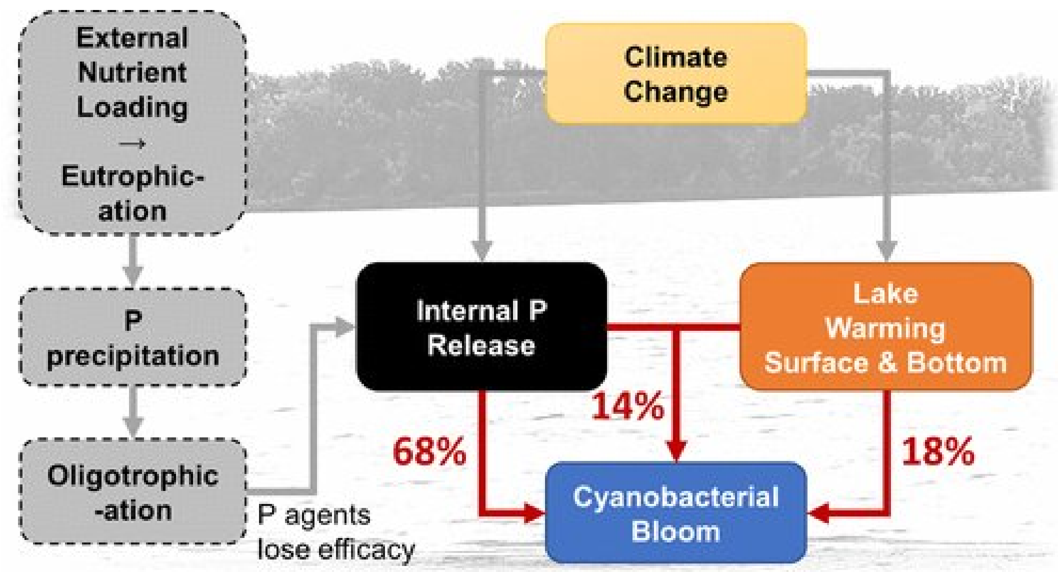
Warming and internal nutrient loading together interfere with long-term stability of lake restoration

February 27 2023, by Zhang Nannan



Graphical abstract. Credit: *Environmental Science & Technology* (2023). DOI: 10.1021/acs.est.2c07181

Urban lakes are ubiquitous worldwide and tend to be highly eutrophic, indicating an increase in the frequency, duration and magnitude of harmful algal blooms as a widespread threat to ecological and human health.

For more than half a century, phosphate (P) precipitation has been one of the most effective treatments to mitigate eutrophication in these lakes. However, after a period of high effectiveness, re-eutrophication could occur, leading to the return of harmful algal blooms. While such abrupt ecological changes have been attributed to internal P loading, the role of lake warming and its potential synergistic effects with the internal loading, thus far, has been largely unexplored.

Researchers led by Dr. Kong Xiangzhen and Prof. Dr. Xue Bin from the Nanjing Institute of Geography and Limnology of the Chinese Academy of Sciences, together with their international collaborators, have addressed this question by quantifying the contributions of lake warming and the potential synergistic effects with internal P loading in an urban lake located in central Germany that suffered from the abrupt re-eutrophication and cyanobacterial blooms in 2016 (30 years after the first P precipitation).

Their results were published in *Environmental Science & Technology* on Feb. 20.

In this study, a process-based lake ecosystem model (GOTM-WET) was developed using a high-frequency monitoring dataset covering eutrophic/oligo-trophic conditions over 30 years.

Model analyses indicated that for the abrupt onset of cyanobacterial blooms, internal P release accounted for 68% of the biomass increase, while lake warming contributed to 32%, including both direct effects via promotion (18%) and synergistic effects via intensification of internal P loading (14%). The model further showed that the synergy was due to prolonged warming of the lake hypolimnion and oxygen depletion.

"Our study exemplifies how process-based mechanistic modeling can help to tease apart important drivers of abrupt shifts and cyanobacterial blooms in lakes, especially in an era of rapid global change, including climate change and human activities," said Dr. Kong.

This study unravels the substantial role of lake warming in promoting cyanobacterial blooms in re-eutrophicated lakes. The indirect effects of warming on cyanobacteria by promoting internal loading need more attention in future lake research and management.

"Our results will have far-reaching implications for lake restoration and management, as the nutrient targets we have been using to reach or maintain a certain trophic state will not work in a much warmer future and will need to be adapted, i.e., greater nutrient reductions and restoration efforts will be required," said Dr. Kong.

More information: Xiangzhen Kong et al, Synergistic Effects of Warming and Internal Nutrient Loading Interfere with the Long-Term Stability of Lake Restoration and Induce Sudden Re-eutrophication, *Environmental Science & Technology* (2023). DOI: 10.1021/acs.est.2c07181

Provided by Chinese Academy of Sciences