2-1s CL/DGT sediment | 2 | SED-NB | 1CL | 1 | 45.88 | 1 | 0.158 | 0.8 | 229.3833333 | 332.032375 | 0.096 | 0.0000053 | 86400 | 4.572 | 15.225 |
| 13 3-1s CL/DGT sediment | 3 | SED-NB | 1CL | 1 | 39.84 | 1 | 0.158 | 0.8 | 199.2166667 | 288.366125 | 0.096 | 0.0000053 | 86400 | 4.572 | 13.223 |
| 43 7-1s CL/DGT sediment | 7 | SED-B | 1CL | 1 | 11.45 | 1 | 0.158 | 0.8 | 57.25 | 82.869375 | 0.096 | 0.0000053 | 86400 | 4.572 | 3.800 |
| 49 8-1s CL/DGT sediment | 8 | SED-B | 1CL | 1 | 12.53 | 1 | 0.158 | 0.8 | 62.65 | 90.685875 | 0.096 | 0.0000053 | 86400 | 4.572 | 4.158 |
| 55 9-1s CL/DGT sediment | 9 | SED-B | 1CL | 1 | 5.417 | 1 | 0.158 | 0.8 | 27.08666667 | 39.20795 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.798 |
| 2 1-1s A/DGT sediment | 1 | SED-NB | 3A | 1 | 22.53 | 1 | 0.158 | 0.8 | 112.65 | 163.060875 | 0.096 | 0.0000053 | 86400 | 4.572 | 7.477 |
| 8 2-1s A/DGT sediment | 2 | SED-NB | 3A | 1 | 29.67 | 1 | 0.158 | 0.8 | 148.3333333 | 214.7125 | 0.096 | 0.0000053 | 86400 | 4.572 | 9.845 |
| 14 3-1s A/DGT sediment | 3 | SED-NB | 3A | 1 | 22.41 | 1 | 0.158 | 0.8 | 112.0333333 | 162.16825 | 0.096 | 0.0000053 | 86400 | 4.572 | 7.436 |
| 44 7-1s A/DGT sediment | 7 | SED-B | 3A | 1 | 10.11 | 1 | 0.158 | 0.8 | 50.56666667 | 73.19525 | 0.096 | 0.0000053 | 86400 | 4.572 | 3.356 |
| 50 8-1s A/DGT sediment | 8 | SED-B | 3A | 1 | 9.267 | 1 | 0.158 | 0.8 | 46.335 | 67.0699125 | 0.096 | 0.0000053 | 86400 | 4.572 | 3.075 |
| 56 9-1s A/DGT sediment | 9 | SED-B | 3A | 1 | 4.358 | 1 | 0.158 | 0.8 | 21.79166667 | 31.5434375 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.446 |
| 3 1-1s B/DGT sediment | 1 | SED-NB | 4B | 1 | 17.84 | 1 | 0.158 | 0.8 | 89.21666667 | 129.141125 | 0.096 | 0.0000053 | 86400 | 4.572 | 5.922 |
| 9 2-1s B/DGT sediment | 2 | SED-NB | 4B | 1 | 19.94 | 1 | 0.158 | 0.8 | 99.68333333 | 144.291625 | 0.096 | 0.0000053 | 86400 | 4.572 | 6.616 |
| 15 3-1s B/DGT sediment | 3 | SED-NB | 4B | 1 | 16.54 | 1 | 0.158 | 0.8 | 82.7 | 119.70825 | 0.096 | 0.0000053 | 86400 | 4.572 | 5.489 |
| 45 7-1s B/DGT sediment | 7 | SED-B | 4B | 1 | 8.780 | 1 | 0.158 | 0.8 | 43.89833333 | 63.5428375 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.914 |
| 51 8-1s B/DGT sediment | 8 | SED-B | 4B | 1 | 7.115 | 1 | 0.158 | 0.8 | 35.57333333 | 51.4924 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.361 |
| 57 9-1s B/DGT sediment | 9 | SED-B | 4B | 1 | 4.878 | 1 | 0.158 | 0.8 | 24.39 | 35.304525 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.619 |
| 4 1-2s CL/DGT sediment | 1 | SED-NB | 1CL | 2 | 44.00 | 1 | 0.158 | 0.8 | 220.0166667 | 318.474125 | 0.096 | 0.0000053 | 86400 | 4.572 | 14.603 |
| 10 2-2s CL/DGT sediment | 2 | SED-NB | 1CL | 2 | 37.99 | 1 | 0.158 | 0.8 | 189.9666667 | 274.97675 | 0.096 | 0.0000053 | 86400 | 4.572 | 12.609 |
| 16 3-2s CL/DGT sediment | 3 | SED-NB | 1CL | 2 | 39.12 | 1 | 0.158 | 0.8 | 195.6 | 283.131 | 0.096 | 0.0000053 | 86400 | 4.572 | 12.983 |
| 46 7-2s CL/DGT sediment | 7 | SED-B | 1CL | 2 | 6.193 | 1 | 0.158 | 0.8 | 30.96666667 | 44.82425 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.055 |
| 52 8-2s CL/DGT sediment | 8 | SED-B | 1CL | 2 | 19.06 | 1 | 0.158 | 0.8 | 95.28333333 | 137.922625 | 0.096 | 0.0000053 | 86400 | 4.572 | 6.324 |
| 58 9-2s CL/DGT sediment | 9 | SED-B | 1CL | 2 | 3.123 | 1 | 0.158 | 0.8 | 15.61666667 | 22.605125 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.037 |
| 5 1-2s A/DGT sediment | 1 | SED-NB | 3A | 2 | 28.52 | 1 | 0.158 | 0.8 | 142.6 | 206.4135 | 0.096 | 0.0000053 | 86400 | 4.572 | 9.465 |
| 11 2-2s A/DGT sediment | 2 | SED-NB | 3A | 2 | 22.93 | 1 | 0.158 | 0.8 | 114.6666667 | 165.98 | 0.096 | 0.0000053 | 86400 | 4.572 | 7.611 |
| 17 3-2s A/DGT sediment | 3 | SED-NB | 3A | 2 | 27.76 | 1 | 0.158 | 0.8 | 138.7833333 | 200.888875 | 0.096 | 0.0000053 | 86400 | 4.572 | 9.212 |
| 47 7-2s A/DGT sediment | 7 | SED-B | 3A | 2 | 6.703 | 1 | 0.158 | 0.8 | 33.51666667 | 48.515375 | 0.096 | 0.0000053 | 86400 | 4.572 | 2.225 |
| 53 8-2s A/DGT sediment | 8 | SED-B | 3A | 2 | 13.88 | 1 | 0.158 | 0.8 | 69.38333333 | 100.432375 | 0.096 | 0.0000053 | 86400 | 4.572 | 4.605 |
| 60 9-2s A/DGT sediment | 9 | SED-B | 3A | 2 | 2.724 | 1 | 0.158 | 0.8 | 13.62166667 | 19.7173625 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.904 |
| 6 1-2s B/DGT sediment | 1 | SED-NB | 4B | 2 | 14.02 | 1 | 0.158 | 0.8 | 70.1 | 101.46975 | 0.096 | 0.0000053 | 86400 | 4.572 | 4.653 |

Table A1.90. (continued).

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 2-2s B/DGT sediment | 2 | SED-NB | 4B | 2 | 15.36 | 1 | 0.158 | 0.8 | 76.78333333 | 111.143875 | 0.096 | 0.0000053 | 86400 | 4.572 | 5.096 |
| 18 3-2s B/DGT sediment | 3 | SED-NB | 4B | 2 | 24.24 | 1 | 0.158 | 0.8 | 121.1833333 | 175.412875 | 0.096 | 0.0000053 | 86400 | 4.572 | 8.043 |
| 48 7-2s B/DGT sediment | 7 | SED-B | 4B | 2 | 4.949 | 1 | 0.158 | 0.8 | 24.745 | 35.8183875 | 0.096 | 0.0000053 | 86400 | 4.572 | 1.642 |
| 54 8-2s B/DGT sediment | 8 | SED-B | 4B | 2 | 15.46 | 1 | 0.158 | 0.8 | 77.3 | 111.89175 | 0.096 | 0.0000053 | 86400 | 4.572 | 5.131 |
| 61 9-2s B/DGT sediment | 9 | SED-B | 4B | 2 | 2.474 | 1 | 0.158 | 0.8 | 12.37 | 17.905575 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.821 |
| 86 Blank 1 A/DGT sediment | blank | sed blank | sed blank | 1 | 0.165 | 1 | 0.158 | 0.8 | 0.826666667 | 1.1966 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.055 |
| 87 Blank 1 B/DGT sediment | blank | sed blank | sed blank | 1 | 0.153 | 1 | 0.158 | 0.8 | 0.763333333 | 1.104925 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.051 |
| 88 Blank 2 A/DGT sediment | blank | sed blank | sed blank | 2 | 0.138 | 1 | 0.158 | 0.8 | 0.69 | 0.998775 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.046 |
| 89 Blank 2 B/DGT sediment | blank | sed blank | sed blank | 2 | 0.166 | 1 | 0.158 | 0.8 | 0.831666667 | 1.2038375 | 0.096 | 0.0000053 | 86400 | 4.572 | 0.055 |

Table A1.91. Raw data for Cu concentrations (µg $kg^{-1}$) measured by DGT probes ($C_{DGT}$) in cap and sediment and calculation of ($C_{DGT}$). See Table A1.4 for additional details. VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; delta G is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit.

| Sample ID | Tank | Treatment | Layers | rep | Cu | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 1-1s CL/DGT sediment | 1 | SED-NB | 1CL | 1 | 10.07 | 1 | 0.158 | 0.8 | 50.35 | 72.881625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.268 |
| 4 1-2s CL/DGT sediment | 1 | SED-NB | 1CL | 2 | 5.749 | 1 | 0.158 | 0.8 | 28.745 | 41.6083875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.866 |
| 2 1-1s A/DGT sediment | 1 | SED-NB | 3A | 1 | 15.28 | 1 | 0.158 | 0.8 | 76.4 | 110.589 | 0.096 | 5.42E-06 | 86400 | 4.572 | 4.959 |
| 5 1-2s A/DGT sediment | 1 | SED-NB | 3A | 2 | 5.092 | 1 | 0.158 | 0.8 | 25.45833333 | 36.8509375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.652 |
| 3 1-1s B/DGT sediment | 1 | SED-NB | 4B | 1 | 65.74 | 1 | 0.158 | 0.8 | 328.7 | 475.79325 | 0.096 | 5.42E-06 | 86400 | 4.572 | 21.334 |
| 6 1-2s B/DGT sediment | 1 | SED-NB | 4B | 2 | 7.169 | 1 | 0.158 | 0.8 | 35.84333333 | 51.883225 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.326 |
| 7 2-1s CL/DGT sediment | 2 | SED-NB | 1CL | 1 | 18.43 | 1 | 0.158 | 0.8 | 92.16666667 | 133.41125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 5.982 |
| 10 2-2s CL/DGT sediment | 2 | SED-NB | 1CL | 2 | 5.067 | 1 | 0.158 | 0.8 | 25.33666667 | 36.674825 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.644 |
| 8 2-1s A/DGT sediment | 2 | SED-NB | 3A | 1 | 6.103 | 1 | 0.158 | 0.8 | 30.51666667 | 44.172875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.981 |
| 11 2-2s A/DGT sediment | 2 | SED-NB | 3A | 2 | 4.937 | 1 | 0.158 | 0.8 | 24.685 | 35.7315375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.602 |
| 9 2-1s B/DGT sediment | 2 | SED-NB | 4B | 1 | 9.196 | 1 | 0.158 | 0.8 | 45.98166667 | 66.5584625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.984 |
| 12 2-2s B/DGT sediment | 2 | SED-NB | 4B | 2 | 4.183 | 1 | 0.158 | 0.8 | 20.91666667 | 30.276875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.358 |
| 13 3-1s CL/DGT sediment | 3 | SED-NB | 1CL | 1 | 6.817 | 1 | 0.158 | 0.8 | 34.08333333 | 49.335625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.212 |
| 16 3-2s CL/DGT sediment | 3 | SED-NB | 1CL | 2 | 4.357 | 1 | 0.158 | 0.8 | 21.785 | 31.5337875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.414 |
| 14 3-1s A/DGT sediment | 3 | SED-NB | 3A | 1 | 4.623 | 1 | 0.158 | 0.8 | 23.115 | 33.4589625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.500 |
| 17 3-2s A/DGT sediment | 3 | SED-NB | 3A | 2 | 4.438 | 1 | 0.158 | 0.8 | 22.19166667 | 32.1224375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.440 |
| 15 3-1s B/DGT sediment | 3 | SED-NB | 4B | 1 | 10.48 | 1 | 0.158 | 0.8 | 52.38333333 | 75.824875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.400 |
| 18 3-2s B/DGT sediment | 3 | SED-NB | 4B | 2 | 4.969 | 1 | 0.158 | 0.8 | 24.845 | 35.9631375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.613 |
| 19 4-1s CL/DGT sediment | 4 | A-NB | 1CL | 1 | 4.813 | 1 | 0.158 | 0.8 | 24.06333333 | 34.831675 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.562 |
| 23 4-2s CL/DGT sediment | 4 | A-NB | 1CL | 2 | 4.125 | 1 | 0.158 | 0.8 | 20.62333333 | 29.852275 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.339 |
| 20 4-1 s A cap/DGT sediment | 4 | A-NB | 2cap | 1 | 7.280 | 1 | 0.158 | 0.8 | 36.39833333 | 52.6865875 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.181 |
| 24 4-2 s A cap/DGT sediment | 4 | A-NB | 2cap | 2 | 7.291 | 1 | 0.158 | 0.8 | 36.45333333 | 52.7662 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.183 |
| 21 4-1s A/DGT sediment | 4 | A-NB | 3A | 1 | 4.265 | 1 | 0.158 | 0.8 | 21.32333333 | 30.865525 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.384 |
| 25 4-2s A/DGT sediment | 4 | A-NB | 3A | 2 | 5.214 | 1 | 0.158 | 0.8 | 26.06833333 | 37.7339125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.692 |
| 22 4-1s B/DGT sediment | 4 | A-NB | 4B | 1 | 4.011 | 1 | 0.158 | 0.8 | 20.05333333 | 29.0272 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.302 |
| 26 4-2s B/DGT sediment | 4 | A-NB | 4B | 2 | 5.285 | 1 | 0.158 | 0.8 | 26.42333333 | 38.247775 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.715 |
| 27 5-1s CL/DGT sediment | 5 | A-NB | 1CL | 1 | 5.155 | 1 | 0.158 | 0.8 | 25.77333333 | 37.3069 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.673 |
| 31 5-2s CL/DGT sediment | 5 | A-NB | 1CL | 2 | 4.612 | 1 | 0.158 | 0.8 | 23.06 | 33.37935 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.497 |
| 28 5-1 s A cap/DGT sediment | 5 | A-NB | 2cap | 1 | 6.022 | 1 | 0.158 | 0.8 | 30.11166667 | 43.5866375 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.977 |
| 32 5-2 s A cap/DGT sediment | 5 | A-NB | 2cap | 2 | 5.684 | 1 | 0.158 | 0.8 | 28.41833333 | 41.1355375 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.922 |
| 29 5-1s A/DGT sediment | 5 | A-NB | 3A | 1 | 3.971 | 1 | 0.158 | 0.8 | 19.85666667 | 28.742525 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.289 |
| 33 5-2s A/DGT sediment | 5 | A-NB | 3A | 2 | 2.860 | 1 | 0.158 | 0.8 | 14.30166667 | 20.7016625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.928 |
| 30 5-1s B/DGT sediment | 5 | A-NB | 4B | 1 | 5.235 | 1 | 0.158 | 0.8 | 26.17666667 | 37.890725 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.699 |

Table A1.91. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 5-2s B/DGT sediment | 5 | A-NB | 4B | 2 | 4.633 | 1 | 0.158 | 0.8 | 23.16333333 | 33.528925 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.503 |
| 35 6-1s CL/DGT sediment | 6 | A-NB | 1CL | 1 | 4.079 | 1 | 0.158 | 0.8 | 20.39666667 | 29.524175 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.324 |
| 39 6-2s CL/DGT sediment | 6 | A-NB | 1CL | 2 | 4.736 | 1 | 0.158 | 0.8 | 23.67833333 | 34.2743875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.537 |
| 36 6-1 s A cap/DGT sediment | 6 | A-NB | 2cap | 1 | 6.349 | 1 | 0.158 | 0.8 | 31.745 | 45.9508875 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.030 |
| 40 6-2 s A cap/DGT sediment | 6 | A-NB | 2cap | 2 | 9.547 | 1 | 0.158 | 0.8 | 47.73666667 | 69.098825 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.549 |
| 37 6-1s A/DGT sediment | 6 | A-NB | 3A | 1 | 4.636 | 1 | 0.158 | 0.8 | 23.17833333 | 33.5506375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.504 |
| 41 6-2s A/DGT sediment | 6 | A-NB | 3A | 2 | 5.608 | 1 | 0.158 | 0.8 | 28.03833333 | 40.5854875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.820 |
| 38 6-1s B/DGT sediment | 6 | A-NB | 4B | 1 | 5.059 | 1 | 0.158 | 0.8 | 25.29333333 | 36.6121 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.642 |
| 42 6-2s B/DGT sediment | 6 | A-NB | 4B | 2 | 5.204 | 1 | 0.158 | 0.8 | 26.02 | 37.66395 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.689 |
| 43 7-1s CL/DGT sediment | 7 | SED-B | 1CL | 1 | 3.953 | 1 | 0.158 | 0.8 | 19.76666667 | 28.61225 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.283 |
| 46 7-2s CL/DGT sediment | 7 | SED-B | 1CL | 2 | 3.422 | 1 | 0.158 | 0.8 | 17.11166667 | 24.7691375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.111 |
| 44 7-1s A/DGT sediment | 7 | SED-B | 3A | 1 | 5.635 | 1 | 0.158 | 0.8 | 28.17333333 | 40.7809 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.829 |
| 47 7-2s A/DGT sediment | 7 | SED-B | 3A | 2 | 2.829 | 1 | 0.158 | 0.8 | 14.14333333 | 20.472475 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.918 |
| 45 7-1s B/DGT sediment | 7 | SED-B | 4B | 1 | 3.731 | 1 | 0.158 | 0.8 | 18.65666667 | 27.005525 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.211 |
| 48 7-2s B/DGT sediment | 7 | SED-B | 4B | 2 | 5.095 | 1 | 0.158 | 0.8 | 25.475 | 36.8750625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.653 |
| 49 8-1s CL/DGT sediment | 8 | SED-B | 1CL | 1 | 4.959 | 1 | 0.158 | 0.8 | 24.795 | 35.8907625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.609 |
| 52 8-2s CL/DGT sediment | 8 | SED-B | 1CL | 2 | 5.570 | 1 | 0.158 | 0.8 | 27.85166667 | 40.3152875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.808 |
| 50 8-1s A/DGT sediment | 8 | SED-B | 3A | 1 | 4.918 | 1 | 0.158 | 0.8 | 24.59166667 | 35.5964375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.596 |
| 53 8-2s A/DGT sediment | 8 | SED-B | 3A | 2 | 5.490 | 1 | 0.158 | 0.8 | 27.45 | 39.733875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.782 |
| 51 8-1s B/DGT sediment | 8 | SED-B | 4B | 1 | 4.502 | 1 | 0.158 | 0.8 | 22.51166667 | 32.5856375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.461 |
| 54 8-2s B/DGT sediment | 8 | SED-B | 4B | 2 | 5.938 | 1 | 0.158 | 0.8 | 29.69166667 | 42.9786875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.927 |
| 55 9-1s CL/DGT sediment | 9 | SED-B | 1CL | 1 | 25.82 | 1 | 0.158 | 0.8 | 129.0833333 | 186.848125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 8.378 |
| 58 9-2s CL/DGT sediment | 9 | SED-B | 1CL | 2 | 3.076 | 1 | 0.158 | 0.8 | 15.38 | 22.26255 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.998 |
| 56 9-1s A/DGT sediment | 9 | SED-B | 3A | 1 | 15.83 | 1 | 0.158 | 0.8 | 79.13333333 | 114.5455 | 0.096 | 5.42E-06 | 86400 | 4.572 | 5.136 |
| 60 9-2s A/DGT sediment | 9 | SED-B | 3A | 2 | 3.115 | 1 | 0.158 | 0.8 | 15.575 | 22.5448125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.011 |
| 57 9-1s B/DGT sediment | 9 | SED-B | 4B | 1 | 6.113 | 1 | 0.158 | 0.8 | 30.56333333 | 44.240425 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.984 |
| 61 9-2s B/DGT sediment | 9 | SED-B | 4B | 2 | 434.8 | 1 | 0.158 | 0.8 | 2174.166667 | 3147.10625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 141.112 |
| 62 10-1s CL/DGT sediment | 10 | A-B | 1CL | 1 | 3.418 | 1 | 0.158 | 0.8 | 17.08833333 | 24.7353625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.109 |
| 66 10-2s CL/DGT sediment | 10 | A-B | 1CL | 2 | 3.445 | 1 | 0.158 | 0.8 | 17.225 | 24.9331875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.118 |
| 63 10-1 s A cap/DGT sediment | 10 | A-B | 2cap | 1 | 5.183 | 1 | 0.158 | 0.8 | 25.915 | 37.5119625 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.841 |
| 67 10-2 s A cap/DGT sediment | 10 | A-B | 2cap | 2 | 4.712 | 1 | 0.158 | 0.8 | 23.56 | 34.1031 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.765 |
| 64 10-1s A/DGT sediment | 10 | A-B | 3A | 1 | 1.739 | 1 | 0.158 | 0.8 | 8.695 | 12.5860125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.564 |
| 68 10-2s A/DGT sediment | 10 | A-B | 3A | 2 | 3.561 | 1 | 0.158 | 0.8 | 17.805 | 25.7727375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.156 |
| 65 10-1s B/DGT sediment | 10 | A-B | 4B | 1 | 3.792 | 1 | 0.158 | 0.8 | 18.96 | 27.4446 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.231 |
| 69 10-2s B/DGT sediment | 10 | A-B | 4B | 2 | 3.160 | 1 | 0.158 | 0.8 | 15.79833333 | 22.8680875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.025 |

Table A1.91. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 11-1s CL/DGT sediment | 11 | A-B | 1CL | 1 | 4.448 | 1 | 0.158 | 0.8 | 22.23833333 | 32.1899875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.443 |
| 74 11-2s CL/DGT sediment | 11 | A-B | 1CL | 2 | 3.027 | 1 | 0.158 | 0.8 | 15.135 | 21.9079125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.982 |
| 71 11-1 s A cap/DGT sediment | 11 | A-B | 2cap | 1 | 5.677 | 1 | 0.158 | 0.8 | 28.38333333 | 41.084875 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.921 |
| 75 11-2 s A cap/DGT sediment | 11 | A-B | 2cap | 2 | 5.293 | 1 | 0.158 | 0.8 | 26.46666667 | 38.3105 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.859 |
| 72 11-1s A/DGT sediment | 11 | A-B | 3A | 1 | 262.9 | 1 | 0.158 | 0.8 | 1314.333333 | 1902.4975 | 0.096 | 5.42E-06 | 86400 | 4.572 | 85.305 |
| 76 11-2s A/DGT sediment | 11 | A-B | 3A | 2 | 3.781 | 1 | 0.158 | 0.8 | 18.90666667 | 27.3674 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.227 |
| 73 11-1s B/DGT sediment | 11 | A-B | 4B | 1 | 7.156 | 1 | 0.158 | 0.8 | 35.77833333 | 51.7891375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.322 |
| 77 11-2s B/DGT sediment | 11 | A-B | 4B | 2 | 4.953 | 1 | 0.158 | 0.8 | 24.765 | 35.8473375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.607 |
| 78 12-1s CL/DGT sediment | 12 | A-B | 1CL | 1 | 4.988 | 1 | 0.158 | 0.8 | 24.93833333 | 36.0982375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.619 |
| 82 12-2s CL/DGT sediment | 12 | A-B | 1CL | 2 | 4.552 | 1 | 0.158 | 0.8 | 22.76 | 32.9451 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.477 |
| 79 12-1 s A cap/DGT sediment | 12 | A-B | 2cap | 1 | 6.719 | 1 | 0.158 | 0.8 | 33.59666667 | 48.631175 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.090 |
| 83 12-2 s A cap/DGT sediment | 12 | A-B | 2cap | 2 | 6.312 | 1 | 0.158 | 0.8 | 31.56166667 | 45.6855125 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.024 |
| 80 12-1s A/DGT sediment | 12 | A-B | 3A | 1 | 4.038 | 1 | 0.158 | 0.8 | 20.19166667 | 29.2274375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.311 |
| 84 12-2s A/DGT sediment | 12 | A-B | 3A | 2 | 385.9 | 1 | 0.158 | 0.8 | 1929.666667 | 2793.1925 | 0.096 | 5.42E-06 | 86400 | 4.572 | 125.243 |
| 81 12-1s B/DGT sediment | 12 | A-B | 4B | 1 | 4.670 | 1 | 0.158 | 0.8 | 23.35166667 | 33.8015375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.516 |
| 85 12-2s B/DGT sediment | 12 | A-B | 4B | 2 | 5.715 | 1 | 0.158 | 0.8 | 28.575 | 41.3623125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.855 |
| 86 Blank 1 A/DGT sediment | blank | sed blank | sed blank | 1 | 2.057 | 1 | 0.158 | 0.8 | 10.28666667 | 14.88995 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.668 |
| 87 Blank 1 B/DGT sediment | blank | sed blank | sed blank | 1 | 3.193 | 1 | 0.158 | 0.8 | 15.96666667 | 23.11175 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.036 |
| 88 Blank 2 A/DGT sediment | blank | sed blank | sed blank | 2 | 5.553 | 1 | 0.158 | 0.8 | 27.76666667 | 40.19225 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.802 |
| 89 Blank 2 B/DGT sediment | blank | sed blank | sed blank | 2 | 2.532 | 1 | 0.158 | 0.8 | 12.66 | 18.32535 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.822 |

Table A1.92. Raw data for Ni concentrations (µg $kg^{-1}$) measured by DGT probes ($C_{DGT}$) in cap and sediment and calculation of $C_{DGT}$. See Table A1.4 for additional details. VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; delta G is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit

| Sample ID | Tank | Treatment | Layers | Rep | Ni | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 1-1s CL/DGT sediment | 1 | SED-NB | 1CL | 1 | 13.56 | 1 | 0.158 | 0.8 | 67.78333333 | 98.116375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 4.399 |
| 4 1-2s CL/DGT sediment | 1 | SED-NB | 1CL | 2 | 18.08 | 1 | 0.158 | 0.8 | 90.4 | 130.854 | 0.096 | 5.42E-06 | 86400 | 4.572 | 5.867 |
| 2 1-1s A/DGT sediment | 1 | SED-NB | 3A | 1 | 9.913 | 1 | 0.158 | 0.8 | 49.56333333 | 71.742925 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.217 |
| 5 1-2s A/DGT sediment | 1 | SED-NB | 3A | 2 | 12.05 | 1 | 0.158 | 0.8 | 60.26666667 | 87.236 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.912 |
| 3 1-1s B/DGT sediment | 1 | SED-NB | 4B | 1 | 8.360 | 1 | 0.158 | 0.8 | 41.80166667 | 60.5079125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.713 |
| 6 1-2s B/DGT sediment | 1 | SED-NB | 4B | 2 | 8.585 | 1 | 0.158 | 0.8 | 42.92333333 | 62.131525 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.786 |
| 7 2-1s CL/DGT sediment | 2 | SED-NB | 1CL | 1 | 16.20 | 1 | 0.158 | 0.8 | 80.98333333 | 117.223375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 5.256 |
| 10 2-2s CL/DGT sediment | 2 | SED-NB | 1CL | 2 | 19.90 | 1 | 0.158 | 0.8 | 99.5 | 144.02625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 6.458 |
| 8 2-1s A/DGT sediment | 2 | SED-NB | 3A | 1 | 9.719 | 1 | 0.158 | 0.8 | 48.59666667 | 70.343675 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.154 |
| 11 2-2s A/DGT sediment | 2 | SED-NB | 3A | 2 | 14.37 | 1 | 0.158 | 0.8 | 71.86666667 | 104.027 | 0.096 | 5.42E-06 | 86400 | 4.572 | 4.664 |
| 9 2-1s B/DGT sediment | 2 | SED-NB | 4B | 1 | 6.974 | 1 | 0.158 | 0.8 | 34.86833333 | 50.4719125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.263 |
| 12 2-2s B/DGT sediment | 2 | SED-NB | 4B | 2 | 8.827 | 1 | 0.158 | 0.8 | 44.13666667 | 63.887825 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.865 |
| 13 3-1s CL/DGT sediment | 3 | SED-NB | 1CL | 1 | 16.86 | 1 | 0.158 | 0.8 | 84.28333333 | 122.000125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 5.470 |
| 16 3-2s CL/DGT sediment | 3 | SED-NB | 1CL | 2 | 15.59 | 1 | 0.158 | 0.8 | 77.95 | 112.832625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 5.059 |
| 14 3-1s A/DGT sediment | 3 | SED-NB | 3A | 1 | 10.78 | 1 | 0.158 | 0.8 | 53.88333333 | 77.996125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.497 |
| 17 3-2s A/DGT sediment | 3 | SED-NB | 3A | 2 | 11.67 | 1 | 0.158 | 0.8 | 58.35 | 84.461625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.787 |
| 15 3-1s B/DGT sediment | 3 | SED-NB | 4B | 1 | 7.452 | 1 | 0.158 | 0.8 | 37.26166667 | 53.9362625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.418 |
| 18 3-2s B/DGT sediment | 3 | SED-NB | 4B | 2 | 10.09 | 1 | 0.158 | 0.8 | 50.445 | 73.0191375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 3.274 |
| 19 4-1s CL/DGT sediment | 4 | A-NB | 1CL | 1 | 7.696 | 1 | 0.158 | 0.8 | 38.48 | 55.6998 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.498 |
| 23 4-2s CL/DGT sediment | 4 | A-NB | 1CL | 2 | 6.623 | 1 | 0.158 | 0.8 | 33.11333333 | 47.93155 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.149 |
| 20 4-1 s A cap/DGT sediment | 4 | A-NB | 2cap | 1 | 7.409 | 1 | 0.158 | 0.8 | 37.045 | 53.6226375 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.202 |
| 24 4-2 s A cap/DGT sediment | 4 | A-NB | 2cap | 2 | 8.113 | 1 | 0.158 | 0.8 | 40.565 | 58.7178375 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.316 |
| 21 4-1s A/DGT sediment | 4 | A-NB | 3A | 1 | 3.302 | 1 | 0.158 | 0.8 | 16.51 | 23.898225 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.072 |
| 25 4-2s A/DGT sediment | 4 | A-NB | 3A | 2 | 4.386 | 1 | 0.158 | 0.8 | 21.92833333 | 31.7412625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.423 |
| 22 4-1s B/DGT sediment | 4 | A-NB | 4B | 1 | 2.366 | 1 | 0.158 | 0.8 | 11.82833333 | 17.1215125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.768 |
| 26 4-2s B/DGT sediment | 4 | A-NB | 4B | 2 | 3.581 | 1 | 0.158 | 0.8 | 17.90666667 | 25.9199 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.162 |
| 27 5-1s CL/DGT sediment | 5 | A-NB | 1CL | 1 | 5.233 | 1 | 0.158 | 0.8 | 26.16333333 | 37.871425 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.698 |
| 31 5-2s CL/DGT sediment | 5 | A-NB | 1CL | 2 | 2.987 | 1 | 0.158 | 0.8 | 14.935 | 21.6184125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.969 |
| 28 5-1 s A cap/DGT sediment | 5 | A-NB | 2cap | 1 | 6.310 | 1 | 0.158 | 0.8 | 31.54833333 | 45.6662125 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.024 |
| 32 5-2 s A cap/DGT sediment | 5 | A-NB | 2cap | 2 | 4.222 | 1 | 0.158 | 0.8 | 21.11 | 30.556725 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.685 |
| 29 5-1s A/DGT sediment | 5 | A-NB | 3A | 1 | 3.206 | 1 | 0.158 | 0.8 | 16.03166667 | 23.2058375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.041 |
| 33 5-2s A/DGT sediment | 5 | A-NB | 3A | 2 | 2.655 | 1 | 0.158 | 0.8 | 13.27666667 | 19.217975 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.862 |
| 30 5-1s B/DGT sediment | 5 | A-NB | 4B | 1 | 2.869 | 1 | 0.158 | 0.8 | 14.34666667 | 20.7668 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.931 |
| 34 5-2s B/DGT sediment | 5 | A-NB | 4B | 2 | 2.037 | 1 | 0.158 | 0.8 | 10.18666667 | 14.7452 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.661 |

Table A1.92. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 6-1s CL/DGT sediment | 6 | A-NB | 1CL | 1 | 4.452 | 1 | 0.158 | 0.8 | 22.26 | 32.22135 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.445 |
| 39 6-2s CL/DGT sediment | 6 | A-NB | 1CL | 2 | 6.257 | 1 | 0.158 | 0.8 | 31.28666667 | 45.28745 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.031 |
| 36 6-1 s A cap/DGT sediment | 6 | A-NB | 2cap | 1 | 4.986 | 1 | 0.158 | 0.8 | 24.93166667 | 36.0885875 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.809 |
| 40 6-2 s A cap/DGT sediment | 6 | A-NB | 2cap | 2 | 7.458 | 1 | 0.158 | 0.8 | 37.29166667 | 53.9796875 | 0.096 | 5.42E-06 | 86400 | 9.144 | 1.210 |
| 37 6-1s A/DGT sediment | 6 | A-NB | 3A | 1 | 3.071 | 1 | 0.158 | 0.8 | 15.35666667 | 22.228775 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.997 |
| 41 6-2s A/DGT sediment | 6 | A-NB | 3A | 2 | 6.498 | 1 | 0.158 | 0.8 | 32.49166667 | 47.0316875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.109 |
| 38 6-1s B/DGT sediment | 6 | A-NB | 4B | 1 | 3.143 | 1 | 0.158 | 0.8 | 15.71333333 | 22.74505 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.020 |
| 42 6-2s B/DGT sediment | 6 | A-NB | 4B | 2 | 4.159 | 1 | 0.158 | 0.8 | 20.79333333 | 30.09835 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.350 |
| 43 7-1s CL/DGT sediment | 7 | SED-B | 1CL | 1 | 4.556 | 1 | 0.158 | 0.8 | 22.77833333 | 32.9716375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.478 |
| 46 7-2s CL/DGT sediment | 7 | SED-B | 1CL | 2 | 4.396 | 1 | 0.158 | 0.8 | 21.98 | 31.81605 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.427 |
| 44 7-1s A/DGT sediment | 7 | SED-B | 3A | 1 | 3.786 | 1 | 0.158 | 0.8 | 18.92833333 | 27.3987625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.229 |
| 47 7-2s A/DGT sediment | 7 | SED-B | 3A | 2 | 2.153 | 1 | 0.158 | 0.8 | 10.76333333 | 15.579925 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.699 |
| 45 7-1s B/DGT sediment | 7 | SED-B | 4B | 1 | 2.767 | 1 | 0.158 | 0.8 | 13.83333333 | 20.02375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.898 |
| 48 7-2s B/DGT sediment | 7 | SED-B | 4B | 2 | 2.269 | 1 | 0.158 | 0.8 | 11.34333333 | 16.419475 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.736 |
| 49 8-1s CL/DGT sediment | 8 | SED-B | 1CL | 1 | 3.985 | 1 | 0.158 | 0.8 | 19.92666667 | 28.84385 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.293 |
| 52 8-2s CL/DGT sediment | 8 | SED-B | 1CL | 2 | 5.523 | 1 | 0.158 | 0.8 | 27.61333333 | 39.9703 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.792 |
| 50 8-1s A/DGT sediment | 8 | SED-B | 3A | 1 | 3.075 | 1 | 0.158 | 0.8 | 15.375 | 22.2553125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.998 |
| 53 8-2s A/DGT sediment | 8 | SED-B | 3A | 2 | 4.073 | 1 | 0.158 | 0.8 | 20.36666667 | 29.48075 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.322 |
| 51 8-1s B/DGT sediment | 8 | SED-B | 4B | 1 | 2.426 | 1 | 0.158 | 0.8 | 12.12833333 | 17.5557625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.787 |
| 54 8-2s B/DGT sediment | 8 | SED-B | 4B | 2 | 4.471 | 1 | 0.158 | 0.8 | 22.35666667 | 32.361275 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.451 |
| 55 9-1s CL/DGT sediment | 9 | SED-B | 1CL | 1 | 2.972 | 1 | 0.158 | 0.8 | 14.85833333 | 21.5074375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.964 |
| 58 9-2s CL/DGT sediment | 9 | SED-B | 1CL | 2 | 2.192 | 1 | 0.158 | 0.8 | 10.96166667 | 15.8670125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.711 |
| 56 9-1s A/DGT sediment | 9 | SED-B | 3A | 1 | 2.324 | 1 | 0.158 | 0.8 | 11.62 | 16.81995 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.754 |
| 60 9-2s A/DGT sediment | 9 | SED-B | 3A | 2 | 0.905 | 1 | 0.158 | 0.8 | 4.523333333 | 6.547525 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.294 |
| 57 9-1s B/DGT sediment | 9 | SED-B | 4B | 1 | 2.210 | 1 | 0.158 | 0.8 | 11.05 | 15.994875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.717 |
| 61 9-2s B/DGT sediment | 9 | SED-B | 4B | 2 | 6.436 | 1 | 0.158 | 0.8 | 32.18166667 | 46.5829625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 2.089 |
| 62 10-1s CL/DGT sediment | 10 | A-B | 1CL | 1 | 1.832 | 1 | 0.158 | 0.8 | 9.16 | 13.2591 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.595 |
| 66 10-2s CL/DGT sediment | 10 | A-B | 1CL | 2 | 2.409 | 1 | 0.158 | 0.8 | 12.04666667 | 17.43755 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.782 |
| 63 10-1 s A cap/DGT sediment | 10 | A-B | 2cap | 1 | 3.816 | 1 | 0.158 | 0.8 | 19.07833333 | 27.6158875 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.619 |
| 67 10-2 s A cap/DGT sediment | 10 | A-B | 2cap | 2 | 3.171 | 1 | 0.158 | 0.8 | 15.85333333 | 22.9477 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.514 |
| 64 10-1s A/DGT sediment | 10 | A-B | 3A | 1 | 1.382 | 1 | 0.158 | 0.8 | 6.91 | 10.002225 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.448 |
| 68 10-2s A/DGT sediment | 10 | A-B | 3A | 2 | 1.951 | 1 | 0.158 | 0.8 | 9.755 | 14.1203625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.633 |
| 65 10-1s B/DGT sediment | 10 | A-B | 4B | 1 | 4.292 | 1 | 0.158 | 0.8 | 21.45833333 | 31.0609375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.393 |
| 69 10-2s B/DGT sediment | 10 | A-B | 4B | 2 | 2.697 | 1 | 0.158 | 0.8 | 13.48666667 | 19.52195 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.875 |
| 70 11-1s CL/DGT sediment | 11 | A-B | 1CL | 1 | 2.706 | 1 | 0.158 | 0.8 | 13.53 | 19.584675 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.878 |
| 74 11-2s CL/DGT sediment | 11 | A-B | 1CL | 2 | 2.037 | 1 | 0.158 | 0.8 | 10.185 | 14.7427875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.661 |
| 71 11-1 s A cap/DGT sediment | 11 | A-B | 2cap | 1 | 4.351 | 1 | 0.158 | 0.8 | 21.755 | 31.4903625 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.706 |
| 75 11-2 s A cap/DGT sediment | 11 | A-B | 2cap | 2 | 4.569 | 1 | 0.158 | 0.8 | 22.84666667 | 33.07055 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.741 |

Table A1.92. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 11-1s A/DGT sediment | 11 | A-B | 3A | 1 | 3.996 | 1 | 0.158 | 0.8 | 19.98166667 | 28.9234625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.297 |
| 76 11-2s A/DGT sediment | 11 | A-B | 3A | 2 | 2.563 | 1 | 0.158 | 0.8 | 12.81666667 | 18.552125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.832 |
| 73 11-1s B/DGT sediment | 11 | A-B | 4B | 1 | 2.616 | 1 | 0.158 | 0.8 | 13.07833333 | 18.9308875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.849 |
| 77 11-2s B/DGT sediment | 11 | A-B | 4B | 2 | 2.282 | 1 | 0.158 | 0.8 | 11.40833333 | 16.5135625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.740 |
| 78 12-1s CL/DGT sediment | 12 | A-B | 1CL | 1 | 3.314 | 1 | 0.158 | 0.8 | 16.57 | 23.985075 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.075 |
| 82 12-2s CL/DGT sediment | 12 | A-B | 1CL | 2 | 3.895 | 1 | 0.158 | 0.8 | 19.475 | 28.1900625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 1.264 |
| 79 12-1 s A cap/DGT sediment | 12 | A-B | 2cap | 1 | 3.697 | 1 | 0.158 | 0.8 | 18.48333333 | 26.754625 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.600 |
| 83 12-2 s A cap/DGT sediment | 12 | A-B | 2cap | 2 | 3.161 | 1 | 0.158 | 0.8 | 15.80333333 | 22.875325 | 0.096 | 5.42E-06 | 86400 | 9.144 | 0.513 |
| 80 12-1s A/DGT sediment | 12 | A-B | 3A | 1 | 2.695 | 1 | 0.158 | 0.8 | 13.47666667 | 19.507475 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.875 |
| 84 12-2s A/DGT sediment | 12 | A-B | 3A | 2 | 2.119 | 1 | 0.158 | 0.8 | 10.59666667 | 15.338675 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.688 |
| 81 12-1s B/DGT sediment | 12 | A-B | 4B | 1 | 3.038 | 1 | 0.158 | 0.8 | 15.19166667 | 21.9899375 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.986 |
| 85 12-2s B/DGT sediment | 12 | A-B | 4B | 2 | 1.788 | 1 | 0.158 | 0.8 | 8.941666667 | 12.9430625 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.580 |
| 86 Blank 1 A/DGT sediment | blank | sed blank | sed blank | 1 | 2.748 | 1 | 0.158 | 0.8 | 13.74 | 19.88865 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.892 |
| 87 Blank 1 B/DGT sediment | blank | sed blank | sed blank | 1 | 0.539 | 1 | 0.158 | 0.8 | 2.695 | 3.9010125 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.175 |
| 88 Blank 2 A/DGT sediment | blank | sed blank | sed blank | 2 | 0.000 | 1 | 0.158 | 0.8 | 0 | 0 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.000 |
| 89 Blank 2 B/DGT sediment | blank | sed blank | sed blank | 2 | 1.712 | 1 | 0.158 | 0.8 | 8.558333333 | 12.3881875 | 0.096 | 5.42E-06 | 86400 | 4.572 | 0.555 |

Table A1.93. Raw data for Pb concentrations (µg $kg^{-1}$) measured by DGT probes ($C_{DGT}$) in cap and sediment and calculation of $C_{DGT}$. See Table A1.4 for additional details. VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; delta G is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit.

| Sample ID | Tank | Treatment | Layers | Rep | Pb | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C Cdgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 1-1s CL/DGT sediment | 1 | SED-NB | 1CL | 1 | 0.711 | 1 | 0.158 | 0.8 | 3.555 | 5.1458625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.179 |
| 4 1-2s CL/DGT sediment | 1 | SED-NB | 1CL | 2 | 1.035 | 1 | 0.158 | 0.8 | 5.176666667 | 7.493225 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.261 |
| 2 1-1s A/DGT sediment | 1 | SED-NB | 3A | 1 | 0.697 | 1 | 0.158 | 0.8 | 3.485 | 5.0445375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.175 |
| 5 1-2s A/DGT sediment | 1 | SED-NB | 3A | 2 | 0.727 | 1 | 0.158 | 0.8 | 3.633333333 | 5.25925 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.183 |
| 3 1-1s B/DGT sediment | 1 | SED-NB | 4B | 1 | 4.322 | 1 | 0.158 | 0.8 | 21.60833333 | 31.2780625 | 0.096 | 0.00000699 | 86400 | 4.572 | 1.087 |
| 6 1-2s B/DGT sediment | 1 | SED-NB | 4B | 2 | 1.213 | 1 | 0.158 | 0.8 | 6.065 | 8.7790875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.305 |
| 10 2-2s CL/DGT sediment | 2 | SED-NB | 1CL | 2 | 1.286 | 1 | 0.158 | 0.8 | 6.431666667 | 9.3098375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.324 |
| 7 2-1s CL/DGT sediment | 2 | SED-NB | 1CL | 1 | 1.277 | 1 | 0.158 | 0.8 | 6.385 | 9.2422875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.321 |
| 11 2-2s A/DGT sediment | 2 | SED-NB | 3A | 2 | 1.011 | 1 | 0.158 | 0.8 | 5.055 | 7.3171125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.254 |
| 8 2-1s A/DGT sediment | 2 | SED-NB | 3A | 1 | 1.606 | 1 | 0.158 | 0.8 | 8.031666667 | 11.6258375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.404 |
| 12 2-2s B/DGT sediment | 2 | SED-NB | 4B | 2 | 1.019 | 1 | 0.158 | 0.8 | 5.096666667 | 7.377425 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.256 |
| 9 2-1s B/DGT sediment | 2 | SED-NB | 4B | 1 | 2.731 | 1 | 0.158 | 0.8 | 13.65666667 | 19.768025 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.687 |
| 13 3-1s CL/DGT sediment | 3 | SED-NB | 1CL | 1 | 1.444 | 1 | 0.158 | 0.8 | 7.221666667 | 10.4533625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.363 |
| 16 3-2s CL/DGT sediment | 3 | SED-NB | 1CL | 2 | 0.869 | 1 | 0.158 | 0.8 | 4.345 | 6.2893875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.219 |
| 14 3-1s A/DGT sediment | 3 | SED-NB | 3A | 1 | 0.843 | 1 | 0.158 | 0.8 | 4.216666667 | 6.103625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.212 |
| 17 3-2s A/DGT sediment | 3 | SED-NB | 3A | 2 | 0.935 | 1 | 0.158 | 0.8 | 4.673333333 | 6.76465 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.235 |
| 15 3-1s B/DGT sediment | 3 | SED-NB | 4B | 1 | 0.822 | 1 | 0.158 | 0.8 | 4.11 | 5.949225 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.207 |
| 18 3-2s B/DGT sediment | 3 | SED-NB | 4B | 2 | 1.207 | 1 | 0.158 | 0.8 | 6.033333333 | 8.73325 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.304 |
| 19 4-1s CL/DGT sediment | 4 | A-NB | 1CL | 1 | 0.803 | 1 | 0.158 | 0.8 | 4.016666667 | 5.814125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.202 |
| 23 4-2s CL/DGT sediment | 4 | A-NB | 1CL | 2 | 0.709 | 1 | 0.158 | 0.8 | 3.543333333 | 5.128975 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.178 |
| 20 4-1 s A cap/DGT sediment | 4 | A-NB | 2cap | 1 | 0.986 | 1 | 0.158 | 0.8 | 4.931666667 | 7.1385875 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.124 |
| 24 4-2 s A cap/DGT sediment | 4 | A-NB | 2cap | 2 | 1.197 | 1 | 0.158 | 0.8 | 5.985 | 8.6632875 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.151 |
| 21 4-1s A/DGT sediment | 4 | A-NB | 3A | 1 | 0.581 | 1 | 0.158 | 0.8 | 2.906666667 | 4.2074 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.146 |
| 25 4-2s A/DGT sediment | 4 | A-NB | 3A | 2 | 0.884 | 1 | 0.158 | 0.8 | 4.42 | 6.39795 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.222 |
| 22 4-1s B/DGT sediment | 4 | A-NB | 4B | 1 | 0.517 | 1 | 0.158 | 0.8 | 2.586666667 | 3.7442 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.130 |
| 26 4-2s B/DGT sediment | 4 | A-NB | 4B | 2 | 0.596 | 1 | 0.158 | 0.8 | 2.978333333 | 4.3111375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.150 |
| 27 5-1s CL/DGT sediment | 5 | A-NB | 1CL | 1 | 1.072 | 1 | 0.158 | 0.8 | 5.358333333 | 7.7561875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.270 |
| 31 5-2s CL/DGT sediment | 5 | A-NB | 1CL | 2 | 0.934 | 1 | 0.158 | 0.8 | 4.671666667 | 6.7622375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.235 |
| 28 5-1 s A cap/DGT sediment | 5 | A-NB | 2cap | 1 | 0.912 | 1 | 0.158 | 0.8 | 4.558333333 | 6.5981875 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.115 |
| 32 5-2 s A cap/DGT sediment | 5 | A-NB | 2cap | 2 | 1.142 | 1 | 0.158 | 0.8 | 5.711666667 | 8.2676375 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.144 |
| 29 5-1s A/DGT sediment | 5 | A-NB | 3A | 1 | 0.774 | 1 | 0.158 | 0.8 | 3.871666667 | 5.6042375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.195 |
| 33 5-2s A/DGT sediment | 5 | A-NB | 3A | 2 | 0.530 | 1 | 0.158 | 0.8 | 2.651666667 | 3.8382875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.133 |
| 30 5-1s B/DGT sediment | 5 | A-NB | 4B | 1 | 1.093 | 1 | 0.158 | 0.8 | 5.465 | 7.9105875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.275 |
| 34 5-2s B/DGT sediment | 5 | A-NB | 4B | 2 | 1.180 | 1 | 0.158 | 0.8 | 5.901666667 | 8.5426625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.297 |

Table A1.93. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 6-1s CL/DGT sediment | 6 | A-NB | 1CL | 1 | 0.685 | 1 | 0.158 | 0.8 | 3.425 | 4.9576875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.172 |
| 39 6-2s CL/DGT sediment | 6 | A-NB | 1CL | 2 | 0.711 | 1 | 0.158 | 0.8 | 3.553333333 | 5.14345 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.179 |
| 36 6-1 s A cap/DGT sediment | 6 | A-NB | 2cap | 1 | 0.949 | 1 | 0.158 | 0.8 | 4.745 | 6.8683875 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.119 |
| 40 6-2 s A cap/DGT sediment | 6 | A-NB | 2cap | 2 | 1.104 | 1 | 0.158 | 0.8 | 5.52 | 7.9902 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.139 |
| 37 6-1s A/DGT sediment | 6 | A-NB | 3A | 1 | 0.630 | 1 | 0.158 | 0.8 | 3.148333333 | 4.5572125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.158 |
| 41 6-2s A/DGT sediment | 6 | A-NB | 3A | 2 | 0.575 | 1 | 0.158 | 0.8 | 2.875 | 4.1615625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.145 |
| 38 6-1s B/DGT sediment | 6 | A-NB | 4B | 1 | 0.911 | 1 | 0.158 | 0.8 | 4.556666667 | 6.595775 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.229 |
| 42 6-2s B/DGT sediment | 6 | A-NB | 4B | 2 | 0.606 | 1 | 0.158 | 0.8 | 3.028333333 | 4.3835125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.152 |
| 43 7-1s CL/DGT sediment | 7 | SED-B | 1CL | 1 | 0.511 | 1 | 0.158 | 0.8 | 2.556666667 | 3.700775 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.129 |
| 46 7-2s CL/DGT sediment | 7 | SED-B | 1CL | 2 | 1.079 | 1 | 0.158 | 0.8 | 5.393333333 | 7.80685 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.271 |
| 44 7-1s A/DGT sediment | 7 | SED-B | 3A | 1 | 0.821 | 1 | 0.158 | 0.8 | 4.106666667 | 5.9444 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.207 |
| 47 7-2s A/DGT sediment | 7 | SED-B | 3A | 2 | 0.564 | 1 | 0.158 | 0.8 | 2.82 | 4.08195 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.142 |
| 45 7-1s B/DGT sediment | 7 | SED-B | 4B | 1 | 0.670 | 1 | 0.158 | 0.8 | 3.35 | 4.849125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.169 |
| 48 7-2s B/DGT sediment | 7 | SED-B | 4B | 2 | 0.526 | 1 | 0.158 | 0.8 | 2.63 | 3.806925 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.132 |
| 49 8-1s CL/DGT sediment | 8 | SED-B | 1CL | 1 | 0.824 | 1 | 0.158 | 0.8 | 4.118333333 | 5.9612875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.207 |
| 52 8-2s CL/DGT sediment | 8 | SED-B | 1CL | 2 | 0.703 | 1 | 0.158 | 0.8 | 3.516666667 | 5.090375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.177 |
| 50 8-1s A/DGT sediment | 8 | SED-B | 3A | 1 | 0.594 | 1 | 0.158 | 0.8 | 2.971666667 | 4.3014875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.150 |
| 53 8-2s A/DGT sediment | 8 | SED-B | 3A | 2 | 0.863 | 1 | 0.158 | 0.8 | 4.313333333 | 6.24355 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.217 |
| 51 8-1s B/DGT sediment | 8 | SED-B | 4B | 1 | 0.599 | 1 | 0.158 | 0.8 | 2.996666667 | 4.337675 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.151 |
| 54 8-2s B/DGT sediment | 8 | SED-B | 4B | 2 | 0.934 | 1 | 0.158 | 0.8 | 4.67 | 6.759825 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.235 |
| 55 9-1s CL/DGT sediment | 9 | SED-B | 1CL | 1 | 0.714 | 1 | 0.158 | 0.8 | 3.568333333 | 5.1651625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.180 |
| 58 9-2s CL/DGT sediment | 9 | SED-B | 1CL | 2 | 0.416 | 1 | 0.158 | 0.8 | 2.08 | 3.0108 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.105 |
| 56 9-1s A/DGT sediment | 9 | SED-B | 3A | 1 | 0.672 | 1 | 0.158 | 0.8 | 3.358333333 | 4.8611875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.169 |
| 60 9-2s A/DGT sediment | 9 | SED-B | 3A | 2 | 0.345 | 1 | 0.158 | 0.8 | 1.723333333 | 2.494525 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.087 |
| 57 9-1s B/DGT sediment | 9 | SED-B | 4B | 1 | 1.190 | 1 | 0.158 | 0.8 | 5.948333333 | 8.6102125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.299 |
| 61 9-2s B/DGT sediment | 9 | SED-B | 4B | 2 | 22.58 | 1 | 0.158 | 0.8 | 112.8833333 | 163.398625 | 0.096 | 0.00000699 | 86400 | 4.572 | 5.681 |
| 62 10-1s CL/DGT sediment | 10 | A-B | 1CL | 1 | 0.289 | 1 | 0.158 | 0.8 | 1.446666667 | 2.09405 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.073 |
| 66 10-2s CL/DGT sediment | 10 | A-B | 1CL | 2 | 0.423 | 1 | 0.158 | 0.8 | 2.116666667 | 3.063875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.107 |
| 63 10-1 s A cap/DGT sediment | 10 | A-B | 2cap | 1 | 0.556 | 1 | 0.158 | 0.8 | 2.778333333 | 4.0216375 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.070 |
| 67 10-2 s A cap/DGT sediment | 10 | A-B | 2cap | 2 | 0.619 | 1 | 0.158 | 0.8 | 3.095 | 4.4800125 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.078 |
| 64 10-1s A/DGT sediment | 10 | A-B | 3A | 1 | 0.212 | 1 | 0.158 | 0.8 | 1.06 | 1.53435 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.053 |
| 68 10-2s A/DGT sediment | 10 | A-B | 3A | 2 | 0.489 | 1 | 0.158 | 0.8 | 2.446666667 | 3.54155 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.123 |
| 65 10-1s B/DGT sediment | 10 | A-B | 4B | 1 | 0.537 | 1 | 0.158 | 0.8 | 2.685 | 3.8865375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.135 |
| 69 10-2s B/DGT sediment | 10 | A-B | 4B | 2 | 0.691 | 1 | 0.158 | 0.8 | 3.456666667 | 5.003525 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.174 |
| 70 11-1s CL/DGT sediment | 11 | A-B | 1CL | 1 | 0.772 | 1 | 0.158 | 0.8 | 3.858333333 | 5.5849375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.194 |
| 74 11-2s CL/DGT sediment | 11 | A-B | 1CL | 2 | 0.958 | 1 | 0.158 | 0.8 | 4.788333333 | 6.9311125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.241 |
| 71 11-1 s A cap/DGT sediment | 11 | A-B | 2cap | 1 | 0.623 | 1 | 0.158 | 0.8 | 3.115 | 4.5089625 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.078 |
| 75 11-2 s A cap/DGT sediment | 11 | A-B | 2cap | 2 | 1.370 | 1 | 0.158 | 0.8 | 6.851666667 | 9.9177875 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.172 |

Table A1.93. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 11-1s A/DGT sediment | 11 | A-B | 3A | 1 | 0.574 | 1 | 0.158 | 0.8 | 2.87 | 4.154325 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.144 |
| 76 11-2s A/DGT sediment | 11 | A-B | 3A | 2 | 0.540 | 1 | 0.158 | 0.8 | 2.7 | 3.90825 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.136 |
| 73 11-1s B/DGT sediment | 11 | A-B | 4B | 1 | 0.584 | 1 | 0.158 | 0.8 | 2.92 | 4.2267 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.147 |
| 77 11-2s B/DGT sediment | 11 | A-B | 4B | 2 | 0.706 | 1 | 0.158 | 0.8 | 3.528333333 | 5.1072625 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.178 |
| 78 12-1s CL/DGT sediment | 12 | A-B | 1CL | 1 | 0.911 | 1 | 0.158 | 0.8 | 4.553333333 | 6.59095 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.229 |
| 82 12-2s CL/DGT sediment | 12 | A-B | 1CL | 2 | 0.624 | 1 | 0.158 | 0.8 | 3.12 | 4.5162 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.157 |
| 79 12-1 s A cap/DGT sediment | 12 | A-B | 2cap | 1 | 1.195 | 1 | 0.158 | 0.8 | 5.975 | 8.6488125 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.150 |
| 83 12-2 s A cap/DGT sediment | 12 | A-B | 2cap | 2 | 0.871 | 1 | 0.158 | 0.8 | 4.356666667 | 6.306275 | 0.096 | 0.00000699 | 86400 | 9.144 | 0.110 |
| 80 12-1s A/DGT sediment | 12 | A-B | 3A | 1 | 0.751 | 1 | 0.158 | 0.8 | 3.756666667 | 5.437775 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.189 |
| 84 12-2s A/DGT sediment | 12 | A-B | 3A | 2 | 0.766 | 1 | 0.158 | 0.8 | 3.831666667 | 5.5463375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.193 |
| 81 12-1s B/DGT sediment | 12 | A-B | 4B | 1 | 0.819 | 1 | 0.158 | 0.8 | 4.093333333 | 5.9251 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.206 |
| 85 12-2s B/DGT sediment | 12 | A-B | 4B | 2 | 1.032 | 1 | 0.158 | 0.8 | 5.158333333 | 7.4666875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.260 |
| 86 Blank 1 A/DGT sediment | blank | sed blank | sed blank | 1 | 0.454 | 1 | 0.158 | 0.8 | 2.268333333 | 3.2834125 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.114 |
| 87 Blank 1 B/DGT sediment | blank | sed blank | sed blank | 1 | 0.451 | 1 | 0.158 | 0.8 | 2.253333333 | 3.2617 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.113 |
| 88 Blank 2 A/DGT sediment | blank | sed blank | sed blank | 2 | 0.505 | 1 | 0.158 | 0.8 | 2.525 | 3.6549375 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.127 |
| 89 Blank 2 B/DGT sediment | blank | sed blank | sed blank | 2 | 0.637 | 1 | 0.158 | 0.8 | 3.183333333 | 4.607875 | 0.096 | 0.00000699 | 86400 | 4.572 | 0.160 |

Table A1.94. Raw data for Zn concentrations (µg $kg^{-1}$) measured by DGT probes ($C_{DGT}$) in cap and sediment and calculation of $C_{DGT}$. See Table A1.4 for additional details. VNO3 is the amount of nitric acid required to submerged the resin-gel layer (cm); $V_{gel}$ is the volume of the resin gel; FE is the elution factor; $C_e$ is the resulting concentration from the diluted aliquot was then adjusted for dilution to determine the concentration of metals in the 1M $HNO_3$ elution; M is the mass of metal accumulated in the resin gel layer; delta G is the thickness of the diffusive layer and filter layer; D is the diffusion coefficient for each metal at the retrieval temperature; t is the deployment time; A is the exposed area of the DGT unit.

| Sample ID | Tank | Treatment | Layers | Rep | Zn | VNO3 ml | Vgel ml | FE | Ce (ug/L) | M | delta G cm | D Cu 20o | time s | A cm2 | C dgt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 1-1s CL/DGT sediment | 1 | SED-NB | 1CL | 1 | 285.1 | 1 | 0.158 | 0.8 | 1425.5 | 2063.41125 | 0.096 | 0.00000529 | 86400 | 4.572 | 94.794 |
| 2 1-1s A/DGT sediment | 1 | SED-NB | 3A | 1 | 273.3 | 1 | 0.158 | 0.8 | 1366.666667 | 1978.25 | 0.096 | 0.00000529 | 86400 | 4.572 | 90.882 |
| 3 1-1s B/DGT sediment | 1 | SED-NB | 4B | 1 | 299.2 | 1 | 0.158 | 0.8 | 1496.166667 | 2165.70125 | 0.096 | 0.00000529 | 86400 | 4.572 | 99.493 |
| 4 1-2s CL/DGT sediment | 1 | SED-NB | 1CL | 2 | 181.8 | 1 | 0.158 | 0.8 | 908.8333333 | 1315.53625 | 0.096 | 0.00000529 | 86400 | 4.572 | 60.436 |
| 5 1-2s A/DGT sediment | 1 | SED-NB | 3A | 2 | 173.1 | 1 | 0.158 | 0.8 | 865.5 | 1252.81125 | 0.096 | 0.00000529 | 86400 | 4.572 | 57.555 |
| 6 1-2s B/DGT sediment | 1 | SED-NB | 4B | 2 | 330.1 | 1 | 0.158 | 0.8 | 1650.666667 | 2389.34 | 0.096 | 0.00000529 | 86400 | 4.572 | 109.767 |
| 10 2-2s CL/DGT sediment | 2 | SED-NB | 1CL | 2 | 193.2 | 1 | 0.158 | 0.8 | 966 | 1398.285 | 0.096 | 0.00000529 | 86400 | 4.572 | 64.238 |
| 11 2-2s A/DGT sediment | 2 | SED-NB | 3A | 2 | 183.8 | 1 | 0.158 | 0.8 | 919 | 1330.2525 | 0.096 | 0.00000529 | 86400 | 4.572 | 61.112 |
| 12 2-2s B/DGT sediment | 2 | SED-NB | 4B | 2 | 674.6 | 1 | 0.158 | 0.8 | 3373.003773 | 4882.422962 | 0.096 | 0.00000529 | 86400 | 4.572 | 224.301 |
| 7 2-1s CL/DGT sediment | 2 | SED-NB | 1CL | 1 | 198.7 | 1 | 0.158 | 0.8 | 993.5 | 1438.09125 | 0.096 | 0.00000529 | 86400 | 4.572 | 66.067 |
| 8 2-1s A/DGT sediment | 2 | SED-NB | 3A | 1 | 250.9 | 1 | 0.158 | 0.8 | 1254.5 | 1815.88875 | 0.096 | 0.00000529 | 86400 | 4.572 | 83.423 |
| 9 2-1s B/DGT sediment | 2 | SED-NB | 4B | 1 | 1207 | 1 | 0.158 | 0.8 | 6036.837124 | 8738.321737 | 0.096 | 0.00000529 | 86400 | 4.572 | 401.443 |
| 13 3-1s CL/DGT sediment | 3 | SED-NB | 1CL | 1 | 195.1 | 1 | 0.158 | 0.8 | 975.3333333 | 1411.795 | 0.096 | 0.00000529 | 86400 | 4.572 | 64.859 |
| 14 3-1s A/DGT sediment | 3 | SED-NB | 3A | 1 | 170.8 | 1 | 0.158 | 0.8 | 854 | 1236.165 | 0.096 | 0.00000529 | 86400 | 4.572 | 56.790 |
| 15 3-1s B/DGT sediment | 3 | SED-NB | 4B | 1 | 189.4 | 1 | 0.158 | 0.8 | 947 | 1370.7825 | 0.096 | 0.00000529 | 86400 | 4.572 | 62.974 |
| 16 3-2s CL/DGT sediment | 3 | SED-NB | 1CL | 2 | 186.7 | 1 | 0.158 | 0.8 | 933.5 | 1351.24125 | 0.096 | 0.00000529 | 86400 | 4.572 | 62.077 |
| 17 3-2s A/DGT sediment | 3 | SED-NB | 3A | 2 | 186.9 | 1 | 0.158 | 0.8 | 934.6666667 | 1352.93 | 0.096 | 0.00000529 | 86400 | 4.572 | 62.154 |
| 18 3-2s B/DGT sediment | 3 | SED-NB | 4B | 2 | 320.2 | 1 | 0.158 | 0.8 | 1601.166667 | 2317.68875 | 0.096 | 0.00000529 | 86400 | 4.572 | 106.476 |
| 19 4-1s CL/DGT sediment | 4 | A-NB | 1CL | 1 | 271.5 | 1 | 0.158 | 0.8 | 1357.333333 | 1964.74 | 0.096 | 0.00000529 | 86400 | 4.572 | 90.261 |
| 20 4-1 s A cap/DGT sediment | 4 | A-NB | 2cap | 1 | 388.5 | 1 | 0.158 | 0.8 | 1942.5 | 2811.76875 | 0.096 | 0.00000529 | 86400 | 4.572 | 129.174 |
| 21 4-1s A/DGT sediment | 4 | A-NB | 3A | 1 | 265.8 | 1 | 0.158 | 0.8 | 1329.166667 | 1923.96875 | 0.096 | 0.00000529 | 86400 | 4.572 | 88.388 |
| 22 4-1s B/DGT sediment | 4 | A-NB | 4B | 1 | 318.3 | 1 | 0.158 | 0.8 | 1591.666667 | 2303.9375 | 0.096 | 0.00000529 | 86400 | 4.572 | 105.844 |
| 23 4-2s CL/DGT sediment | 4 | A-NB | 1CL | 2 | 833.9 | 1 | 0.158 | 0.8 | 4169.71667 | 6035.66488 | 0.096 | 0.00000529 | 86400 | 4.572 | 277.281 |
| 24 4-2 s A cap/DGT sediment | 4 | A-NB | 2cap | 2 | 342.4 | 1 | 0.158 | 0.8 | 1712 | 2478.12 | 0.096 | 0.00000529 | 86400 | 4.572 | 113.846 |
| 25 4-2s A/DGT sediment | 4 | A-NB | 3A | 2 | 279.4 | 1 | 0.158 | 0.8 | 1397.166667 | 2022.39875 | 0.096 | 0.00000529 | 86400 | 4.572 | 92.910 |
| 26 4-2s B/DGT sediment | 4 | A-NB | 4B | 2 | 276.3 | 1 | 0.158 | 0.8 | 1381.333333 | 1999.48 | 0.096 | 0.00000529 | 86400 | 4.572 | 91.857 |
| 27 5-1s CL/DGT sediment | 5 | A-NB | 1CL | 1 | 251.9 | 1 | 0.158 | 0.8 | 1259.333333 | 1822.885 | 0.096 | 0.00000529 | 86400 | 4.572 | 83.744 |
| 28 5-1 s A cap/DGT sediment | 5 | A-NB | 2cap | 1 | 332.6 | 1 | 0.158 | 0.8 | 1663.166667 | 2407.43375 | 0.096 | 0.00000529 | 86400 | 4.572 | 110.599 |
| 29 5-1s A/DGT sediment | 5 | A-NB | 3A | 1 | 223.8 | 1 | 0.158 | 0.8 | 1119 | 1619.7525 | 0.096 | 0.00000529 | 86400 | 4.572 | 74.412 |
| 30 5-1s B/DGT sediment | 5 | A-NB | 4B | 1 | 282.0 | 1 | 0.158 | 0.8 | 1410 | 2040.975 | 0.096 | 0.00000529 | 86400 | 4.572 | 93.763 |
| 31 5-2s CL/DGT sediment | 5 | A-NB | 1CL | 2 | 333.2 | 1 | 0.158 | 0.8 | 1666 | 2411.535 | 0.096 | 0.00000529 | 86400 | 4.572 | 110.787 |
| 32 5-2 s A cap/DGT sediment | 5 | A-NB | 2cap | 2 | 285.6 | 1 | 0.158 | 0.8 | 1427.833333 | 2066.78875 | 0.096 | 0.00000529 | 86400 | 4.572 | 94.949 |
| 33 5-2s A/DGT sediment | 5 | A-NB | 3A | 2 | 255.2 | 1 | 0.158 | 0.8 | 1276.166667 | 1847.25125 | 0.096 | 0.00000529 | 86400 | 4.572 | 84.864 |
| 34 5-2s B/DGT sediment | 5 | A-NB | 4B | 2 | 274.5 | 1 | 0.158 | 0.8 | 1372.333333 | 1986.4525 | 0.096 | 0.00000529 | 86400 | 4.572 | 91.259 |

Table A1.94. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 6-1s CL/DGT sediment | 6 | A-NB | 1CL | 1 | 362.3 | 1 | 0.158 | 0.8 | 1811.5 | 2622.14625 | 0.096 | 0.00000529 | 86400 | 4.572 | 120.463 |
| 36 6-1 s A cap/DGT sediment | 6 | A-NB | 2cap | 1 | 130.5 | 1 | 0.158 | 0.8 | 652.5 | 944.49375 | 0.096 | 0.00000529 | 86400 | 4.572 | 43.391 |
| 37 6-1s A/DGT sediment | 6 | A-NB | 3A | 1 | 147.0 | 1 | 0.158 | 0.8 | 735 | 1063.9125 | 0.096 | 0.00000529 | 86400 | 4.572 | 48.877 |
| 38 6-1s B/DGT sediment | 6 | A-NB | 4B | 1 | 179.8 | 1 | 0.158 | 0.8 | 898.8333333 | 1301.06125 | 0.096 | 0.00000529 | 86400 | 4.572 | 59.771 |
| 39 6-2s CL/DGT sediment | 6 | A-NB | 1CL | 2 | 281.5 | 1 | 0.158 | 0.8 | 1407.5 | 2037.35625 | 0.096 | 0.00000529 | 86400 | 4.572 | 93.597 |
| 40 6-2 s A cap/DGT sediment | 6 | A-NB | 2cap | 2 | 286.2 | 1 | 0.158 | 0.8 | 1431 | 2071.3725 | 0.096 | 0.00000529 | 86400 | 4.572 | 95.160 |
| 41 6-2s A/DGT sediment | 6 | A-NB | 3A | 2 | 207.5 | 1 | 0.158 | 0.8 | 1037.666667 | 1502.0225 | 0.096 | 0.00000529 | 86400 | 4.572 | 69.004 |
| 42 6-2s B/DGT sediment | 6 | A-NB | 4B | 2 | 149.3 | 1 | 0.158 | 0.8 | 746.6666667 | 1080.8 | 0.096 | 0.00000529 | 86400 | 4.572 | 49.652 |
| 43 7-1s CL/DGT sediment | 7 | SED-B | 1CL | 1 | 221.5 | 1 | 0.158 | 0.8 | 1107.5 | 1603.10625 | 0.096 | 0.00000529 | 86400 | 4.572 | 73.647 |
| 44 7-1s A/DGT sediment | 7 | SED-B | 3A | 1 | 842.0 | 1 | 0.158 | 0.8 | 4209.86135 | 6093.774304 | 0.096 | 0.00000529 | 86400 | 4.572 | 279.951 |
| 45 7-1s B/DGT sediment | 7 | SED-B | 4B | 1 | 292.9 | 1 | 0.158 | 0.8 | 1464.5 | 2119.86375 | 0.096 | 0.00000529 | 86400 | 4.572 | 97.388 |
| 46 7-2s CL/DGT sediment | 7 | SED-B | 1CL | 2 | 1056 | 1 | 0.158 | 0.8 | 5279.929511 | 7642.697968 | 0.096 | 0.00000529 | 86400 | 4.572 | 351.109 |
| 47 7-2s A/DGT sediment | 7 | SED-B | 3A | 2 | 476.9 | 1 | 0.158 | 0.8 | 2384.666667 | 3451.805 | 0.096 | 0.00000529 | 86400 | 4.572 | 158.578 |
| 48 7-2s B/DGT sediment | 7 | SED-B | 4B | 2 | 634.1 | 1 | 0.158 | 0.8 | 3170.477248 | 4589.265817 | 0.096 | 0.00000529 | 86400 | 4.572 | 210.833 |
| 49 8-1s CL/DGT sediment | 8 | SED-B | 1CL | 1 | 282.8 | 1 | 0.158 | 0.8 | 1414 | 2046.765 | 0.096 | 0.00000529 | 86400 | 4.572 | 94.029 |
| 50 8-1s A/DGT sediment | 8 | SED-B | 3A | 1 | 200.4 | 1 | 0.158 | 0.8 | 1002 | 1450.395 | 0.096 | 0.00000529 | 86400 | 4.572 | 66.632 |
| 51 8-1s B/DGT sediment | 8 | SED-B | 4B | 1 | 221.5 | 1 | 0.158 | 0.8 | 1107.5 | 1603.10625 | 0.096 | 0.00000529 | 86400 | 4.572 | 73.647 |
| 52 8-2s CL/DGT sediment | 8 | SED-B | 1CL | 2 | 261.1 | 1 | 0.158 | 0.8 | 1305.666667 | 1889.9525 | 0.096 | 0.00000529 | 86400 | 4.572 | 86.825 |
| 53 8-2s A/DGT sediment | 8 | SED-B | 3A | 2 | 279.1 | 1 | 0.158 | 0.8 | 1395.333333 | 2019.745 | 0.096 | 0.00000529 | 86400 | 4.572 | 92.788 |
| 54 8-2s B/DGT sediment | 8 | SED-B | 4B | 2 | 163.5 | 1 | 0.158 | 0.8 | 817.3333333 | 1183.09 | 0.096 | 0.00000529 | 86400 | 4.572 | 54.352 |
| 55 9-1s CL/DGT sediment | 9 | SED-B | 1CL | 1 | 158.4 | 1 | 0.158 | 0.8 | 792 | 1146.42 | 0.096 | 0.00000529 | 86400 | 4.572 | 52.667 |
| 56 9-1s A/DGT sediment | 9 | SED-B | 3A | 1 | 129.4 | 1 | 0.158 | 0.8 | 647 | 936.5325 | 0.096 | 0.00000529 | 86400 | 4.572 | 43.025 |
| 57 9-1s B/DGT sediment | 9 | SED-B | 4B | 1 | 211.0 | 1 | 0.158 | 0.8 | 1054.833333 | 1526.87125 | 0.096 | 0.00000529 | 86400 | 4.572 | 70.145 |
| 58 9-2s CL/DGT sediment | 9 | SED-B | 1CL | 2 | 215.8 | 1 | 0.158 | 0.8 | 1079 | 1561.8525 | 0.096 | 0.00000529 | 86400 | 4.572 | 71.752 |
| 60 9-2s A/DGT sediment | 9 | SED-B | 3A | 2 | 207.1 | 1 | 0.158 | 0.8 | 1035.666667 | 1499.1275 | 0.096 | 0.00000529 | 86400 | 4.572 | 68.871 |
| 61 9-2s B/DGT sediment | 9 | SED-B | 4B | 2 | 483.4 | 1 | 0.158 | 0.8 | 2416.833333 | 3498.36625 | 0.096 | 0.00000529 | 86400 | 4.572 | 160.717 |
| 62 10-1s CL/DGT sediment | 10 | A-B | 1CL | 1 | 246.1 | 1 | 0.158 | 0.8 | 1230.333333 | 1780.9075 | 0.096 | 0.00000529 | 86400 | 4.572 | 81.816 |
| 63 10-1 s A cap/DGT sediment | 10 | A-B | 2cap | 1 | 294.9 | 1 | 0.158 | 0.8 | 1474.666667 | 2134.58 | 0.096 | 0.00000529 | 86400 | 4.572 | 98.064 |
| 64 10-1s A/DGT sediment | 10 | A-B | 3A | 1 | 99.8 | 1 | 0.158 | 0.8 | 499.0166667 | 722.326625 | 0.096 | 0.00000529 | 86400 | 4.572 | 33.184 |
| 65 10-1s B/DGT sediment | 10 | A-B | 4B | 1 | 211.4 | 1 | 0.158 | 0.8 | 1056.833333 | 1529.76625 | 0.096 | 0.00000529 | 86400 | 4.572 | 70.278 |
| 66 10-2s CL/DGT sediment | 10 | A-B | 1CL | 2 | 261.0 | 1 | 0.158 | 0.8 | 1304.833333 | 1888.74625 | 0.096 | 0.00000529 | 86400 | 4.572 | 86.770 |
| 67 10-2 s A cap/DGT sediment | 10 | A-B | 2cap | 2 | 272.6 | 1 | 0.158 | 0.8 | 1363.166667 | 1973.18375 | 0.096 | 0.00000529 | 86400 | 4.572 | 90.649 |
| 68 10-2s A/DGT sediment | 10 | A-B | 3A | 2 | 240.1 | 1 | 0.158 | 0.8 | 1200.333333 | 1737.4825 | 0.096 | 0.00000529 | 86400 | 4.572 | 79.821 |
| 69 10-2s B/DGT sediment | 10 | A-B | 4B | 2 | 923.3 | 1 | 0.158 | 0.8 | 4616.727003 | 6682.712337 | 0.096 | 0.00000529 | 86400 | 4.572 | 307.007 |
| 70 11-1s CL/DGT sediment | 11 | A-B | 1CL | 1 | 178.7 | 1 | 0.158 | 0.8 | 893.3333333 | 1293.1 | 0.096 | 0.00000529 | 86400 | 4.572 | 59.406 |
| 71 11-1 s A cap/DGT sediment | 11 | A-B | 2cap | 1 | 225.8 | 1 | 0.158 | 0.8 | 1128.833333 | 1633.98625 | 0.096 | 0.00000529 | 86400 | 4.572 | 75.066 |
| 72 11-1s A/DGT sediment | 11 | A-B | 3A | 1 | 191.8 | 1 | 0.158 | 0.8 | 959.1666667 | 1388.39375 | 0.096 | 0.00000529 | 86400 | 4.572 | 63.783 |
| 73 11-1s B/DGT sediment | 11 | A-B | 4B | 1 | 169.4 | 1 | 0.158 | 0.8 | 847.1666667 | 1226.27375 | 0.096 | 0.00000529 | 86400 | 4.572 | 56.336 |
| 74 11-2s CL/DGT sediment | 11 | A-B | 1CL | 2 | 425.2 | 1 | 0.158 | 0.8 | 2126 | 3077.385 | 0.096 | 0.00000529 | 86400 | 4.572 | 141.377 |
| 75 11-2 s A cap/DGT sediment | 11 | A-B | 2cap | 2 | 968.7 | 1 | 0.158 | 0.8 | 4843.54012 | 7011.024323 | 0.096 | 0.00000529 | 86400 | 4.572 | 322.090 |

Table A1.94. (continued).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76 11-2s A/DGT sediment | 11 | A-B | 3A | 2 | 161.2 | 1 | 0.158 | 0.8 | 806 | 1166.685 | 0.096 | 0.00000529 | 86400 | 4.572 | 53.598 |
| 77 11-2s B/DGT sediment | 11 | A-B | 4B | 2 | 177.9 | 1 | 0.158 | 0.8 | 889.3333333 | 1287.31 | 0.096 | 0.00000529 | 86400 | 4.572 | 59.140 |
| 78 12-1s CL/DGT sediment | 12 | A-B | 1CL | 1 | 252.9 | 1 | 0.158 | 0.8 | 1264.333333 | 1830.1225 | 0.096 | 0.00000529 | 86400 | 4.572 | 84.077 |
| 79 12-1 s A cap/DGT sediment | 12 | A-B | 2cap | 1 | 383.5 | 1 | 0.158 | 0.8 | 1917.5 | 2775.58125 | 0.096 | 0.00000529 | 86400 | 4.572 | 127.512 |
| 80 12-1s A/DGT sediment | 12 | A-B | 3A | 1 | 894.3 | 1 | 0.158 | 0.8 | 4471.694975 | 6472.778477 | 0.096 | 0.00000529 | 86400 | 4.572 | 297.363 |
| 81 12-1s B/DGT sediment | 12 | A-B | 4B | 1 | 307.6 | 1 | 0.158 | 0.8 | 1538 | 2226.255 | 0.096 | 0.00000529 | 86400 | 4.572 | 102.275 |
| 82 12-2s CL/DGT sediment | 12 | A-B | 1CL | 2 | 258.7 | 1 | 0.158 | 0.8 | 1293.5 | 1872.34125 | 0.096 | 0.00000529 | 86400 | 4.572 | 86.016 |
| 83 12-2 s A cap/DGT sediment | 12 | A-B | 2cap | 2 | 884.5 | 1 | 0.158 | 0.8 | 4422.709178 | 6401.871535 | 0.096 | 0.00000529 | 86400 | 4.572 | 294.105 |
| 84 12-2s A/DGT sediment | 12 | A-B | 3A | 2 | 262.8 | 1 | 0.158 | 0.8 | 1314.166667 | 1902.25625 | 0.096 | 0.00000529 | 86400 | 4.572 | 87.391 |
| 85 12-2s B/DGT sediment | 12 | A-B | 4B | 2 | 190.1 | 1 | 0.158 | 0.8 | 950.6666667 | 1376.09 | 0.096 | 0.00000529 | 86400 | 4.572 | 63.218 |
| 86 Blank 1 A/DGT sediment | blank | sed blank | sed blanl | 1 | 178.1 | 1 | 0.158 | 0.8 | 890.5 | 1288.99875 | 0.096 | 0.00000529 | 86400 | 4.572 | 59.217 |
| 87 Blank 1 B/DGT sediment | blank | sed blank | sed blanl | 1 | 300.0 | 1 | 0.158 | 0.8 | 1499.833333 | 2171.00875 | 0.096 | 0.00000529 | 86400 | 4.572 | 99.737 |
| 88 Blank 2 A/DGT sediment | blank | sed blank | sed blanl | 2 | 272.4 | 1 | 0.158 | 0.8 | 1362 | 1971.495 | 0.096 | 0.00000529 | 86400 | 4.572 | 90.571 |

Table A1.95. Sediment pH in experimental mesocosms with different treatments (A = apatite cap, SED = uncapped sediment) and presence (B) or absence (NB) of bioturbation. Results are reported for the following sediment layers: contaminated layer (CL), apatite cap (CAP), A layer (0-2.5 cm beneath the CL or CAP), and B layer (2.5-4.0 cm beneath the CL or CAP).

| Group | Tank | Layer | pH |
|---|---|---|---|
| SED-NB | 1 | Cl | 5.49 |
| SED-NB | 1 | A | 5.44 |
| SED-NB | 1 | B | 5.26 |
| SED-NB | 2 | Cl | 5.52 |
| SED-NB | 2 | A | 5.45 |
| SED-NB | 2 | B | 5.31 |
| SED-NB | 3 | Cl | 5.52 |
| SED-NB | 3 | A | 5.42 |
| SED-NB | 3 | B | 5.23 |
| A-NB | 4 | Cl | 7.01 |
| A-NB | 4 | CAP | 8.1 |
| A-NB | 4 | A | 7.12 |
| A-NB | 4 | B | 7.02 |
| A-NB | 5 | Cl | 7.25 |
| A-NB | 5 | CAP | 8.08 |
| A-NB | 5 | A | 7.5 |
| A-NB | 5 | B | 7.42 |
| A-NB | 6 | Cl | 7.39 |
| A-NB | 6 | CAP | 8.07 |
| A-NB | 6 | A | 7.46 |
| A-NB | 6 | B | 7.46 |
| SED-B | 7 | Cl | 6.37 |
| SED-B | 7 | A | 6.58 |
| SED-B | 7 | B | 5.97 |
| SED-B | 8 | Cl | 6.44 |
| SED-B | 8 | A | 6.53 |
| SED-B | 8 | B | 5.3 |
| SED-B | 9 | Cl | 6.5 |
| SED-B | 9 | A | 6.52 |
| SED-B | 9 | B | 5.97 |
| A-B | 10 | Cl | 8.12 |
| A-B | 10 | CAP | 8.03 |
| A-B | 10 | A | 8.25 |
| A-B | 10 | B | 7.9 |
| A-B | 11 | Cl | 8.13 |
| A-B | 11 | CAP | 8.16 |
| A-B | 11 | A | 8.21 |
| A-B | 11 | B | 7.9 |
| A-B | 12 | Cl | 8.23 |
| A-B | 12 | CAP | 8.08 |
| A-B | 12 | A | 8.13 |
| A-B | 12 | B | 7.95 |

# APPENDIX 2- PUBLICATIONS

**Books and Special Issues:**

1. Seaman, J.C., **A.S. Knox**, K. Scheckel, and D.C. Adriano (editors) 2020. Third edition of a book "Trace Elements in Terrestrial Environments," Springer Publisher (in press).
2. The virtual special issue (VSI) titled "Trace elements in the cycle of soils, sediments, waters, and plants" was published in Chemosphere. Editors: J. Rinklebe, F. Tack, and **A. Knox (2018)**.
3. Seaman, J. C. and **A.S. Knox**, 2018. Book of Abstracts of 19th ICHMET2018, 7/21-25, 2018, Athens, GA, USA (https://ichmet2018usa.org/).
4. Rinklebe, J., A.S. Knox, and M.H. Paller, editors. 2016. Trace Elements in Waterlogged Soils and Sediments. CRC Press, Boca Raton, FL.

**Papers:**

1. **Knox, A.S.** and M.H. Paller. 2019. Effect of bioturbation on contaminated sediment deposited over remediated sediment. Sci. of Tot. Environ. (in press).
2. **Knox, A.S.**, Paller, M.H., and Seaman, J.C. 2019. Removal of low levels of Cu from ongoing sources in the presence of other elements – Implications for remediated contaminated sediments. Sci. of Tot. Environ. 668:645-657.
3. Paller, M.H., Harmon, S.M., **Knox, A.S**., Kuhne, W.W., Halverson, N.V. 2019. Assessing effects of dissolved organic carbon and water hardness on metal toxicity to *Ceriodaphnia dubia* using diffusive gradients in thin films (DGT). Sci. of Tot. Environ. 697.
4. Li, D., D. Kaplan, A. Sams, B. Powell and **A.S. Knox**. 2018. Removal capacity and chemical speciation of groundwater iodide (I-) and iodate (IO3-) sequestered by organoclays and granular activated carbon. Journal of Environmental Radioactivity, 192:505-512.
5. **Knox, A.S**., Michael H. Paller, Charles E. Milliken, T. M. Redder, J. R. Wolfe, and J. Seaman. 2016. Environmental impact of ongoing sources of metal contamination on remediated sediments. Sci. of Tot. Environ. 563-564:108-117.
6. **Knox, A.S**., Paller, M.H., and Dixon, K. L. 2014. Evaluation of active cap materials for metal retention in sediments, Remediation 24(3):49-69.

**Book Chapters:**

1. **Knox, A.S.**, M.H. Paller, and M. 2020. Copper. Invited book chapter for Third edition of a book "Trace Elements in Terrestrial Environments," Springer Publisher (in press).
2. **Knox, A.S.,** M.H. Paller, and D. Li. 2019. A review of nickel in sediments. Invited book chapter for Nickel in Soils and Plants book, CRC Press.
3. **Knox, A.S.** and M.H. Paller. 2016. Remediation of Metal Contaminated Sediments. *In* Trace elements in temporary waterlogged soils and sediments - bioavailability, geochemical processes, management, and remediation approaches, Editors: Jörg Rinklebe, Anna S. Knox, Michael Paller, CRC Press.
4. Paller, M.H. and **A.S. Knox.** 2016. Understanding the Relationship between Metal Bioavailability in Contaminated Sediments and Biological Receptors. *In* Trace

elements in temporary waterlogged soils and sediments - bioavailability, geochemical processes, management, and remediation approaches, CRC Press. Editors: Jörg Rinklebe, Anna S. Knox, Michael Paller, CRC Press.

**Abstracts:**

1. Knox, A.S. and M.H. Paller. Understanding the Relationships Among Low Level Metal Influx, Remediated Sediments, and Biological Receptors (ER-2427). SERDP Symposium, DC., December 2 – 5, 2019.
2. Knox, A.S. and M.P. Paller. Diffusive gradients in thin films (DGT) probes for evaluation of active caps for remediating contaminated sediments. 6th Conference on Diffusive Gradients in Films 2019, September 17-20, 2019, Vienna, Austria.
3. Knox, A.S. and M.P. Paller. Removal of low levels of Cu from ongoing sources in the presence of other elements. 15th International Conference on the Biogeochemistry of Trace Elements, Nanjing, China, May 5-9, 2019.
4. Knox, A.S. Environmental impact of ongoing sources of contaminants on remediated aquatic ecosystem. 10th International Conference on the Remediation and Management of Contaminated Sediments, New Orleans, Louisiana, February 11-14, 2019.
5. Huddleston, M., A.S. Knox and M. H. Paller. Savannah River Site's A-01 Constructed Wetland System: A Model for Sustainable Ecological Risk Mitigation. AEES, 2019.
6. Knox, A.S., M.H. Paller, T. Redder. 2018. Removal of Contaminants from Ongoing Sources Using Chemically Active Sequestering Agents. SERDP Symposium, DC., December 2018.
7. Li, D., D.I. Kaplan, J.C. Seaman, A.S. Knox, B. Powell, A. Sams. 2018. Sequestration of pertechnetate ($TcO_4^-$), iodide ($I^-$) and iodate ($IO_3^-$) from groundwater by organoclays and granular activated carbon: capacity and chemical speciation. 19th International Conference on Heavy Metals in the Environment (ICHMET2018), July 21-25, 2018, Athens, Georgia, USA.
8. Knox, A.S., M. Paller, D. Li. 2018. Global distribution of Ni in sediments. 19th International Conference on Heavy Metals in the Environment (ICHMET2018), July 21-25, 2018, Athens, Georgia, USA.
9. Knox, A.S. and M.H. Paller. 2018. Environmental impact of ongoing sources of metal contamination on remediated aquatic ecosystem. 19th International Conference on Heavy Metals in the Environment (ICHMET2018), July 21-25, 2018, Athens, Georgia, USA.
10. Paller, M.H., S. Blas, and A.S. Knox. 2018. Estimating the ecological risks of metal contamination in aquatic ecosystems. 19th International Conference on Heavy Metals in the Environment (ICHMET2018), July 21-25, 2018, Athens, Georgia, USA.
11. Knox, A.S., and M.H. Paller. 2018. Metal mobility and retention in constructed wetland sediments. 12th International Symposium on Biogeochemistry of Wetlands, April 23-26, 2018, Coral Springs, Florida, USA.
12. Paller, M.H., and A.S. Knox. 2018.Using DGT to measure bioavailable metals in a constructed wetland treatment system. 12th International Symposium on Biogeochemistry of Wetlands, April 23-26, 2018, Coral Springs, Florida, USA.
13. Knox, A.S., M.H. Paller, C. Milliken, T. Redder, J. Wolfe. 2017. Removal of Contaminants from Ongoing Sources Using Chemically Active Sequestering Agents. SERDP and ESTCP Symposium 2017, November 28-30, 2017, Washington, DC.

14. Knox, A.S. and M.H. Paller. 2017. Risk assessment and remediation of trace elements in sediment. 14th International Conference on the Biogeochemistry of Trace Elements (ICOBTE2017), July 16-20, 2017, Zurich, Switzerland.
15. Paller, M.H., S.M. Harmon, A.S. Knox. 2017. Effects of water hardness and dissolved organic matter content on DGT measurements of copper and zinc toxicity to Ceriodaphina dubia. 14th International Conference on the Biogeochemistry of Trace Elements (ICOBTE2017), July 16-20, 2017, Zurich, Switzerland.
16. Knox, A.S., M.H. Paller, C. Milliken. 2017. Understanding the relationships among low-level metal influx and remediated sediments. Ninth International Conference on Remediation and Management of Contaminated Sediments, New Orleans, Louisiana, January 9-12, 2017.
17. Knox, A.S. and M.H. Paller. 2016. Evaluation of metal bioavailability of metal in remediated contaminated sediments. 18th International Conference on Heavy Metals in the Environment (ICHMET2016), September 12-15, 2016, Ghent, Belgium.
18. Knox, A.S. 2016. Current status, gaps and needs in sustainable treatment of metal contaminated sediments. 18th International Conference on Heavy Metals in the Environment (ICHMET2016), September 12-15, 2016, Ghent, Belgium.
19. Knox, A.S. 2015. Logical Progression in Remediation of Contaminated Sediments. Dredging Conference 2015, October19 – 22, 2015, Savannah, GA.
20. Knox, A.S. 2015. Remediation of Metal Contaminated Sediments. The 13th International Conference on the Biochemistry of Trace Elements (13th ICOBTE), July 15, 2015, Fukuoka, Japan.
21. Knox, A.S. 2015. Understanding the relationships among low level metal influx and remediated sediments – Zone of Influence (ZOI). Eighth International Conference on Remediation and management of Contaminated Sediments, January 12-15, 2015, New Orleans, Louisiana.
22. Knox, A.S. and M.H. Paller. 2014. Remediation of Metal Contaminated Sediments. International Conference of Heavy Metals in the Environment (17th ICHMET 2014), 22-26 September, 2014, Guiyang, China.
23. Paller, M. H. and A.S. Knox. 2014. Bioavailability of metals in contaminated sediments and its role in remediation. International Conference of Heavy Metals in the Environment (17th ICHMET 2014), 22-26 September, 2014, Guiyang, China.

**Presentations:**

**Oral Presentations at Professional Meetings/Invited presentations and others**

1. **Knox, A.S**. Environmental impact of ongoing sources of contaminants on remediated aquatic ecosystem. 10th International Conference on the Remediation and Management of Contaminated Sediments, New Orleans, Louisiana, February 11-14, 2019
2. **Knox, A.S**. Removal of low levels of Cu from ongoing sources in the presence of other elements. 15th International Conference on the Biogeochemistry of Trace Elements, Nanjing, China, May 5-9, 2019 (keynote speaker).

3. **Knox, A.S.** Diffusive gradients in thin films (DGT) probes for evaluation of active caps for remediating contaminated sediments. 6th Conference on Diffusive Gradients in Films 2019, September 17-20, 2019, Vienna, Austria.
4. **Knox, A.S.** Removal of low levels of Cu from ongoing sources in the presence of other elements. SRNL tech eXchange, November 14, 2019.
5. **Knox, A.S.**, M. Paller, D. Li. 2018. Global distribution of Ni in sediments. 19th International Conference on Heavy Metals in the Environment (ICHMET2018), July 21-25, 2018, Athens, Georgia, USA.
6. **Knox, A.S.** and M.H. Paller. 2018. Environmental impact of ongoing sources of metal contamination on remediated aquatic ecosystem. 19th International Conference on Heavy Metals in the Environment (ICHMET2018), July 21-25, 2018, Athens, Georgia, USA.
7. **Knox, A.S.**, and M.H. Paller. 2018. Metal mobility and retention in constructed wetland sediments. 12th International Symposium on Biogeochemistry of Wetlands, April 23-26, 2018, Coral Springs, Florida, USA.
8. **Knox, A.S.** and M.H. Paller. 2017. Risk assessment and remediation of trace elements in sediment. 14th International Conference on the Biogeochemistry of Trace Elements (ICOBTE2017), July 16-20, 2017, Zurich, Switzerland.
9. Paller, M.H., S.M. Harmon, **A.S. Knox**. 2017. Effects of water hardness and dissolved organic matter content on DGT measurements of copper and zinc toxicity to Ceriodaphina dubia. 14th International Conference on the Biogeochemistry of Trace Elements (ICOBTE2017), July 16-20, 2017, Zurich, Switzerland.
10. **Knox, A.S.**, M.H. Paller, C. Milliken. 2017. Understanding the relationships among low-level metal influx and remediated sediments. Ninth International Conference on Remediation and Management of Contaminated Sediments, New Orleans, Louisiana, January 9-12, 2017.
11. **Knox, A.S.** and M.H. Paller. 2016. Evaluation of metal bioavailability of metal in remediated contaminated sediments. 18th International Conference on Heavy Metals in the Environment (ICHMET2016), September 12-15, 2016, Ghent, Belgium.
12. **Knox, A.S.** 2016. Current status, gaps and needs in sustainable treatment of metal contaminated sediments. 18th International Conference on Heavy Metals in the Environment (ICHMET2016), September 12-15, 2016, Ghent, Belgium (plenary speaker).
13. **Knox, A.S.** 2015. Logical Progression in Remediation of Contaminated Sediments. Dredging Conference 2015, October19 – 22, 2015, Savannah, GA.
14. **Knox, A.S.** 2015. Remediation of Metal Contaminated Sediments. The 13th International Conference on the Biochemistry of Trace Elements (13th ICOBTE), July 15, 2015, Fukuoka, Japan.
15. **Knox, A.S**. 2015. Understanding the relationships among low level metal influx and remediated sediments – Zone of Influence (ZOI). Eighth International Conference on Remediation and management of Contaminated Sediments, January 12-15, 2015, New Orleans, Louisiana.
16. **Knox, A.S**. and M.H. Paller. 2014. Remediation of Metal Contaminated Sediments. International Conference of Heavy Metals in the Environment (17th ICHMET 2014), 22-26 September, 2014, Guiyang, China.

17. Paller, M. H. and **A.S. Knox**. 2014. Bioavailability of metals in contaminated sediments and its role in remediation. International Conference of Heavy Metals in the Environment (17th ICHMET 2014), 22-26 September, 2014, Guiyang, China.

**Poster Presentations at Professional Meetings**

1. **Knox, A.S.** and M.H. Paller. 2019. Understanding the Relationships Among Low Level Metal Influx, Remediated Sediments, and Biological Receptors (ER-2427). SERDP Symposium, DC., December 2 – 5, 2019.
2. **Knox, A.S.**, M.H. Paller, T. Redder. 2018. Removal of Contaminants from Ongoing Sources Using Chemically Active Sequestering Agents. SERDP Symposium, DC., December 2018.
3. **Knox, A.S.,** M.H. Paller, C. Milliken, T. Redder, J. Wolfe. 2017. Removal of Contaminants from Ongoing Sources Using Chemically Active Sequestering Agents. SERDP and ESTCP Symposium 2017, November 28-30, 2017, Washington, DC.
4. **Knox, A.S.,** M.H. Paller, C. Milliken. 2017. Understanding the relationships among low-level metal influx and remediated sediments. Ninth International Conference on Remediation and Management of Contaminated Sediments, New Orleans, Louisiana, January 9-12, 2017.

## APPENDIX 3 - TRANSITION PLAN

The expected outcome of this research work is a definitive understanding of active capping technology and the ability of active capping to remediate/reduce contaminant bioavailability in sediments. This will result in setting more defensible cleanup goals and establishing more realistic cleanup priorities while still ensuring the protection of human health and the environment. This enhanced understanding will increase the confidence of site managers to incorporate active capping technology into site management decisions. Results from this project are being promoted to DoD, scientists, and the public via DoD websites, presentations in internationally recognized scientific conferences/session/symposia, publication in peer-reviewed scientific journals, and reports. Feedback from international symposium/session attendees provides guidance that will be used to adjust the conceptual framework to improve the effectiveness of active capping technology.

The following conferences/sessions/symposia were organized in 2014 - 2020:

1. Seaman, J.C. and A.S. Knox organized **the 19th International Conference on Heavy Metals in the Environment (ICHMET)**, Athens, GA, July 21-25, 2018.
2. A special session on **Metals in Sediments and Remediation Technologies** was organized and chaired by *Anna Knox*. The session was a part of the 17th International Conference on Heavy Metals in the Environment (17th ICHMET2014), September 22-26, 2014, Guiyang, China
3. A symposium on **Fate and transport of metals in contaminated sediments – new approaches in remediation during t**he 13th International Conference on the Biochemistry of Trace Elements (13th ICOBTE), July 15, 2015, Fukuoka, Japan. The symposium organizers were Anna Sophia Knox (SRNL) and Jörg Rinklebe (Wuppertal University, Germany).
4. A session on **Heavy Metals in Sediments: Biogeochemistry and Remediation and Heavy Metals in the Aquatic Environment.** The session was a part of the 18th International Conference on Heavy Metals in the Environment (18th ICHMET2016), September 12-15, 2016, Ghent, Belgium.
5. Dr. Knox organized a session on **Risk Assessment and Remediation of Trace Elements in Sediments**. The session was a part of the 14th International Conference on the Biogeochemistry of Trace Elements (ICOBTE2017), 16-20 July, 2017, Zurich, Switzerland.
6. Dr. Knox and Dr. Paller organized a session on **Assessment of Contaminant Removal and Retention in Wetland Sediments** during the 12th International Symposium on Biogeochemistry of Wetlands, 4/ 23-26, 2018, Coral Springs, FL, USA.
7. Knox, A.S., J. Rinklebe, and M.H. Paller organized a session on **Biogeochemistry of Heavy Metals in Flooded Soils and Sediments** during the 19th ICHMET, Athens, GA, 7/21-25, 2018
8. Knox, A.S. and Filip Tack organized a session on Heavy **Metals in Aquatic Environments Organizers** during the 19th ICHMET, Athens, GA, 7/ 21-25, 2018.

9. **Knox, A.S.** and Filip Tack organized and chaired a special symposium "**New Approaches in Management and Remediation of Contaminated sediments and Soils**" during 15th International Conference on the Biogeochemistry of Trace Elements, Nanjing, China, May 5-9, 2019.
10. Accepted session proposal titled "**Management and Remediation of Water Resources in a Changing Climate: The Influence of Hydrological and Biogeochemical Controls on Water and Sediment Quality"** to Goldschmidt 2020. Session organizers are Anna Sophia Knox, Sarah Fakhreddine, Daniel Kaplan, Debra Hausladen, Michael Paller, and Sam Ying.
11. Accepted a special session on **Risk Assessment and Remediation of Metal Contaminated Sediments and Flooded Soils**, 20th International Conference on Heavy Metals in the Environment (ICHMET 2020), Seoul, South Korea. Session organizers are Anna Sophia Knox and Jorg Rinklebe.