Minnesota Pollution Control Agency

Regional Division

Phosphorus: Sources, Forms, Impact on Water Quality

- A General Overview

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Phosphorus is an essential nutrient for plants, animals and humans. It is one of the 20 most abundant elements in the solar system, and the 11th most abundant in the earth's crust. Under natural conditions phosphorus (P) is typically scarce in water. Human activities, however, have resulted in excessive loading of phosphorus into many freshwater systems. This can cause water pollution by promoting excessive algae growth, particularly in lakes. Lakes that appear relatively clear in spring can resemble green soup in late summer due to algae blooms fueled by phosphorus. Water quality can be further impaired when bacteria consume dead algae and use up dissolved oxygen, suffocating fish and other aquatic life.

Because phosphorus changes form, most scientists measure total phosphorus rather than any single form to determine the amount of nutrient that can feed the growth of aquatic plants such as algae.

In some water bodies, the concentration of phosphorus is low enough to limit the growth of algae and/or aquatic plants. In this case, scientists say phosphorus is the **limiting nutrient**. For example, in water bodies having total phosphorus concentrations less than 10 parts per billion (1 ppb – equal to one drop in a railroad tank car), waters will be nutrient-poor and will not support large quantities of algae and aquatic plants. At the other extreme, total phosphorus levels of 100 or more ppb categorize lakes as highly eutrophic, with high nutrient and algae levels.

Sources of Phosphorus

Under normal water flows, roughly two-thirds of the total phosphorus load to lakes and rivers comes from nonpoint sources such as runoff from pasture and croplands, atmospheric deposition and stream bank erosion. Phosphorus loading contributed by runoff from pastures and croplands is largest source of nonpoint phosphorus on a statewide basis. Other nonpoint sources include urban runoff, non-agricultural rural runoff and seepage from individual sewage treatment systems.

Approximately 30 percent of the phosphorus load to Minnesota waters comes from point sources such as municipal and industrial wastewater treatment facilities. The magnitude of various sources of phosphorus varies greatly throughout the state due to the diverse nature of Minnesota's watersheds. ("Detailed Assessment of Phosphorus Sources to Minnesota Watersheds," MPCA, February 2004).

Forms of Phosphorus

Phosphorus in water exists in two main forms: dissolved (soluble) and particulate (attached to or a component of particulate matter). *Ortho phosphorus* is the primary dissolved form of phosphorus and is

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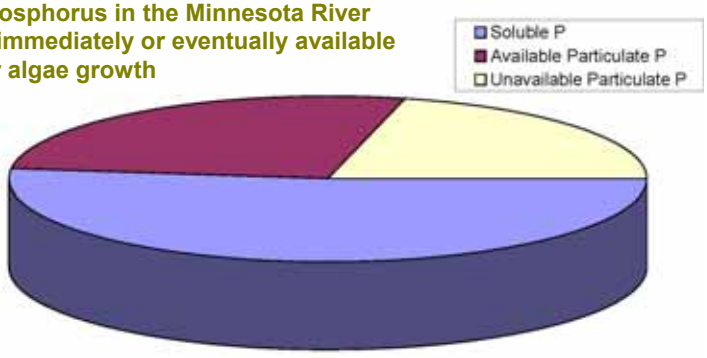
More than three-fourths of total phosphorus in the Minnesota River is immediately or eventually available for algae growth



Source: William F. James, Eau Galle Aquatic Ecology Laboratory

readily available to algae and aquatic plants. Most of the phosphorus discharged by wastewater treatment facilities is in the dissolved form.

Particulate phosphorus can change from one form to another (called *cycling*) in response to a variety of environmental conditions. A portion of particulate phosphorus is contained in organic matter such as algae, plant and animal tissue, waste solids, or other organic matter. Microbial decomposition of organic compounds can convert organic particulate P to dissolved P. Some of the P in soil mineral particles can also be converted to dissolved P both in the water column and during chemical and physical changes in bottom sediment. Only the most tightly bound forms of particulate phosphorus such as aluminum-bound phosphorus are not generally available for algal growth.

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Minnesota River Basin-Lake Pepin

Three major river basins empty into Lake Pepin in southeastern Minnesota – St. Croix, Upper Mississippi, and the Minnesota. Lake Pepin is listed as an impaired water due to sediment and eutrophication (excessive nutrients and algae). The Minnesota River contributes a majority of the sediment. In a highly turbid water body such as the Minnesota River, much of the phosphorus load is attached to eroded soil particles, especially at higher flows. Much of the particulate phosphorus in the Minnesota River converts to the soluble that can become available to algae. This occurs in several ways: chemical and physical change (diagenesis) of sediment in the river or lake bed, interaction with dissolved chemicals in the water, and decay of organic P releasing dissolved phosphorus from soil particles. Models being used in the Lake Pepin and Minnesota River Total Maximum Daily Load projects keep track of both particulate and dissolved forms of phosphorus.

MPCA Phosphorus Strategy

Controlling phosphorus is an important part of protecting Minnesota's water resources. In 1996 MPCA developed a comprehensive phosphorus strategy. The strategy was adopted in March of 2000. Information is available on the Web at: www.pca.state.mn.us/water/phosphorus.html.
In February 2004, the MPCA submitted a report to the legislature entitled a "Detailed Assessment of Phosphorus Sources to Minnesota Watersheds" (cited on previous page). The report evaluates sources of phosphorus to Minnesota's surface waters and to municipal wastewater www.pca.state.mn.us/hot/legislature/reports/phosphorus-report.html.
Phosphorus Management Plans (PMP) will be recommended or required in many new or reissued National Pollutant Discharge Elimination System permits. PMPs are a tool being used to determine if public wastewater treatment facilities and industrial wastewater dischargers contribute substantial loads of total phosphorus that could be reduced through pollution prevention or improved wastewater treatment methods.

Minnesota River Basin Phosphorus Permit

In December 2005 the MPCA issued a general NPDES permit limiting the amount of phosphorus discharged at 156 municipal and industrial discharges in the Minnesota River Basin from the outlet of the Lac Qui Parle reservoir to the city of Shakopee. The Phase I goal is an aggregate 35% staged reduction in phosphorus discharged to the basin by 2010. Phase II (2010-15) sets a goal of the 1 mg/L phosphorus limit on all facilities discharging more than 1,800 pounds of phosphorus per year and to guarantee that there is no net increase in the amount of phosphorus discharged to the basin. More information is available on the Web at www.pca.state.mn.us/water/basins/mnriver/mnriver-phosphoruspermit.html.

For More Information

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