

Angelos N. Findikakis  
Hydrolink Editor

Marco Pilotti  
Guest Editor

# EDITORIAL



In 2021, the world renowned limnologist Jörg Imberger coordinated a first Hydrolink issue on deep lakes, focused on the threats to deep lakes from climate change and increased anthropic-related nutrient loads. Considering the extraordinary relevance of lakes as a source of fresh water and the value of the ecosystem services they provide, it is easy to understand why IAHR decided to further address this topic with a second Hydrolink issue that widens its scope also to shallow lakes and to reservoirs. If deep lakes dominate in mountain regions, shallow lakes are a ubiquitous presence and reservoirs play almost everywhere a fundamental role for energy production and storage, drinking water supply and irrigation.

Several recent publications have drawn attention to the problems of many lakes around the world which are experiencing rapid degradation. Anthropogenic stressors and climate change threaten the health of lakes with consequences for their ecosystem services and the quality of life of the communities living nearby. Eutrophication, the most important water quality issue worldwide, causes algal blooms and contributes to oxygen depletion, with an overall disruption of the ecosystem. Acidification, salinization and increased concentrations of hazardous pollutants are other important problems in many lakes. In addition, several lakes are shrinking because of overexploitation of the water sources that feed them or because of lower runoff and higher evaporation in their basins. Well-known examples include the disappearing Aral Sea and Lake Chad.

Mitigation and remediation of the degraded state of these lakes requires policies for the control of point and non-point pollution sources and sustainable water management practices at the basin scale for these lakes. In parallel, it is important that research and monitoring improve the understanding of the interrelationship between the hydrodynamics and the biochemistry of lakes and how it impacts the aquatic ecology. It will not be possible to find effective solutions to these challenges without a coordinated effort of the scientific community. The community of hydraulic researchers can and must play a key role in this effort.

This issue of Hydrolink includes articles describing monitoring and research in six lakes in different parts of the world. The first of these articles, by Michio Kumagai, discusses research in Lake Biwa, one of the oldest lakes in the world, hosting at its bottom aquatic organisms known to have been there for hundreds of thousands of years. Recently higher water temperatures due to climate change disrupted the annual vertical circulation of the lake resulting in lower oxygen levels at its bottom and causing a decline in the number of benthic organisms as confirmed by a special investigation of the bottom of the lake. In the search for mitigation measures a series of experiments were undertaken using wave pumps to induce downwelling of surface water to increase oxygen levels at the bottom of the lake. These experiments demonstrated the high energy conversion efficiency of the wave pumps, suggesting that they are a sustainable tool that can contribute to the remediation of hypoxia in lakes.

In the second article, S. Geoffrey Schladow and Shohei Watanabe review data and observations in Lake Tahoe, a famous deep alpine lake in California, well known for the clarity of its waters, which has experienced a steady decline in clarity despite a reduction in pollutant discharges and a small reduction in nutrient concentrations. The article shows the importance of long-term monitoring of lakes. The observed increase in water temperature, changes in lake's thermal stratification and in the timing of inflows caused by earlier snowmelt over the years, focused ongoing research on understanding the different processes that affect the lake's clarity.

An example of the complexities in the management of large deep lakes is Lake Garda, in northern Italy, a natural lake which is now regulated for hydropower, flood protection, and water supply after the construction of a downstream dam. A group of researchers from the University of Trento led by Marco Toffolon discusses the analysis of the water balance of the lake based on multi-year data records and numerical modeling of mixing processes in the lake. This work helped understand better the role of local climate changes in the decline of water quality of the lake. The ultimate goal of this research is to support the development of management strategies for both water quality and quantity in the lake.

The fourth article by Francisco Rueda *et al.* shows how eutrophication in reservoirs creates special problems as it affects the quality of water releases and withdrawals. Drawing from the experience with several reservoirs in Spain, the authors discuss how selective withdrawals is used to ensure acceptable water quality from reservoirs used for domestic water supply, and how this is complicated by more frequent droughts that cause very low water levels. In situ water quality methods like hypolimnetic oxygenation and artificial destratification may be alternative solutions but it is important to consider carefully the uncertainties involved in their application.

The fifth article by Boqiang Qin discusses the challenges in dealing with eutrophication and cyanobacterial blooms in lake Taihu, a large shallow lake situated in the delta of the Yangtze River. The lake is affected by the combination of inadequate treatment of the wastewater discharges, the lack of non-point source pollution control, a relevant internal loading of nutrients whose consequences are amplified by cyanobacterial blooms and climate warming. The complex role of all these factors is illustrated by this paradigmatic case.

Finally, the last contribution illustrates the meaning of the photograph on the cover of this issue. The explanation bridges the topics of hydraulic engineering and physical limnology, showing how the residual nutrient load discharged from sewer spillways along the mixed sewer of Lake Iseo can contribute to explaining the slow recovery of eutrophic lakes in many areas of the world.

With four articles on deep lakes, one on shallow lakes and one focusing mostly on regulated reservoirs, this issue of Hydrolink provides a glimpse at the variety of research around the world aimed at developing lake management and mitigation strategies.