Effects of External Nutrient Inputs on Phytoplankton and Nutrient Dynamics in the Three Gorges Reservoir Under Extreme Heatwave Conditions

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Abstract

Summer algal blooms frequently occur in tributaries of the Three Gorges Reservoir, yet the relative contributions of external versus internal nutrient loads remain poorly understood under extreme climate events. This study investigated an intense heatwave from July 30 to August 5, 2025, with temperatures exceeding 34°C, using in situ incubation devices and natural water controls to assess the effects of external nutrient inputs on nutrient cycling and phytoplankton dynamics. Results indicated that: (1) under high temperatures, external inputs primarily controlled phosphorus dynamics. In natural waters, surface thermal accumulation led to a sharp decline in total phosphorus (TP) from 0.04 to 0.01 mg/L due to rapid assimilation by algal blooms. In contrast, TP in the enclosed systems, where external inputs were blocked, accumulated from 0.03 to 0.08 mg/L, highlighting sediment release and algal decomposition as dominant internal phosphorus sources. (2) Extreme heat accelerated organic nitrogen mineralization, with ammonium (NH_4^+) in natural water increasing from 0.02 to 0.18 mg/L, whereas NH_4^+ in the enclosures declined to 0.08 mg/L, indicating preferential uptake of high-efficiency nitrogen sources by phytoplankton under nutrient-limited conditions. (3) Prolonged heatwaves induced strong thermal stratification, with surface dissolved oxygen exceeding 20 mg/L, while pH dropped sharply from 9.66 to 6.54, suggesting a metabolic shift from photosynthesis-dominated to heterotrophic respiration-dominated processes. (4) Total algal biomass in natural water ranged from 3.28 to 20.45 mg/L, dominated by dinoflagellates and cyanobacteria, whereas enclosures lacking external inputs exhibited lower biomass (1.96–4.58 mg/L) and rapid succession toward diatom dominance.These findings demonstrate that extreme heat alters water column stability and reinforces the critical role of external nutrient inputs in promoting harmful algal blooms.

Keywords

Three Gorges Reservoir, Heatwave; External Nutrients, In Situ Incubation, Phytoplankton