AAL-TDR-64-17

OBSERVATIONS ON A SEWAGE OXIDATION POND IN SOUTHCENTRAL ALASKA

TECHNICAL DOCUMENTARY REPORT AAL-TDR-64-17

January 1965

ARCTIC AEROMEDICAL LABORATORY

AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
FORT WAINWRIGHT, ALASKA

Project 8246, Task 824601

(Prepared under an Interservice Agreement by
D. K. Hilliard, Arctic Health Research Center,
U. S. Public Health Service, Department of Health,
Education and Welfare, Anchorage, Alaska)

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

ABSTRACT

Observations were made on a sewage pond during the period May through December of 1963. The water chemistry of this facility indicated that during the period of maximum photosynthetic activity (May through August), ammonium compounds and phosphate phosphorus appeared to be readily utilized by the algae, but during the colder months these compounds built up significantly. Similarly, the biological oxygen demand (BOD) was generally low during the warmer months (30 mg/l or less) but increased appreciably with the advent of ice cover. The pH and dissolved oxygen content both indicate a photosynthetically healthy regime during the warmer months, but the latter parameter became depressed with occurrence of ice. During the course of this investigation, pond odor was not detectable until after ice cover had formed. Matting occurred only once but disappeared within a short time. Plankton analyses indicated 18 taxa of photosynthetically active algae, belonging principally to Chlorococcales and Volvocales. Of the last named order, 11 species are new for North America and presumably are new records as sewage-tolerant organisms. The Alaskan pond was compared with an experimental pond receiving comparable BOD loading at Fayette, Missouri, and the results are discussed.

PUBLICATION REVIEW

Horace F. Drury

HORACE F. DRURY
Director of Research

OBSERVATIONS ON A SEWAGE OXIDATION POND IN SOUTHCENTRAL ALASKA

SECTION 1. INTRODUCTION

During the period May through December of 1963, observations were made on the sewage pond at the Lazy Mountain Children's Home near Palmer, Alaska. The purposes of the study were: (1) to learn something of the phytoplankton, in terms of species composition and abundance; (2) to observe the periodicity of these organisms as reflected in changes in the pond's chemistry and solar radiation; and (3) to make an intensive taxonomic study of all organisms present. In addition, it would have been desirable to examine the pond's performance in stabilizing organic wastes, but direct measurements of biological oxygen demand (BOD) and bacterial reduction could not be made. Instead, an assessment of the pond's performance was made in terms of its algae and its water chemistry, as well as by comparing it with another facility of similar magnitude.

SECTION 2. DESCRIPTION

Lazy Mountain Children's Home is a small community situated about 3 miles north and east of Palmer, Alaska, at latitude N 61° 40' and an elevation of about 700 feet. The population served by the pond during the course of this study included 36 people. Sewage discharged by the facility was of a household nature and excluded laundry wastes.

Oxidation pond. The facility is composed of two rectangular ponds in series. The function of the second pond is to stabilize excess wastes from the receiving pond when necessary. The ponds are situated about 270 yards west of the Home at a slightly reduced elevation. The ponds are 80 to 85 feet square and are surrounded by 10-foot dirt dikes. The dikes and pond bottoms are composed of compacted soils of the area — mostly mineral earth with gravel intermixed. Since the soil material lacks clays and an adequate sealant never was used, considerable seepage has occurred. Weeds cover the lower slopes of the dikes to the water line. There is little evidence of erosion at the upper levels.

The sewage is gravity fed and enters the pond from a six-inch concrete pipe, through an inlet situated near the center of the pond. A cleanout elbow is buried below the dike, adjacent to the pond's inlet, but there are no manholes between the pond and the housing units. This pond never was provided with an outlet.

Loading. Because of the pond design (i.e., no accessible inlet or outlet) it was not possible to sample either raw sewage or treated effluent; hence biological and chemical measurements could be made only from the pond proper. With the 36 contributing occupants, the BOD loading for the pond was calculated to be approximately 40 lb/acre/day, based, a priori, on the premise that each person contributed 0.167 pounds of BOD per day.

The calculated loading of the oxidation pond, which has a mean depth of 2 feet, was 240 persons per acre per day — a figure over twice that of the accepted North Dakota loading standard of 100 persons per acre per day.

Seepage losses from this pond were considerable. In order to stabilize the water level, water from a bypass line was introduced periodically, thus affording a volumetric stability of about 300 gallons.

Appearance of phytoplankton. The algae, principally *Chlamydomonas* and *Chlorella*, appeared before all the ice had left on 14 May. They were first found attached to stems of old vegetation and soil clumps along the margins of the pond. Within two weeks, the aforementioned genera were replaced, principally by *Scenedesmus*, which soon attained "bloom" proportions; this condition prevailed until 23 July. From the latter date until nearly mid-August, the pond nurtured few algal organisms due to the fact that, by accident, an undisclosed quantity of paint thinner had been flushed into the system. By mid-August, however, *Scenedesmus* had returned to its previous state of numerical abundance, a situation which was sustained until late December.

Following the introduction of the paint thinner, matting occurred in the northeast corner of the pond. It was composed mainly of dead or moribund *Chlamydomonas*, *Haematococcus*, and *Oscillatoria*, with a few diatoms interspersed. Within a week of this incident, the mat had disappeared, and at no time did it create an odor problem.

Ice cover. Ice first occurred on 22 October, when a layer of about 1/16 inch covered the entire surface. Following this date there was a weekly increase of about 2.1 inches of ice, so that by 31 December the ice had attained a thickness of 25 inches, leaving only 3 inches of liquid underneath. Presumably, as the winter progressed, the pond froze to the bottom. Had the soil been adequately sealed against seepage, it is conceivable that the sewage would have backed up to its source and prevented the pond from receiving additional wastes for the remainder of the winter.

Color. When the last of the ice disappeared on 14 May, the pond appeared slightly turbid due to a high concentration of suspensoids. By 19 May, a faint tinge of green was in evidence as the algae began to proliferate. On 30 May the pond color was a dark green, a situation which prevailed until about mid-November (except after the introduction of the paint thinner, at which time the pond was essentially devoid of algae for two weeks and assumed a coffee-color).

Odors. Two weeks following first ice cover (22 October), a noticeable odor developed. This became more pronounced as the ice thickened and was still in evidence when sampling was discontinued 31 December. In contrast to observations of other investigators on oxidation ponds following ice removal, there were no detectable odors from the pond at that time nor at any time during the ice-free period.

Temperature. Due to the shallowness and comparatively small volume of the pond, considerable variation in the temperature of the surface water was noted. Weekly fluctuations in air and water temperatures are given in Figure 1. The pond surface temperatures were fairly uniform throughout May and somewhat depressed during early June. The maximum for the season (25° C) occurred on 9 July. From mid-September until ice formation on 22 October, the water temperature declined steadily. Following ice formation, water temperatures remained at about 1.5° C.

SECTION 3. CHEMICAL FEATURES

General results of chemical analyses of the pond are given in Table I.

pH. If, as is generally conceded, carbon is made available to the plants when the pH is 8 or more (here the bicarbonates are broken down to provide CO_2 and normal carbonates, which elevate the pH), then it appears that the pond under discussion was metabolically healthy. With the exception of the first few days following breakup and again during late July and early August when the paint thinner was introduced, the pond sustained a pH in excess of 10 until mid-September, indicating a vigorous photosynthetic process.

Normally following the formation of ice cover in pond operations, the pH (Figure 2) will drop appreciably as the pond becomes more septic; also, if an operation is overloaded to such a degree as to induce septicity, then the pH will generally be lowered. In the lagoon at Lazy Mountain Children's Home, even with the sharp rise in BOD just prior to and following ice cover, the pH did not drop much below 8. This phenomenon is attributed to the high concentration of ammonium nitrogen, which began to build up around 1 October.

TABLE I

ANALYSIS RESULTS

Lazy Mountain Children's Home Oxidation Pond

Date	Water Temp. (^{o} C)	pH	DO (mg/l)	BOD (mg/l)	NH_3-N (mg/l)	O-N (mg/l)	NO_3-N (mg/l)	NO_2-N (mg/l)
5-14	3.9	7.0	0.15	12.8	8.0	2.8	0.5	--
5-16	6.6	6.9	0.7	16.1	5.6	5.4	0.5	--
5-19	16.1	7.5	12.2	--	8.2	14	0.5	--
5-21	18.3	10.3	29.4	6.2	7.8	34	0.5	--
5-25	16.7	9.8	21.2	--	7.5	4.8	0.5	--
5-28	17.2	10.4	16.8	13.2	3.8	6.1	0.5	--
6-4	12.8	10.5	12.3	40.9	5.3	11.4	1.1	--
6-10	12.8	8.8	13.1	--	8.4	6.8	1.1	--
6-18	16.1	10.6	15.7	25	2	13	0.6	0.4
6-25	17.2	10.8	15.0	23	1.6	13	0.7	0.6
7-2	20	10.7	14.5	32	1.2	16	--	--
7-9	25	10.7	17.4	19	1.7	19	1.2	0.3
7-16	15	10.9	9.3	--	1.4	15.7	1	0.3
7-23	16.2	7.4	0.24	21	9.5	5.8	0.5	--
8-1	16.6	7.4	1.1	--	10	3	--	--
8-6	13.5	7.4	2.4	14	16	3	0.5	0.3
8-13	18.1	10.8	33	43	6	13	0.5	0.8

8-20	16.5	10.3	20.9	40	5	12	0.5	0.9
8-27	16	10.5	14.5	43	5.6	12	0.3	0.7
9-6	15.8	11.0	23.6	22	1.0	10.8	0.5	0.8
9-10	13.5	11.2	16.1	22.6	0.7	2.2	0.5	1.2
9-17	9.2	9.4	11.2	40	9.8	2.3	0.5	0.5
9-24	7.9	9.6	11.6	36	7.6	2.6	0.5	0.7
10-1	7.5	9.1	9.5	36	10.2	2.6	0.5	0.4
10-15	4.3	9.0	9.9	33	13.5	2.6	0.5	0.3
10-22	1.8	8.6	8.5	34	17.0	1.8	0.5	0.4
Ice Cover								
10-28	1.5	8.9	4.6	40	20	1.9	0.5	0.3
11-1	1.5	8.9	5.1	33	22.7	1.7	0.5	0.2
11-5	1.5	8.4	1.5	40	24.1	1.8	0.5	0.1
11-8	1.5	8.2	0.6	43	27	2.0	0.5	0.0
11-12	1.5	8.2	0.2	--	38.9	1.7	0.5	0.0
11-18	1.5	8.0	0.1	--	57.6	2.3	0.0	0.0
11-22	1.5	7.8	0.0	98.4	67.5	3.0	0.0	0.0
11-27	1.5	8.5	0.0	111.5	90.0	1.8	0.0	0.0
12-4	1.5	8.4	0.0	129	110.0	4.5	0.5	0.0
12-11	1.5	8.4	1.5	93	--	0.0	0.5	0.0
12-18	1.5	8.7	0.0	195	123	17.9	0.0	0.0

TABLE I (Contd)

ANALYSIS RESULTS

Lazy Mountain Children's Home Oxidation Pond

Date	O-PO_4 (mg/l)	Total PO_4 (mg/l)	Poly PO_4 (mg/l)	Cl^-	SpCond (MOHS)	CO_3 ALK (mg/l)	HCO_3 ALK (mg/l)
5-14	3.5	3.8	--	--	155	0	67.2
5-16	4.2	4.2	--	3.6	181	0	64.4
5-19	1.9	4.8	--	9.3	183	0	78.4
5-21	4	6.0	--	10.1	158	40	36.8
5-25	4.2	6.8	--	16.5	125	41.4	28.1
5-28	5.7	7.8	--	19.9	126	39.8	38.2
6-4	7.8	8.8	--	24.8	155	41.4	33.7
6-10	6.8	9.4	--	26.1	179	41.4	50.6
6-18	8.4	10.5	--	21	180	44.7	42.7
6-25	8.4	11.5	--	23	176	--	--
7-2	--	10.4	--	29	193	38.6	39.4
7-9	7.6	9.6	0.4	36	260	50.7	56.1
7-16	7.2	8.8	0.2	35	223	49.7	47.7
7-23	8.6	10.7	0.3	37	--	0	140
8-1	4.4	5.6	0.3	27	340	0	154
8-6	9.0	11.2	0.6	29	348	0	154
8-13	6.8	8.0	--	30	271	77.3	53.4
8-20	3.3	7.2	--	27	226	48.3	80

8-27	6.0	7.8	0.6	30	224	--	--
9-6	--	--	--	26	230	78.6	70.3
9-10	7.5	7.8	0.3	28	312	66	46.4
9-17	12.0	13.3	1.3	32	370	21.6	151
9-24	13.4	13.6	0.2	28	344	33.6	178
10-1	15.2	16.0	0.8	37	418	24	167
10-15	16.0	16.4	0.4	34	420	21.6	163
10-22	15.6	16.0	0.4	34	490	2.4	202
Ice Cover							
10-28	14.8	14.8	0.0	37	530	0	220
11-1	17.2	17.6	0.4	41	580	0	239
11-5	17.6	18.0	0.4	41	610	0	265
11-8	19.2	20.0	0.8	46	670	0	287
11-12	23.4	24.5	1.1	52	790	0	312
11-18	33.7	34.0	0.3	66	1060	0	441
11-22	39.0	41.0	2.0	83	1270	0	482
11-27	46.0	47.0	1.0	98.8	1564	0	613
12-4	54.0	56.0	2.0	117.5	1841	0	915
12-11	33.7	34.5	0.8	60.0	970	0	319
12-18	52.1	53.2	1.1	121.3	2111	0	955
12-31	55.2	55.4	0.2	94.9	1630	--	--

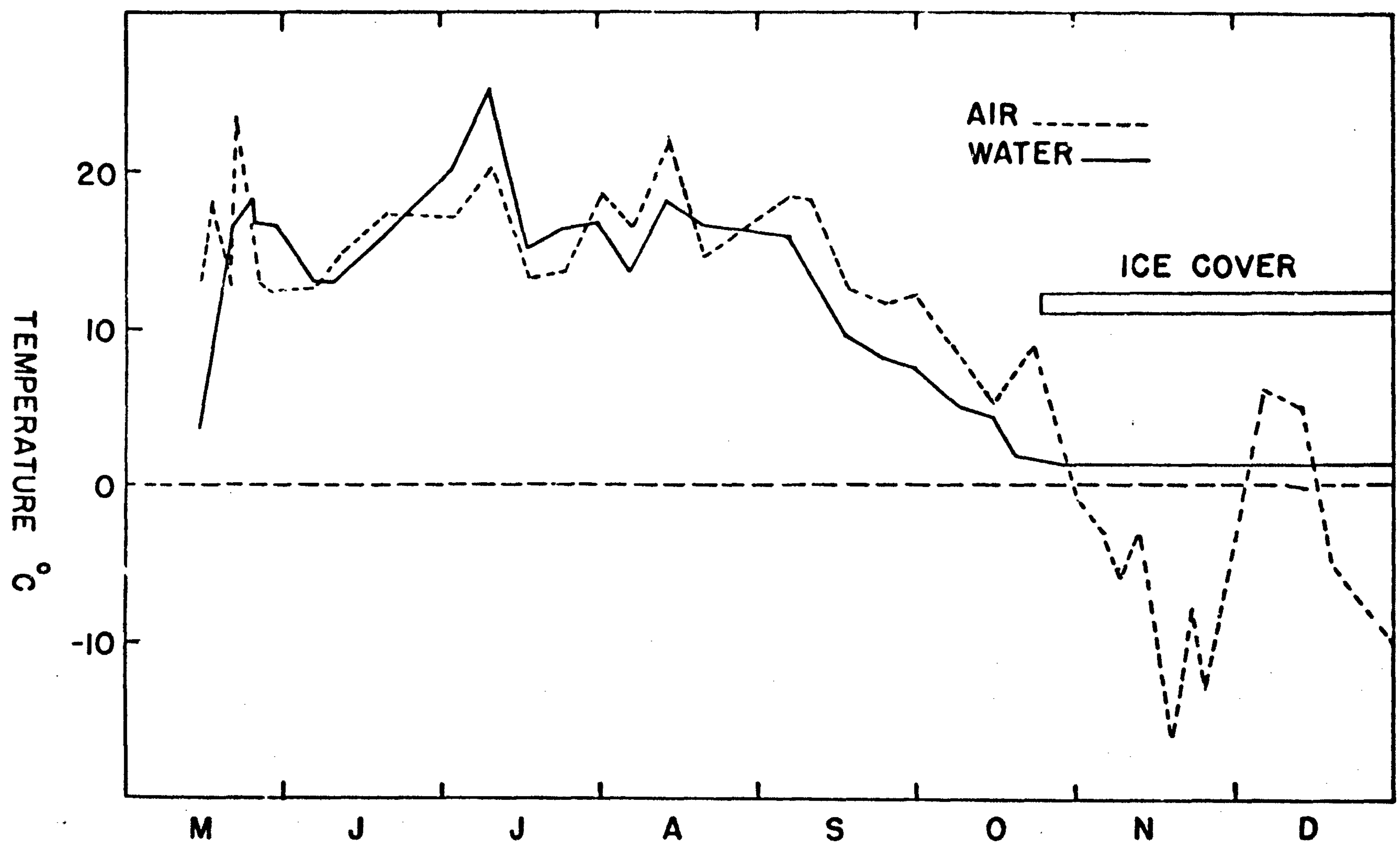

FIGURE 1

A comparison of air and water temperatures
at Lazy Mountain Children's Home oxidation pond

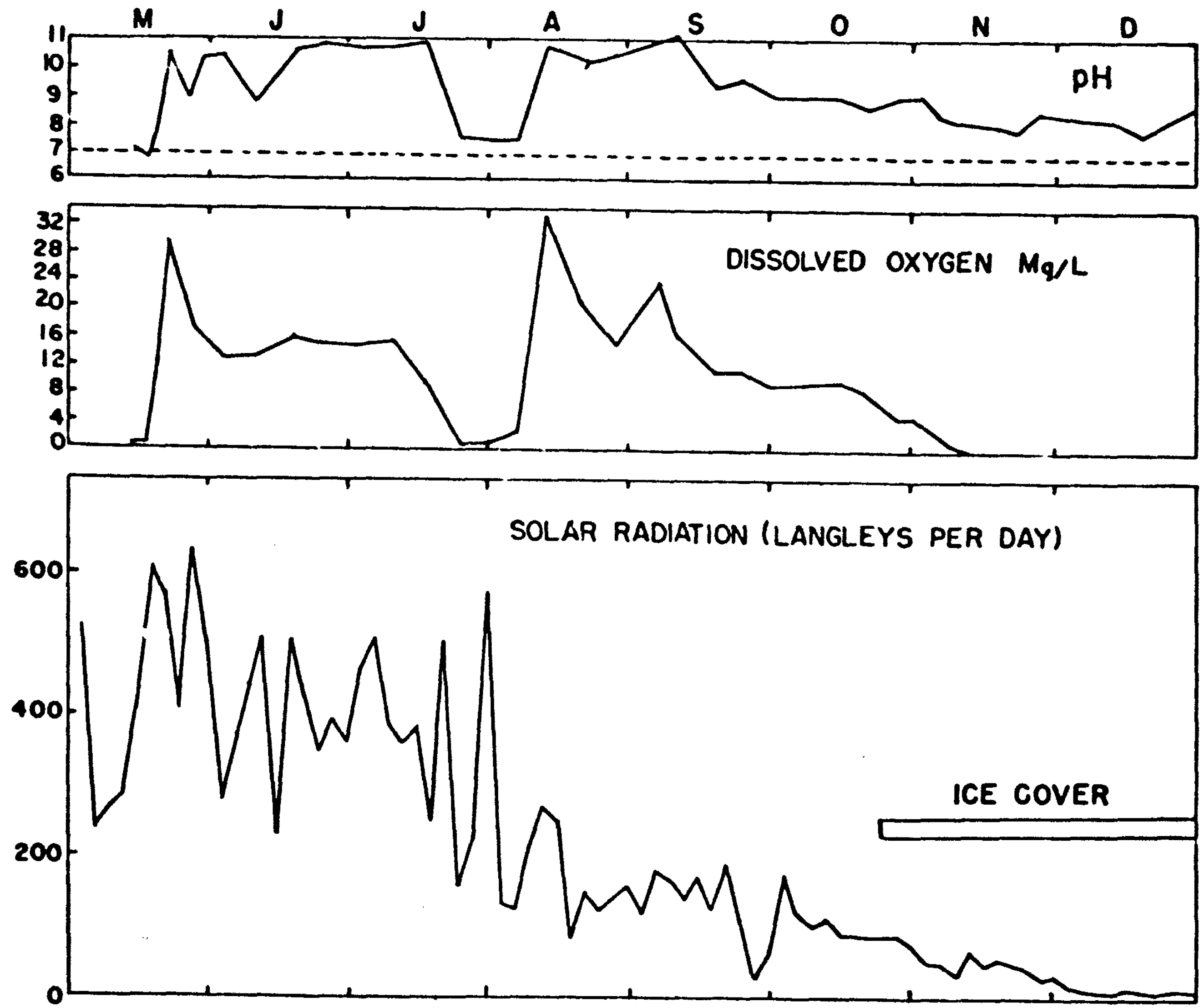

FIGURE 2

Lazy Mountain Children's Home oxidation pond. Selected data.

Alkalinity. Alkalinity was lowest during the more active photosynthetic periods and highest following formation of ice cover. The monocarbonate (phenolphthalein) alkalinity occurred during the period of highest photosynthetic activity. This period can be correlated with both oxygen and plankton pulses.

Nitrogen cycle. Nitrate and nitrite nitrogen remained low throughout the season, indicating rapid utilization by the algae. Ammonia nitrogen (Figure 3) provided the main source of nitrogen for the plankton, as indicated by its diminution during periods of maximum algal density. There was a pronounced buildup of this compound following formation of the ice cover, however.

Phosphate. The phosphate burden (Figure 3) was utilized by the algae during the growing season, as is evidenced by the accelerated buildup following formation of the ice cover.

Chloride. The chloride content was generally low throughout the summer (ca. 30 mg/l) and showed no appreciable rise until after occurrence of ice. From 1 November until the completion of the sampling schedule, the chloride concentration rose from 40 mg/l to over 110 mg/l. The latter figure can be explained, in part, by the fact that as the ice thickened the cations became more concentrated. Following breakup in May, however, the readings were the lowest for the season. This is because as the ice formed, the chloride ions were excluded from the ice so that, in effect, the ice became essentially salt-free. During melting in the spring, the ice-melt diluted any residual material collected during the winter that was not otherwise lost through seepage. This is shown graphically by Figure 4.

SECTION 4. BIOLOGICAL FEATURES

Bacteria. As previously stated, it was not possible to determine bacterial reduction between influent and effluent as neither could be sampled. However, microscopic observations of the plankton did show that only during a brief period after breakup and again shortly following ice formation was there any evidence of bacterial activity. During the ice-free season, and especially during periods of maximum algal growth, bacteria appeared very sparingly.

Phytoplankton — taxonomic consideration. Plankton analyses revealed 8 genera representing 18 taxa of photosynthetically active organisms. The breakdown according to principal taxonomic groups follows:

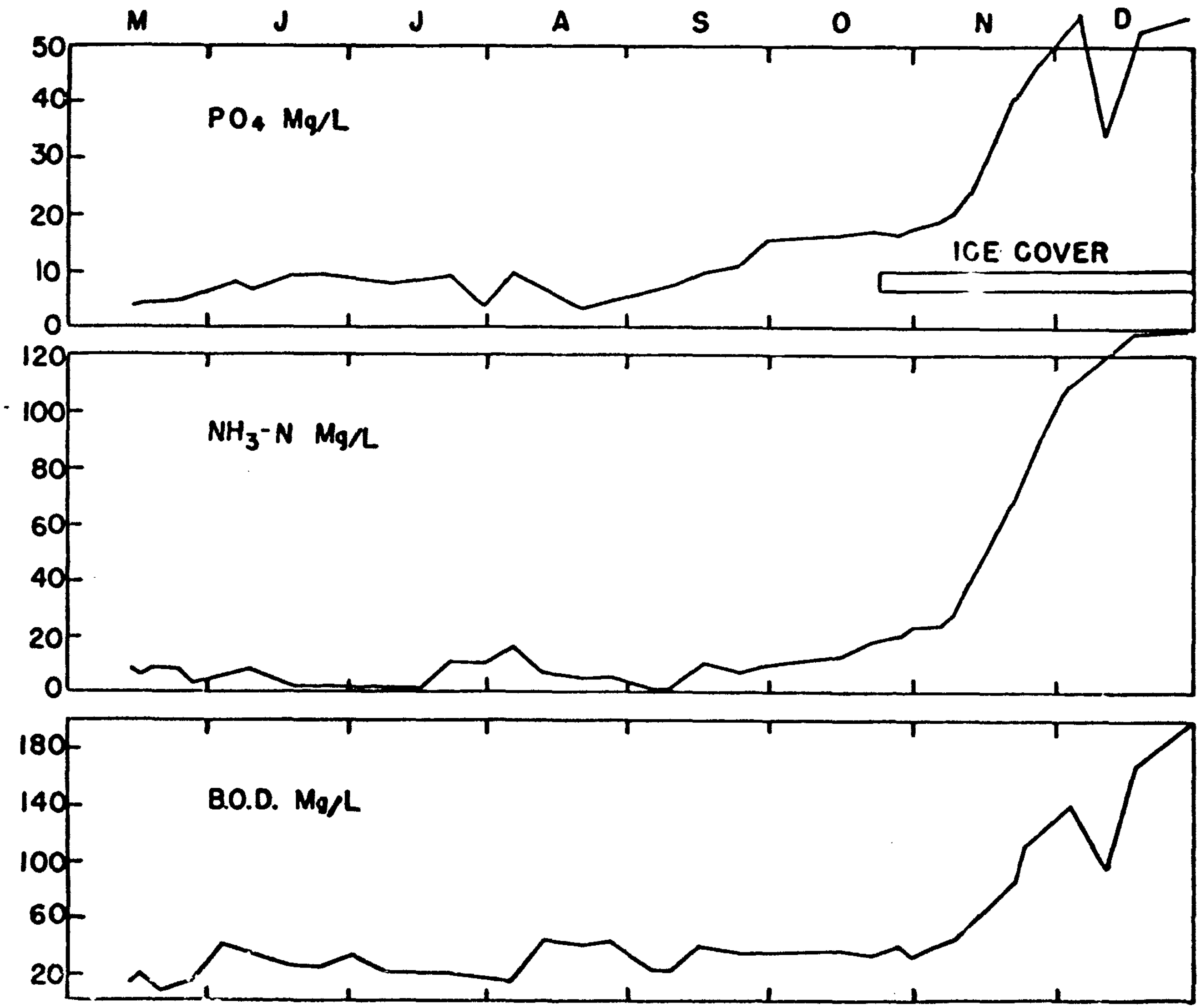

FIGURE 3

Lazy Mountain Children's Home oxidation pond. Selected data.

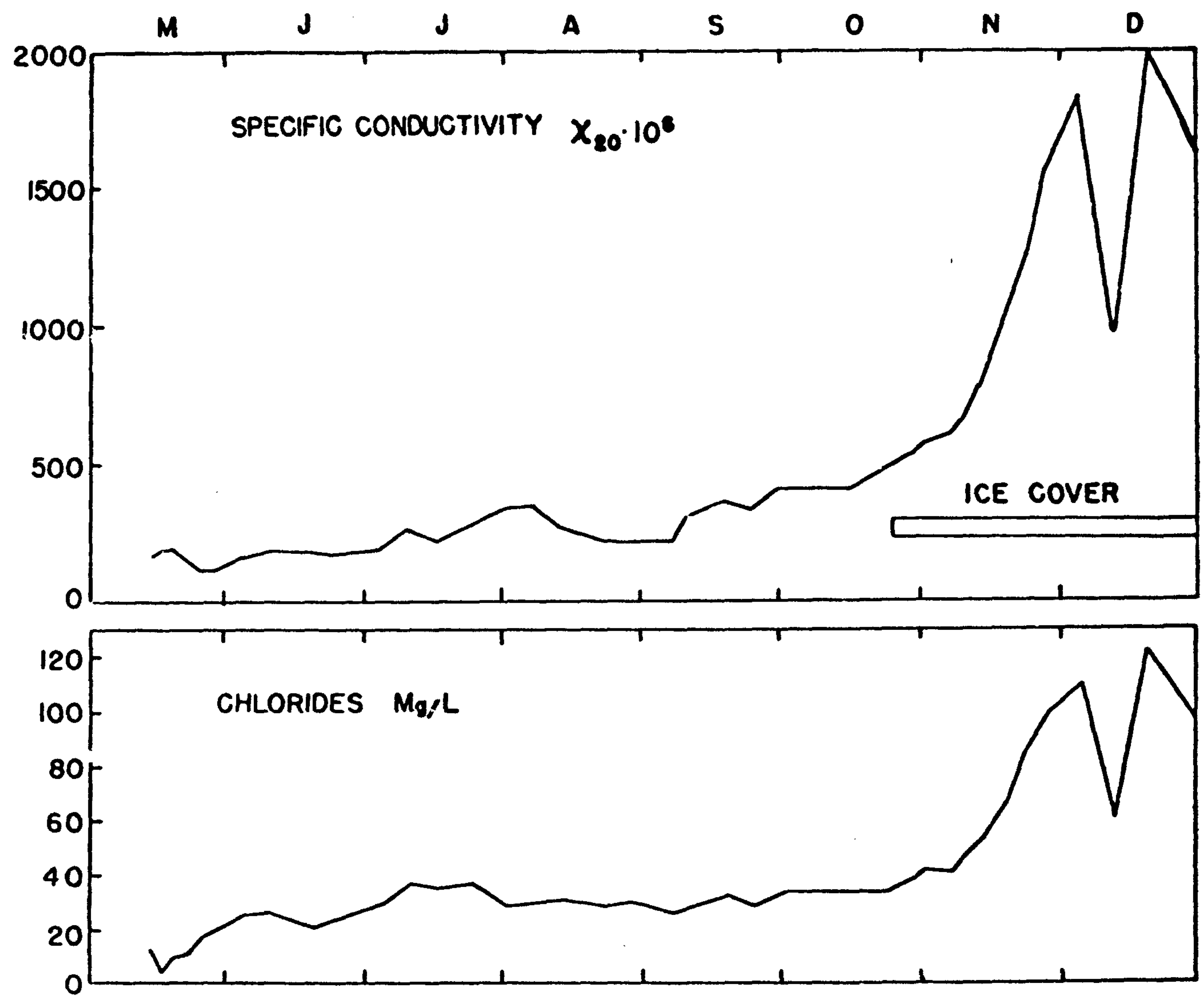

FIGURE 4

Lazy Mountain Children's Home oxidation pond. Selected data.

Chlorococcales

Ankistrodesmus falcatus var. spirilliformis

Chlorella pyrenoidosa

Scenedesmus obliquus

Volvocales

Chlamydomonas applanata

Chlamydomonas heterogama

Chlamydomonas isogama

Chlamydomonas oblonga

Chlamydomonas perpusilla

Chlamydomonas pulstilla

Chlamydomonas reinhardti

Chlamydomonas reinhardti var. minor

Chlamydomonas simplex

Chlorogonium fusiforme

Diplostauron pentagonium

Haematococcus draebakensis

Diatoms

Nitzchia palea

Blue-green Algae

Oscillatoria rubescens

According to Huber-Pestalozzi (1), all volvocalean forms listed herein, with the exception of Chlamydomonas reinhardti, previously have not been reported from North America. Likewise Palmer (4), in his list of pollution-tolerant species of algae, cites only Chlamydomonas reinhardti. This does not preclude the possibility that the other species are not normally sewage-tolerant, but it merely points out that they have not previously been observed or reported from a sewage environment and stresses the need for additional study of lagoon organisms, especially in Alaska. The occurrence of Haematococcus draebakensis following the descendency of Scenedesmus obliquus, in late July, is noteworthy, especially since the latter species represents a genus not normally considered pollution-tolerant. This species previously was reported from Norway.

Nitzchia palea and Oscillatoria rubescens did not occur in the plankton but appeared in the algal mat previously discussed. Both species occurred very sparingly.

Phytoplankton — quantitative features. Figure 3 indicates the several genera in terms of abundance and seasonal distribution. The Chlamydomonas complex (with 10 taxa) first appeared, before the last of the ice had left the pond, attached to stems of dead vegetation along the pond's margins. These became planktonic within a short period (16 May) and attained maximum numbers on 21 June (ca. 320,000 per ml). By 4 June there were about 187,000 cells per ml, but following this date all Chlamydomonas species disappeared from the plankton until 1 August, when these organisms were observed for a period of two weeks. Occurring concurrently with the last-named genus were the following: Chlorella pyrenoidosa, Ankistrodemus falcatus var. spirilliformis and Scenedesmus obliquus. Chlorella attained its seasonal maximum slightly later then Chlamydomonas (25 May) and, like the latter genus, completely disappeared from the plankton on 4 June and was not observed for the remainder of the season. Ankistrodesmus appeared sparingly (ca. 600 per ml) on 16 May, attained maximum density during the course of this pulse on 4 June, and then reappeared in greater numbers (ca. 8,000 per ml) during early August. From September through 12 November, this taxon was reasonably well represented, even though much of this time was during a period of ice cover.

The dominant alga observed during the course of this investigation, in terms of both numbers and volume, was Scenedesmus obliquus. This species occurred concurrently with the last-named genera. By the first of June, over 1,000,000 cells per ml were recorded, and by 9 July, the cell count was in excess of 10,000,000 per ml. On 23 July, however, the population was reduced to less than 14,000 cells per ml due to the toxic effects of the paint thinner. Within a period of two weeks, the count had returned to over 1,000,000 per ml and by 1 October, a seasonal maximum of 13,360,000 cells per ml was attained. From this date until 18 December, the plankton averaged over 2,000,000 cells per ml, even though much of this period was represented by ice cover.

Concurrent with the decline in numbers of Scenedesmus obliquus, a new alga, Haematococcus draebekensis, made its appearance with ca. 2 specimens per ml on 1 August. A maximum of 67, 000 per ml was recorded on 20 August, and within a week's time the count had been reduced to 5 per ml, with subsequent extinction.

It is of particular interest here that with the sharp acclivity of Scenedesmus, Chlorella, Chlamydomonas and Ankistrodemus, on 4 June all genera except Scenedesmus disappeared from the plankton, and it reached a count in excess of 1, 500, 000 per ml. With the decline of Scenedesmus on 23 July, when this alga was reduced to fewer than 14, 000 per ml, there was a slight pulse of those genera hitherto missing from the plankton. Their numbers showed a substantial increase until Scenedesmus again appeared in excess of 1, 000, 000 per ml, at which time the other genera again disappeared. These two phenomena may be explained, in part, by the fact that Scenedesmus may have liberated extracellular material which inhibited the growth of the other algae. In situations which are highly eutrophic, such as oxidation ponds, one genus often thrives at the expense of all others.

Zooplankton. The normally stalked protozoan, Vorticella microstoma, occurred as a free-swimming entity in the plankton. It first appeared in late May with about 500 per ml and attained a seasonal maximum on 4 June with 1200 per ml. It fluctuated considerably in numbers during the remainder of the season until mid-November, at which time it died out (Figure 5). Beginning 4 June, there was a slight pulse of a rotifer (tentatively identified as Pompholyx sulcata) which never exceeded 40 per ml. After a month of active grazing on Scenedesmus, it disappeared for the remainder of the season. According to Liebmann (2), the protozoan Vorticella microstoma is considered polysabrobic and is an indicator of pollution, but he makes no reference to the rotifer genus Pompholyx.

SECTION 5. COMPARISON WITH OTHER FACILITIES

As previously stated, the Lazy Mountain Children's Home pond has no outlet, nor is there a means for compositing influent samples. Therefore there is no way to evaluate this pond in terms of BOD and bacterial reduction, the two principal criteria used in assessing oxidation pond performance. In order to learn something of the Alaska pond's capabilities, the pond was compared with one already studied which had comparable dimensions and BOD loading. The qualities of the two ponds were compared in terms of their water chemistry, physical characteristics and biology. The pond used for comparison was reported on by Neel et al (3) at Fayette, Missouri. In Neel's study, loading levels of 20, 40, 60, 80 and 100 lbs BOD/day/acre

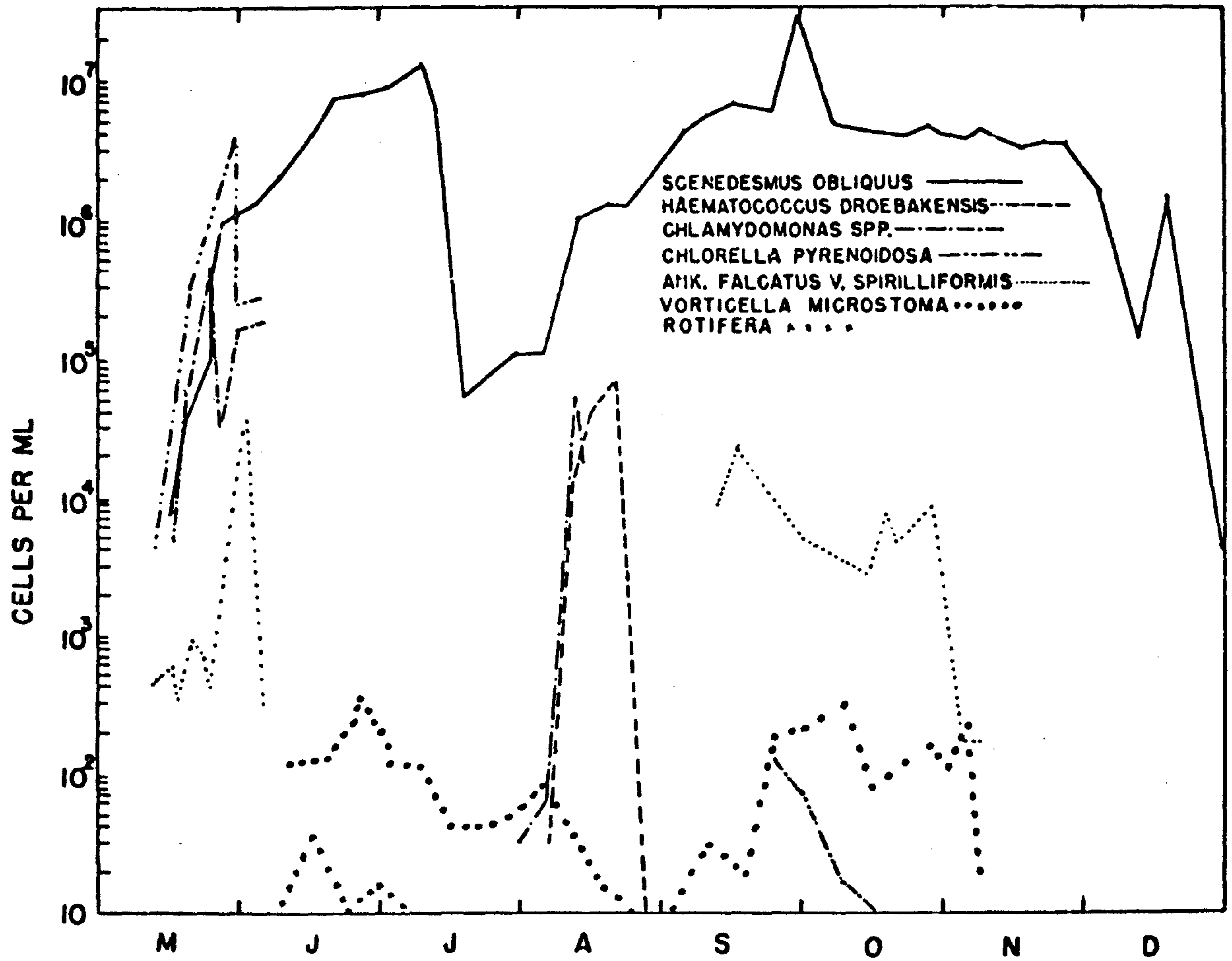

FIGURE 5

Seasonal distribution and abundance of oxidation pond plankton.

were made in a multiple-cell facility, with each cell having an area of 3/4 acre. Since the Alaska pond was loaded consistently at 40 lbs of BOD/day/acre, the cell of the Missouri pond with a comparable loading was used for comparison. In Table II selected data on the Missouri and Alaska ponds are compared, using average monthly figures. In comparing these data, it should be borne in mind that the Alaska pond samples represent incomplete treatment, since these were collected from the pond proper rather than the point of discharge. A comparison of the two ponds follows: Average temperatures show that during the bulk of the growing season (i. e., May through October) the Fayette pond's temperatures are 10 to 15° C higher than those of the Alaska pond, while during the remainder of the period (November and December), the Fayette temperatures were 2 to 6° C higher. Air temperatures for the two stations show a corresponding trend.

The pH values for the two ponds paralleled one another except during July and August, when a minimum reading of 7.4 was observed in the Alaska pond as a result of the introduction of the paint thinner.

Average dissolved oxygen values were greatest for the Alaska pond during the months of May and June, when algal growth was particularly accelerated. Throughout July, however, the reading dropped to about half that of the Fayette pond, presumably due to the depressing effects of the paint thinner on the algae as well as a prolonged period of rain and overcast skies. During August and September both ponds had comparable readings, but from October through December the oxygen in the Alaska facility decreased significantly due to the formation of ice; throughout December there was essentially no oxygen. At Fayette, the occurrence of ice was not long, and average dissolved oxygen values generally remained about 10 mg/l. Solar radiation at Fayette was much higher in every month (Table II).

BOD values for the Alaska pond were considerably lower (from one-third to one-half) those of the Fayette installation from May through July. The BOD in both facilities was about the same during September and October. With the beginning of ice cover in October, there was an appreciable rise in BOD for the Alaska pond, so that by December a value of 146 mg/l was attained, as compared with 37 mg/l for the Fayette installation. This situation indicates more complete aerobic treatment for the latter pond, while the thickness of ice (25 inches by 31 December) and low water temperature (1.5° C) in the Alaska facility minimized biological treatment.

Phosphorus utilization by the Alaska pond was generally more efficient during the more vigorous growing period (May through August) than in the Fayette pond. With the onset of fall and reduced temperatures, however, there was an appreciable buildup of phosphorus in the Alaska installation indicating, as with the BOD cited above, incomplete utilization by the algae due to depressed temperatures and lack of light for photosynthesis.

TABLE II

COMPARISON OF SELECTED CHARACTERISTICS IN MISSOURI AND ALASKA PONDS WITH SIMILAR BOD LOADINGS

	BOD (mg/l)		Phosphate (mg/l)		Organic Nitrogen (mg/l)		NH_3 -N (mg/l)	
Date	Missouri	Alaska	Missouri	Alaska	Missouri	Alaska	Missouri	Alaska
May	31	12.1	--	3.9	--	11.1	--	6.8
June	36	22	11	7.8	9	11.5	12.9	4.3
July	46	18	8.7	7.8	10	14	9.8	3.5
Aug.	37	35	8.6	5.9	7.3	8.5	7.3	8.5
Sept.	56	30	6.1	11	6.2	4.5	6.2	4.8
Oct.	47	37	7.0	15	--	2.2	5.7	15.2
Nov.	33	40	5.5	28	4.6	2	4.9	47
Dec.	37	146	5.2	49	5.7	7.3	5.8	118

	Water Temp. (^{o} C)		Air Temp. (^{o} C)		Solar Radiation (Langleys/day)	
Date	Missouri	Alaska	Missouri	Alaska	Missouri	Alaska
May	24	14	17.8	8.3	--	448
June	29	14	22.8	13.3	553	389
July	33	19	26.2	15.5	550	377
Aug.	29	16	24.6	7.8	515	303
Sept.	22	12	18.6	12.8	388	232
Oct.	16	4	12.1	1.2	286	101
Nov.	8	2.3	5.4	-13.3	198	45
Dec.	3	1.1	3.3	- 5.4	161	13

TABLE II (Cont'd)

Date	pH (Range)		Dissolved Oxygen (mg/l) Average		Dissolved Oxygen (mg/l) Maximum		Dissolved Oxygen (mg/l) Minimum	
	Missouri	Alaska	Missouri	Alaska	Missouri	Alaska	Missouri	Alaska
May	7.3- 9.1	6.9-10.4	13	13.5	26	29.4	TR.	0.15
June	8.8- 9.3	8.8-10.8	10	16.5	13	15.7	9	12.3
July	8.1-11	7.4-10.9	19	10.3	35	17.4	0	0.2
Aug.	8 - 9.6	7.4-10.5	17	14.4	37	33	3	1.1
Sept.	8.9-10.2	9.4-11.2	15	15.6	18	16.1	10	11.6
Oct.	8 -10.2	8.6- 9.1	17	8.1	27	9.9	8	4.6
Nov.	7.9- 9.1	7.8- 8.9	11	1.1	16	1.5	7	0
Dec.	7.2- 8.4	7.8- 8.7	5	0.4	10	1.5	0	0

Date	Chloride (mg/l)		NO_3 -Nitrogen (mg/l)	
	Missouri	Alaska	Missouri	Alaska
May	49	11.9	0.2	0.5
June	57	23.7	0.3	0.9
July	47	34.1	0.1	0.9
Aug.	52	36.6	0.04	0.4
Sept.	54	28.5	0.1	0.5
Oct.	49	35.4	0.1	0.5
Nov.	52	62	0	0.3
Dec.	--	98	0	0.3

Since ammonia nitrogen provides the principal source of nitrogen for the algae, it is interesting to note that in the Alaska installation there is greater utilization of this compound during the more photosynthetically active period (May through September) than was demonstrated by the Fayette facility. But with the onset of ice in October, the ammonia nitrogen shows a progressively greater buildup, indicating a lack of utilization during an anaerobic regime.

Nitrate nitrogen, though never in excess of 0.9 mg/l for the Alaska pond, was generally greater for any given month than was observed at Fayette. The latter installation varied from 0.3 to 0 mg/l, with the lower values occurring during the winter. Organic nitrogen, which is utilized principally by bacteria rather than algae, was generally commensurate for the two facilities, with the exception that in the Alaska pond it was slightly higher through June and July. No values are given for the Fayette pond in May.

The chloride content of the Fayette lagoon was fairly uniform (47 to 57 mg/l) throughout the sampling period. With the Alaska facility, however, values recorded between May and October were substantially less; i.e., 11.9 to 35.4 mg/l. Following formation of ice cover, these values rose to 62 and 98 mg/l during November and December, respectively.

SECTION 6. CONCLUSION

On the basis of field observations and comparison with another facility of comparable BOD loading, the following conclusions are drawn concerning the performance of the Lazy Mountain Children's Home oxidation pond.

This facility appeared to handle readily a BOD burden of 40 lb/acre/day, as was evidenced by the ease with which the phytoplankton metabolized ammonium and phosphorus compounds.

The pond maintained a vigorous dissolved oxygen gradient and pH; both are indicative of good stabilization.

Recovery from an oxygenless state (ice removal in the spring) showed that the pond rallied within a week from an anaerobic situation to an aerobic one, where the algae demonstrated an accelerated growth and the dissolved oxygen became supersaturated.

When an algicide (paint thinner) was inadvertently introduced, the pond recovered within a two-week period, even though BOD loading was continued during this time. Similar situations observed by this investigator in Alaska have shown that when there is induced eutrophy (either artificial or natural), recovery from an anaerobic to an aerobic condition is very slow and frequently proves irreversible.

Of the two algal genera, Euglena and Oscillatoria, which are normally associated with an abundance of nitrogenous material and thus indicate overloading and/or inadequate treatment, only Oscillatoria was observed. This genus appeared sparingly in an algal mat but was not present in the plankton.

Although it had no outlet, this facility never indicated a "distressed" situation as a result of an overabundance of algae. Ordinarily an excess of algae contributes considerably to the BOD burden, since the algal carcasses of the spent plants add appreciably to the loading.

In light of the above observations, this investigator concludes that the Lazy Mountain Children's Home pond performed adequately when loaded at the rate of 40 lb/acre/day.

REFERENCES

1. Huber-Pestalozzi, G. Das Phytoplankton des Susswassers. 5, Teil Chlorophyceae, Ordung: Volvocales. Stuttgart, 1961.

2. Liebmann, H. Handbuch der Frischwasser-und Abwasserbiologie. Munchen, R. Oldenbourg, 1951.

3. Neel, J. K. et al. Experimental lagooning of raw sewage at Fayette, Missouri. Jour. Water Poll. Cont. Fed. 33:603-641, 1961.

4. Palmer, C. M. The effect of pollution on river algae. Ann. N. Y. Acad. Sci. 108:389-395, 1963.