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The Characteristics of Spanish Reservoirs

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Sau Reservoir was first filled in 1963 in a middle stretch of the Ter River, as part of a multi-use scheme, including hydroelectric power, agricultural irrigation, domestic and industrial water supply to metropolitan areas, and also recreational activities. Since it was built, the reservoir has experienced a process of increasing eutrophication (Vidal and Om 1993), from moderately eutrophic during the first years after filling, to severe eutrophication in the late 1980s. Several human activities in the basin fed the process: intensive use of fertilizers, pig and stock farming development, proliferation of industrial areas and changes in land use (Sabater et al. 1990; Sabater et al. 1991; Vidal and Om 1993; Sabater et al. 1995; Espadaler et al. 1997). To improve the quality of water supplied by the reservoir, wastewater treatment plants were built in main urban and industrial areas during the early 1990's (Vidal and Om 1993).

Limnological characterization of Sau Reservoir started in 1963, conducted by the local water supply company ("Aigües Ter-Llobregat", ATLL). Since 1995, this study is executed in collaboration with the Department of Ecology at the University of Barcelona, under supervision of Dr. Joan Armengol. Thus, a good database is available on both changes in the water body and on incoming materials through main inflows (the Ter River and the Major River, accounting for 85% and 8% of land drained by Sau Reservoir, respectively). The basic sampling frequency is monthly. Besides in-situ measured descriptors (i.e. temperature, conductivity, turbidity, dissolved oxygen concentration, pH, redox potential, and water transparency), chemical analyses are conducted on samples taken at several depths. Analyses for nutrients include nitrate, nitrite, ammonia, total dissolved nitrogen, total nitrogen, reactive soluble phosphorus, total dissolved phosphorus, total phosphorus, and silicate. Other dissolved components are analyzed, i.e. carbonates and bicarbonates as alkalinity, and main anionic dissolved substances (chloride and sulphates). Scarce measures of sulphides and metals in deep water are also available. The planktonic community of the reservoir is sampled as phytoplankton in the 5 top meters and zooplankton in the whole column. Measures of chlorophyll are obtained both, as

pigments retained in a filter from water taken at different depths, and as profiles given by a field fluorimeter. Total suspended solids, ash-free suspended solids, and elemental carbon and nitrogen content of suspended solids are also analyzed.

Besides being the frame for the long-term limnological program, Sau Reservoir has been the field for a number of detailed limnological studies. Armengol and co-workers (Armengol et al. 1986; Armengol and Vidal 1988) gave early evidence of the increasing eutrophication process of the reservoir, focusing their studies in the phosphorus content of the sediments. Vidal and Om (1993) put data from the long-term study into an historical framework, reaching similar conclusions. Armengol et al. (1999) and Han et al. (2000) studied the reservoir as a longitudinal water reactor, both from the physical and chemical point of view. Finally, detailed information about the dynamics of the planktonic microbial community of the reservoir can be found in Sommaruga et al. (1995), Comerma et al. (2001), Simek et al. (1998; 2000; 2001), and Gasol et al. (2002).

As general remarks, Sau Reservoir is an 18.5 km long, 130 Hm^3 capacity, canyon-shape eutrophic system. It receives nutrient loads that exceed in the present 10 g $SRP \cdot m^{-2} \cdot year^{-1}$ and 500 g $DIN \cdot m^{-2} \cdot year^{-1}$, supporting more than 250 mg chlorophyll-*a*$\cdot$ m^{-2}. Several hydrological patterns are described for the reservoir, from deep-water circulation during winter, to inter-flow during summer and autumn. The reservoir can be considered as a heterotrophic system in the riverine zone, where carbon imported from the river maintains a rich and high-productive bacterial community. The lacustrine zone, in contrast, develops a classical community maintained by the autochthonous production of phytoplankton.

Current research in the reservoir involves the study of the relevance of the meteorological forcing in the system, mainly focused on finding causal relationships to explain the short-term blooms of phytoplankton observed in the lacustrine area of Sau Reservoir. Also, a detailed historical research of the eutrophication process of the reservoir is being executed. This will include proposals for management targets at the watershed scale, applying both watershed and reservoir state-of-the-art models.

The study of Sau Reservoir limnology goes beyond the academic interest, as confirmed by the efforts from ATLL Water Supply Company to maintain the long-term work in the water body. Sau Reservoir is the main water supply of the city of Barcelona, and results generated during the long-term and detailed studies have been relevant to take management decisions that have improved the water quality supplied by the reservoir (i.e. construction of wastewater treatment plants in the basin, and correct management of reservoir outflows). Also, the social acceptation and use of the stored water is increasing. The hope is that this process will continue, as managers will implement correct measures to improve water quality, thanks to the results generated from limnological studies.

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