Action must be taken to reduce phosphorus inputs to Lake Winnipeg

The effective management of algal blooms is an increasingly pressing question facing jurisdictions across Canada and around the world. Robust evidence must be balanced with resource constraints to arrive at solutions that not only achieve the intended result but are also feasible to implement.

Phosphorus reduction is a widely recognized solution to control algal blooms in freshwater lakes.

Scientists and policy-makers have long agreed on the importance of reducing phosphorus to control algal blooms in freshwater ecosystems. As a result, aggressive phosphorus-reduction policies have been implemented in many jurisdictions since the 1980s.

In Manitoba, action to reduce phosphorus loading to Lake Winnipeg is impeded by an ongoing debate about the need for additional nitrogen reduction. The evidence supporting nitrogen reduction is uncertain – yet demands by the provincial government for nitrogen reduction are preventing progress on phosphorus reduction. Faced with decades-long inaction to address algal blooms on Lake Winnipeg, we remain concerned that robust scientific evidence from whole-ecosystem experiments – directly pertinent to the management of algal blooms on Lake Winnipeg – have been conspicuously ignored by Manitoba's Environmental Approvals Branch and the Water Science and Watershed Management Branch.

The problem: what drives algal growth?

Algal blooms represent the most widespread water-quality issue in the world, with significant risks to human and ecosystem health. Algae are simply microscopic plants that float in the water; like all plants, they need nutrients to grow. An important scientific question has been: which nutrient or nutrients are most important to algal growth? The answer to this question indicates which nutrients must be controlled to limit algae, with important implications for how Manitoba spends its finite resources and directs its efforts to manage nutrient contributions from activities like agriculture and sewage treatment to prevent algal blooms on Lake Winnipeg and other Manitoba lakes.

Scientists and policy makers first formally addressed this question in the 1960s and 1970s, in response to public concerns about algal blooms in the Laurentian Great Lakes. The main nutrient suspects were carbon (C), nitrogen (N), or phosphorus (P). Early research was limited to experiments conducted at small spatial (laboratory, enclosures) and time (days, months) scales - but these experiments were not fully representative of conditions in natural systems.

The best evidence for phosphorus reduction comes from real-world examples and whole-ecosystem experiments conducted over multiple decades.

The need for phosphorus control to prevent algal blooms is widely accepted in science, policy, and management communities and has proven to be effective in Canada (e.g. Laurentian Great Lakes) and many other jurisdictions.

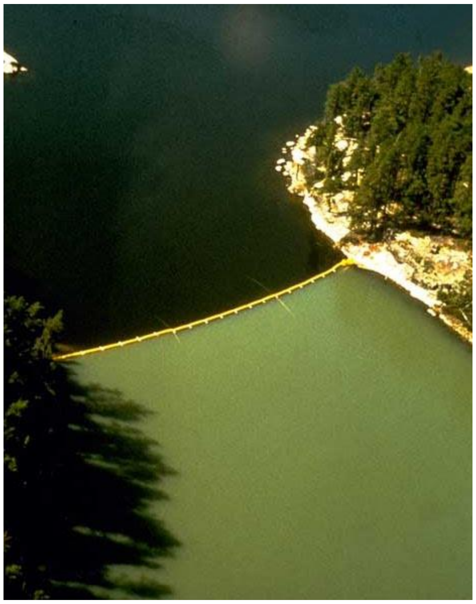

Figure 1. Lake 226 at the IISD-Experimental Lakes Area, demonstrating the connection between phosphorus and algal blooms. Nitrogen and carbon were added to the top basin, while nitrogen, carbon and phosphorus were added to the lower basin. The basin with phosphorus added developed blue-green algal blooms – the other basin did not.

Over its 55-year history, whole-lake nutrient-addition experiments have been undertaken at the IISD - Experimental Lakes Area (ELA) involving all combinations of carbon, nitrogen, and phosphorus. **These experiments have unequivocally demonstrated that phosphorus is most important for causing algal blooms in freshwater lakes and that, in turn, controlling phosphorus will reduce algal blooms.** This research is especially relevant when considering the economic feasibility of various management approaches to reduce algal blooms, as is the case for the Manitoba government's licensing of Winnipeg's North End Water Pollution Control Centre (NEWPCC).

One ELA experiment that directly informed phosphorus-reduction policies in jurisdictions around the Laurentian Great Lakes is the 'Lake 227 experiment.' This experiment began in 1969, continues to the present day, and represents the longest controlled whole-ecosystem experiment on algal blooms in the world. Its findings are consistent with observational data from many lakes that have undergone phosphorus reductions, including the Laurentian Great Lakes. Results from the Lake 227 experiment are equally applicable to Lake Winnipeg, which shares many features with Lake Erie.

Multiple nutrients have been added to Lake 227 over the past 50+ years. Years of research have shown that the complete removal of artificial nitrogen had no effect on reducing algal blooms. Without any experimental additions of nitrogen, algae compensated by taking up atmospheric nitrogen (N_2). Over time, the algal community came to be dominated by species that are able to 'fix' N_2 gas in the same way that legumes (peas, beans, etc.) fix nitrogen in terrestrial landscapes. In the Lake 227 experiment, cutting all artificial nitrogen additions had **no** impact on the magnitude of algal blooms. In the Lake Winnipeg context, much smaller reductions (<10 %) in nitrogen loads via proposed controls at wastewater treatment plants are thus unlikely to have any measurable effect on algal blooms in the lake.

Given this evidence, why do some scientists and policy makers still argue for nitrogen reduction to control algal blooms?

There are four main reasons. First, many scientists are relying on results from inappropriate small-scale experiments. Second, some scientists believe that reductions of nitrogen are needed to specifically decrease toxins associated with algal blooms. Third, some scientists argue that nitrogen reduction is needed to prevent algal blooms in marine ecosystems such as estuaries and oceans. Finally, policy makers are concerned about the potential toxicity of the nitrogen compounds ammonia and nitrate.

Scale: Small-scale, short-term studies do not reliably predict whole-ecosystem dynamics.

Small-scale laboratory and microcosm experiments, in which researchers collect a sample of water from a water body and add various nutrients, are straightforward and inexpensive to undertake, and continue to be widely published. Many of these studies have suggested that nitrogen is an important element limiting algal growth. However, these experiments have a fatal flaw in that they poorly represent what occurs in natural ecosystems. They are too short to allow for changes in the algal community towards species that are capable of fixing atmospheric nitrogen and are too small to include complex feedbacks between algae and their environment. Though numerous, these small-scale studies do not carry the weight of evidence of the ELA whole-ecosystem experiments and do not provide relevant guidance for managing whole ecosystems.

Algal toxins: Reductions of phosphorus will reduce toxic algae.

Algal toxins are one of the major concerns with algal blooms. Recent scientific studies have pointed to the high nitrogen content of algal toxins, suggesting that nitrogen management is critical to prevent toxin production. Despite some uncertainty, it is clear that toxic algae predominantly occur in high phosphorus systems. Because phosphorus ultimately limits algal growth, if phosphorus is controlled all algae will be reduced, including those that produce toxins.

Impacts on marine ecosystems: reductions of nitrogen in Winnipeg are unlikely to affect marine ecosystems.

Some research suggests that nitrogen is the driver of algal blooms in salt-water marine environments, where the algal community is different from that of freshwater environments. This has led to stringent nitrogen limits in some wastewater treatment plants that discharge in proximity to marine ecosystems. In the context of reducing algal blooms in Lake Winnipeg, these marine-focused nitrogen limits are not relevant. There are no issues with algal blooms in marine systems downstream of Lake Winnipeg (i.e. Hudson's Bay) and available research indicates that nitrogen fixation within the lake itself is a much larger source of nitrogen than wastewater treatment plants upstream of the lake.

Ammonia and nitrate toxicity: There is no evidence of acute toxicity in the lower Red River valley or Lake Winnipeg.

We fully recognize the need to limit nitrogen inputs where acute ammonia or nitrate toxicity may be a problem. However, there is no evidence of acute ammonia toxicity downstream of Winnipeg's wastewater treatment plants. Nor is there significant groundwater recharge downstream of these plants that would be cause for concerns about nitrate contamination of drinking water obtained from ground water. Both nitrogen compounds are rapidly processed by bacteria in riverine ecosystems and so do not represent a long-term concern for Lake Winnipeg.

Nitrogen reduction is expensive, will not reduce algal blooms on Lake Winnipeg, and has led to decades of inaction on phosphorus control.

Unfortunately, in Manitoba, expensive nitrogen-control requirements have been coupled to phosphorus control. Concerns about the high cost of these requirements have led to delays and inaction. Despite the strong evidence supporting phosphorus reduction as an effective means to control algal blooms, action to reduce phosphorus from sources within Manitoba has been stalled for decades while prolonged disagreements about nitrogen continue.

The solution: By focusing on phosphorus reduction, we can finally take necessary evidence-based, economically feasible action to protect Lake Winnipeg.

The Manitoba government should make use of the best-available evidence, supported by many examples of jurisdictions addressing algal blooms in the Laurentian Great Lakes and elsewhere, to implement and enforce aggressive phosphorus-reduction policies. A clear focus on phosphorus control should be applied to both point sources (wastewater treatment plants) and non-point sources (agricultural runoff) within Manitoba. This action is urgently needed to reduce algal blooms on Lake Winnipeg.