Nutrient Status and Planktonic Nitrogen Fixation in Lake Victoria, Africa

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by

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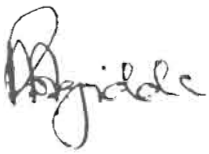
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Abstract

Eutrophication of Lake Victoria is attributable to the burgeoning human population in its watershed. The lake is experiencing increasing anthropogenic P loads from expanding urban, agricultural and industrial development. Paleolimnological and nutrient status indicators indicate excess P on a system scale. Excessive P has stimulated phytoplankton biomass and promoted blooms of N-fixing cyanobacteria. High algal biomass provides organic matter that contributes to extensive oxygen depletion in hypolimnetic waters during the stratified period. Low oxygen concentrations cause a complex suite of direct and indirect impacts including loss of aquatic animals and changes in nutrient cycling. Anoxia may be contributing to fish kills upon upwelling in Lake Victoria, and also causes release of materials bound to the bottom sediments including P. This release of nutrients reinforces eutrophication during periods of deeper and stronger mixing when dissolved nutrients are redistributed in the water column.

Data from this study suggest two patterns controlling nutrient status and phytoplankton biomass production in the surface waters of Lake Victoria. The first is *seasonal alteration of N and P limitation and underwater light*. Circumstantial evidence indicates that thermal stratification led to better light conditions for increased phytoplankton biomass, and increased P and N deficiency. Higher light during stratification compensated for and lessened effects of N deficiency and hence maintained higher algal biomass. Destratification and deeper mixing led to low underwater irradiance and reduced algal biomass and nutrient limitation. Entrainment of nutrient-rich hypolimnetic waters with low algal biomass reduces the potential for nutrient limitation during periods of stronger and deep mixing. A second pattern controlling

nutrient status is a longitudinal pattern of increasing light limitation and decreasing nutrient limitation, especially P, from inshore to offshore. Generally, light was the principal factor limiting phytoplankton production offshore as the ratio I_{24}/I_k was often below one and indicating light deficiency.

Thermal stratification and destratification influenced cyanobacterial species composition. Relatively warmer and shallowly mixing epilimnion promoted elevated N-fixing cyanobacteria and heterocyst biomass production which in turn led to elevated rates of algal N-fixation and rapid N turnover during stratification. N-fixation was an important source of N in Lake Victoria that resulted in increased total N as well as higher particulate N:P ratios during the stratified period. N-fixation in Lake Victoria was predictable from heterocyst abundances and light attenuation. Heterocyst abundances can also be used to infer N-availability in Lake Victoria and as guide to water resource management in the lake.

Overall, Lake Victoria is an example of a large ecosystem in which the phytoplankton community is usually limited by light availability but seasonally limited by nutrient availability. The ability to identify factors limiting phytoplankton community is of considerable importance to water management practices of Lake Victoria. Since both P and N are limiting, their reduction is essential in the control of cyanobacterial blooms and eutrophication of Lake Victoria. Nutrient status also provides a simple and yet an important tool for monitoring water quality.

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