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Impact of nitrogen and phosphorus additions on phytoplankton and zooplankton in deep prairie lakes

E. E. Prepas and A. M. Trimbee

Abstract

The deep lakes in central Alberta are characterized by relatively high total nitrogen to total phosphorus ratios (33 to 55) and high total phosphorus levels (10 to 30 µg/l) in the euphotic zone in summer. These lakes have good light penetration relative to the phytoplankton chlorophyll-*a* levels. The same lakes show indications of nitrogen limitation: (1) blue-green algae are relatively important in summer (24 to 83 % of total biomass by weight) and a large proportion contain heterocysts (up to 38 % of filaments) and (2) inorganic nitrogen levels are extremely low in the surface waters ($NO_2^- + NO_3^- + NH^+ - N < 10$ µg/l). These lakes are in a region with relatively little precipitation (long-term average 493 mm/yr), minimal surface runoff in summer and water residence times of four to 25 yr. These are well-buffered lakes (conductivity 270 to 330 µmhos/cm) with a high pH in the surface waters in summer (8 to 8.5).

To evaluate whether additions of inorganic nitrogen would stimulate algal growth, experiments were carried out in the summers of 1985 and 1986 on water from four deep lakes in central Alberta. In 1985 additions of inorganic nitrogen (600 to 1200 µg/l) did not stimulate plankton growth, whereas additions of inorganic phosphorus (12 to 100 µg/l) stimulated phytoplankton, periphyton, and zooplankton growth up to 24-fold. In 1986 rainfall was unusually high for one week. This rainfall followed a dry spring and a very dry summer in 1985. In all our study lakes, phosphorus levels increased in the surface waters (up to 100 %) but nitrogen levels stayed constant after the storm. The bioassays run with lake water collected within eight days of the storm were stimulated by nitrogen as well as phosphorus additions whereas the bioassays run with water collected more than 18 days after the storm showed the more typical pattern of stimulation with phosphorus alone. In all the experiments run in 1986, the blue-green algal filaments in the phosphorus alone treatments contained more heterocysts (up to 100 % of filaments contained heterocysts) than in the other treatments. Thus for a short period after an injection of water with high phosphorus and low nitrogen levels, deep prairie lakes show signs of nitrogen limitation. Otherwise, the lakes are phosphorus-limited.

Our data suggest that relatively high numbers of blue-green algae, the presence of heterocysts and low inorganic nitrogen levels are not indicative *per se* of nitrogen limitation. Rather these indicators may reflect conditions where there are infrequent injections of phosphorus-rich water, resulting in nitrogen limitation for short periods in otherwise phosphorus limited systems.

Authors' address:

Department of Zoology, The University of Alberta, Edmonton, Alberta T6G 2E9, Canada.