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Editorial

Plateau Lake Water Quality and Eutrophication: Status and Challenges

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1. Introduction

The continuous and widespread deterioration of lake water quality and eutrophication is not only a local problem, but also a global phenomenon. It is not only destroying, or at least limiting the valuable water resources for daily life, but threatening the water security for sustainable social development. More importantly, along with the rapid accumulation of the alga, including novel hypertoxic viruses and new toxic chemicals as well as other organic compounds, these stressors threaten aquatic life, biodiversity and endanger our health [1]. The scientific community, especially environmental scientists and ecologists, needs to pay special attention to this issue and alert the public of the potential ecological and human health effects. The unknown consequences of utilizing trans-watershed or long-distance water diversion to dilute highly polluted lake water as a solution to eutrophication and contamination, an approach often preferred by engineers and hydrologists, must be avoided to provide sustainable water resources.

The costs necessary to control lake pollution and eutrophication are high, not to mention the invisible influences on ecosystem productivity and potential persistent threat to public health. There is a need for watershed management approaches where remedial build on each other to restore and protect water quality in an efficient manner.

The so-called Nine Large Lakes (>30 km^2) in Yunnan Province of southwestern China have experienced dramatic changes, seven of the nine lakes have become heavily polluted during last few decades [1]. These closed and/or semi-closed inland lakes are strongly influenced by the monsoonal climate, which results in a rainy season from mid-May to October and a dry season from November to early May, with a south-southwestern-dominated wind. At the same time, the elevated lake surfaces are exposed to strong ultraviolet radiation. The distinct seasonal contrast leads to large seasonal lake-level fluctuations, influencing the function and structure of the ecological system. These climato-environmental scenarios are what make the lakes in the Yunnan Plateau different to and more sensitive than lakes in other locations. This situation implies that we need to adopt different approaches to manage water pollution and eutrophication, instead of replicating management paradigms from other systems. Understanding the status, evolutionary processes, and mechanisms of lake water systems, as well as predicting future trends, are critical for us to address current and future problems and challenges.

2. Articles

In total, fifteen papers were published in this Special Issue. The article titles, authors and keywords are summarized in Table 1.

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Table 1. Summary of the papers published in the Special Issue entitled "Plateau Lake Water Quality and Eutrophication: Status and Challenges" for the journal *Water*.

Title	Authors	Keywords
Lake Management and Eutrophication Mitigation: Coming down to Earth-In Situ Monitoring, Scientific Management and Well-Organized Collaboration Are Still Crucial	Hucai Zhang	None
Seasonal Stratification Characteristics of Vertical Profiles and Water Quality of Lake Lugu in Southwest China	Fengqin Chang Pengfei Hou Xinyu Wen Lizeng Duan Yang Zhang Hucai Zhang	Lake Lugu Yunnan thermal stratification seasonal changes water quality
Seasonal Variation and Spatial Heterogeneity of Water Quality Parameters in Lake Chenghai in Southwestern China	Pengfei Hou Fengqin Chang Lizeng Duan Yang Zhang Hucai Zhang	Lake Chenghai Yunnan water quality parameters seasonality spatial heterogeneity
Spatiotemporal Changes in Water Quality Parameters and the Eutrophication in Lake Erhai of Southwest China	Kun Chen Lizeng Duan Qi Liu Yang Zhang Xiaonan Zhang Fengwen Liu Hucai Zhang	Lake Erhai Temperature Chl-a seasonal changes eutrophication
Effects of Seasonal Variation on Water Quality Parameters and Eutrophication in Lake Yangzong	Weidong Xu Lizeng Duan Xinyu Wen Huayong Li Donglin Li Yang Zhang Hucai Zhang	Lake Yangzong water quality parameters temporal and spatial variations cyanophyte relative quantity index nutrient reduction
Seasonal Variation in the Water Quality and Eutrophication of Lake Xingyun in Southwestern China	Yanbo Zeng Fengqin Chang Xinyu Wen Lizeng Duan Yang Zhang Qi Liu Hucai Zhang	Lake Xingyun water quality spatial variation temporal variation
Seasonal Variations in Water Quality and Algal Blooming in Hypereutrophic Lake Qilu of Southwestern China	Donglin Li Fengqin Chang Xinyu Wen Lizeng Duan Hucai Zhang	Lake Qilu seasonal variation water temperature dissolved oxygen chlorophyll-a pH turbidity
Seasonal Water Quality Changes and the Eutrophication of Lake Yilong in Southwest China	Qingyu Sui Lizeng Duan Yang Zhang Xiaonan Zhang Qi Liu Hucai Zhang	water quality Lake Yilong spatial-temporal variations anthropogenic activities

Table 1. *Cont.*

Title	Authors	Keywords
Release of Endogenous Nutrients Drives the Transformation of Nitrogen and Phosphorous in the Shallow Plateau of Lake Jian in Southwestern China	Yang Zhang Fengqin Chang Xiaonan Zhang Donglin Li Qi Liu Fengwen Liu Hucai Zhang	plateau lake eutrophication nutrient limitation transformation
Nutrient Thresholds Required to Control Eutrophication: Does It Work for Natural Alkaline Lakes?	Jing Qi Le Deng Yongjun Song Weixiao Qi Chengzhi Hu	nutrient threshold alkaline lake pH phytoplankton blooms
Synergistic Effects and Ecological Responses of Combined In Situ Passivation and Macrophytes toward the Water Quality of a Macrophytes-Dominated Eutrophic Lake	Wei Yu Haiquan Yang Yongqiong Yang Jingan Chen Peng Liao Jingfu Wang Jiaxi Wu Yun He Dan Xu	La-modified material macrophyte Sediments Phosphorus eutrophication
Effect of Ecosystem Degradation on the Source of Particulate Organic Matter in a Karst Lake: A Case Study of the Caohai Lake, China	Jiaxi Wu Haiquan Yang Wei Yu Chao Yin Yun He Zheng Zhang Dan Xu Qingguang Li Jingan Chen	particulate organic matter (POM) carbon and nitrogen stable isotopes source tracing ecosystem degradation Caohai Lake
Influence of Cascade Hydropower Development on Water Quality in the Middle Jinsha River on the Upper Reach of the Yangtze River	Tianbao Xu Fengqin Chang Xiaorong He Qingrui Yang Wei Ma	middle reach of the Jinsha River cascade hydropower development water quality regression discontinuity analysis
Spatial and Temporal Distribution Characteristics of Nutrient Elements and Heavy Metals in Surface Water of Tibet, China and Their Pollution Assessment	Jiarui Hong Jing Zhang Yongyu Song Xin Cao	nutrient elements heavy metal elements spatiotemporal characteristics entropy method-fuzzy evaluation method principal component analysis
Tributary Loadings and Their Impacts on Water Quality of Lake Xingyun, a Plateau Lake in Southwest China	Liancong Luo Hucai Zhang Chunliang Luo Chrisopher McBridge Kohji Muraoka Hong Zhou Changding Hou Fenglong Liu Huiyun Li	external loading internal loading water quality tributary Lake Xingyun

In these papers, the seasonal variation in the water quality and eutrophication of Lake Lugu [2], Lake Chenghai [3], Lake Erhai [4], Lake Yangzong [5], Lake Xingyun [6], Lake Qilu [7], Lake Yilong [8], and a small water body (Lake Jian) [9] in Yunnan Plateau of Southwestern China was examined using current monitoring and research data. As all these lakes are heavily polluted, the situation is such that even if there might exist a

nutrient "threshold" to control the eutrophication in one lake [10], it is difficult to identify a common management approach for all lakes. Fundamentally, many lake processes are almost "dead". Restoring the ecological functioning of the lake should be the priority before, or at least in parallel with, other engineering management approaches.

The quantifying the dynamics of phosphates in lake systems is a crucial first step in controlling eutrophication. La-modified materials and La/Al-co-modified attapulgite along with macrophytes, *Hydrilla verticillata royle* and *Ceratophyllum demersum* L., were investigated and tested as an approach to modify P dynamics. The results indicate that mineralization of organophosphates is an important factor for regulating high internal P loadings and P concentrations. The combination of LMM and macrophytes led to synergistic effects in the efficiency of aquatic ecological restoration compared with individual treatments. It was also concluded that LMM enhanced the conversion rates of redox-sensitive P forms in surface sediments [11].

Organic matter is is a keey component of lakes, and the origins or organic matter vary from one lake to another. The temporal and spatial distributions of particulate organic matter (POM) prior to and after ecosystem degradation in the karst lake (Caohai Lake) were analyzed using a combination of carbon and nitrogen stable isotopes ($\delta^{13}C$–$\delta^{15}N$). This study revealed that environmental factors, including DO, turbidity, water depth, and water temperature, that regulate both photosynthesis and sediment resuspension, are key factors determining the spatiotemporal distribution of POM. Meanwhile, the POM in water is closely related to the dissolved oxygen concentrations and pH, such that decreased dissolved oxygen (DO) concentrations and pH values resulted in an increase of POM [12].

The impact of cascade hydro-power development on water quality was investigated at six hydropower stations that have been in joint operation for seven years along the main course of the middle reach of the Jinsha River in Yunnan and Sichuan Provinces. This study reveals that cascade hydropower development resulted in a decrease in TP concentrations but an increase in the concentration of CODMn and NH_3-N along that section of the river. The concentrations of CODMn and TP are higher during the rainy season and lower in the dry season, which is directly related to the input of non-point-source pollutants in the basin during the period of high surface runoff [13].

To understand the pollution status of the surface water of the Tibet Plateau, the spatial and temporal variation of nutrients, heavy metals with respect to, water quality conditions and pollutant sources were studied in surface water from 41 cross-sectional monitoring sites in 2021. The results revealed that 12 polluting elements, except lead (Pb), had significant seasonal variation. In general, the water quality in most parts of Tibet was observed to be good. The water quality of the 41 monitoring sections met the Class I water standard as per the entropy –fuzzy evaluation method [14].

Models have also been applied to better understand the effects of external nutrient loading impacts on the water quality of the lakes. It was found that the annual inputs of total nitrogen (TN) had higher variability than total phosphorus (TP) in Lake Xingyun, and the highest loadings were during the wet season and the lowest during the dry season. The poor correlation between in-lake nutrient concentrations and tributary nutrient inputs at monthly and annual time scales suggests that both external and internal loadings were regulating lake eutrophication [15].

3. Conclusions

This Special Issue highlights and discusses major threats to Plateau Lakes water quality, and provides an update on both lake current status as well as future challenges. Lake problems, such as pollution and eutrophication, require that we quantify how serious the situation is, identify the probable causes, and recommend how to control the pollution in order to restore and protect water quality. More importantly, this issues stresses the need to manage the lakes and the watershed under a unified approach.

It is important to point out that there are still many other aspects of plateau lake water quality and eutrophication that require further research and monitoring. Although

water pollution and lake eutrophication conditions have recently been protected from further deterioration, this is not due to actions we have taken; instead, it is the result of reduced human disturbance of the plateau lake water and the discharge of nutrients into the lake, which is attributable to the COVID-19 pandemic as well as the abnormal climatic conditions during the last three years. According to our monitoring data, the nutrient concentrations in the plateau lake water are still higher than acceptable values in other lakes. Nevertheless, the fundamental problems still need to be addressed, and therefore, it is not the time to take pride and become complacent. The war continues, even though the battle fields are almost empty. We still have a long way to go to regain the beauty of harmony in mountain–river–lake–water–plants scenery.

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