Guidelines at a Glance

Phosphorus

This fact sheet describes the Canadian Guidance Framework for the management of phosphorus in freshwater systems. It is part of the series *Guidelines at a Glance*, which summarizes information for the Canadian public on toxic substances and other parameters for which there are Canadian Environmental Quality Guidelines.

The National Guidelines and Standards Office of Environment Canada coordinates the development of Canadian Environmental Quality Guidelines in cooperation with the Canadian Council of Ministers of the Environment (CCME).

Where does phosphorus come from?

Phosphorus exists naturally in rocks. An important source of phosphorus is phosphate rock, which contains the mineral apatite. Rocks release phosphorus as they erode under normal weather conditions. Phosphorus enters freshwater systems in four main ways: (i) atmospheric inputs, including rain and dust; (ii) point (discrete) sources, including sewage treatment plants and industrial effluents; (iii) non-point (diffuse) sources, including stormwater, agricultural, and land clearing runoff; and (iv) non-point sources from within the water system, including washout from riverbanks and re-suspension from sediments (internal loading). The rate at which phosphorus loads enter freshwater systems varies with land use, geology, morphology of the drainage basin, soil productivity, human activities, and pollution.

Products such as laundry detergents used to be a large source of phosphorus to freshwater systems. Regulations under the Canadian Environmental Protection Act now control the amount of phosphorus in these products because of the adverse effects of excess phosphorus on freshwater systems (e.g., toxic algal blooms).

What happens to phosphorus released into the environment?

In freshwater systems, phosphorus occurs in three forms: (i) inorganic phosphorus, (ii) particles of organic phosphorus, and (iii) dissolved organic phosphorus. Aquatic algae and plants use an inorganic form of phosphorus for their nutrition. In most lakes and rivers, phosphorus is the primary nutrient that limits the growth of algae and plants. In some systems, the nutrient form of phosphorus is taken up very quickly and so is difficult to measure accurately. Because of this difficulty, it is best to measure the total of all forms of phosphorus.

Excessive phosphorus in a freshwater system increases plant and algal growth. This can lead to: changes in number and type of plants and animals; increases in animal growth and size; increases in turbidity; more organic matter falling to the bottom of the system in the form of dead plants and animals; and losses of oxygen in the water. When there is no oxygen at the bottom of a freshwater system, phosphorus that previously had been locked in the sediment can be released back into the water. This is called internal loading and exacerbates the problem of excessively high productivity.

What effects can phosphorus have on fish and other forms of aquatic life?

Phosphorus can be toxic, but toxicity occurs rarely in nature and is generally not a concern. Of more concern are the indirect effects of phosphorus. All algae and plants require phosphorus to grow. Elevated phosphorus levels, however, can increase a freshwater system's productivity and result in large amounts of organic matter falling to the bottom. Bacteria and other organisms decompose this matter and in the process use a lot of oxygen. In very productive freshwater systems, the oxygen levels can be in such short supply that fish kills occur. A type of algae, called cyanobacteria, grows particularly well in high levels of phosphorus. Cyanobacterial blooms can cause a range of water quality problems, including summer fish kills, bad odours, and tainted drinking water. Some cyanobacteria produce toxins that can kill livestock and wildlife.

What levels of phosphorus are safe for plants and animals that live in Canadian waters?

Total phosphorus (TP) levels vary widely in Canadian fresh waters. Some systems naturally have very low TP levels and may be described as oligotrophic (low nutrient status). Other systems naturally have high TP levels and are described as eutrophic (high nutrient status). Because of the wide variability of natural phosphorus levels in freshwater systems, it is not possible to establish a single meaningful guideline for phosphorus. Instead, a guidance framework has been developed to allow site-specific management of phosphorus.

The framework uses trigger ranges, which are ranges of desired phosphorus level for a specific freshwater system. The appropriate trigger range is determined according to baseline data and management objectives or goals for the system. If phosphorus levels in the system exceed 50 percent of the baseline level or the upper limit of the trigger range, there may be an environmental problem and further investigation is triggered. The trigger ranges for Canadian lakes and rivers are: <4, 4-10, 10-20, 20-35, 35-100, and >100 micrograms of TP per litre of water. The nutrient status labels for these trigger ranges are, in the same order as the ranges above: ultra-oligotrophic, oligotrophic, mesotrophic, meso-eutrophic, eutrophic, and hyper-eutrophic.

How do phosphorus levels in Canadian waters compare to the trigger ranges?

The phosphorus levels in Canadian lakes and rivers vary widely. Freshwater systems close to urban, residential, agricultural, industrial or other human activities likely have higher TP levels than they did before they were affected by humans. However, even freshwater systems far from human activities display a wide range of phosphorus levels. For example, lakes on bedrock such as the Pre-Cambrian Shield tend to have low TP levels. Lakes on sedimentary rocks such as the Boreal Plains of Alberta and lakes or wetlands with a lot of organic matter usually have higher TP levels.

Two case studies were examined to test the guidance framework for phosphorus. For the first, on Lake Simcoe, Ontario, a baseline TP level of 9-10 micrograms per litre of water was set because these are ideal levels for a cold water fishery. So, the lake was placed in the oligotrophic trigger range (4-10 micrograms per litre of water). In the 1970s, TP was 20 micrograms per litre of water and in the 1980s it was 15 micrograms per litre of water. These values exceed the trigger range. Phosphorus loading has been reduced to Lake Simcoe and remediation efforts continue.

The second case study was on Kodiak Lake, Northwest Territories, which has received effluents from a sewage treatment plant and now receives effluent from Canada's first diamond mine, which began operating in 1998. The baseline was defined as 11.1 micrograms of TP per litre of water, which was the average level of TP measured before construction of the mine began. So, Kodiak Lake was placed in the mesotrophic trigger range (10-20 micrograms per litre of water). This information helps form management decisions about lake monitoring and phosphorus reductions.

How can the guidance framework be used to make a difference?

In general, the guidance framework can be used by Canadian federal, provincial, and territorial governments on a voluntary basis to set local guidelines, discharge limits for industry, and clean-up targets. The trigger ranges are most commonly used in environmental assessments as benchmarks or yardsticks to which measured levels are compared. Anyone can use the guidance framework and trigger ranges to determine if the level of phosphorus measured in a sample of water has the potential to cause adverse environmental effects.

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