Phosphorus

Phosphorus (P) is an essential nutrient for all life forms, and is the eleventh-most abundant mineral in the earth's crust. In surface waters, phosphorus is usually present as phosphate (PO_4-P). Phosphorus is needed for plant growth and is required for many metabolic reactions in plants and animals. Organic phosphorus is a part of living plants and animals, their by-products, and their remains. Generally, phosphorus is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used, plant growth will cease, no matter how much nitrogen is available.

Phosphorus typically functions as the "growth-limiting" factor because it is usually present in very low concentrations. The natural scarcity of phosphorus can be explained by its attraction to organic matter and soil particles. Any unattached or "free" phosphorus is quickly removed from the aquatic system by algae and larger aquatic plants. Excessive concentrations of phosphorus can quickly cause extensive growth of aquatic plants and algal blooms. Several detrimental consequences may result.

Excessive algae and plant growth can lead to depletion of the oxygen that is dissolved in the water. Water can hold only a limited supply of dissolved oxygen (DO) and it comes from only two sources- diffusion from the atmosphere and as a byproduct of photosynthesis. Excessive growth leads to depletion of DO because of nighttime respiration by living algae and plants and because of the bacterial decomposition of dead algae/plant material. Depletion of DO adversely affects many animal population and can cause fish kills.

In addition to low DO problems, excessive plant growth can increase the pH of the water because plants and algae remove dissolved carbon dioxide from the water during photosynthesis, thus altering the carbonic acid-carbonate balance. Because plants and algae provide food and habitat to animals, the relative abundance of species affects the composition of the animal community. Drinking water supplies may experience taste and odor problems, and the costs of treating drinking water can increase.

Finally, high nutrient concentrations interfere with recreation and aesthetic enjoyment of water resources by causing reduced water clarity, unpleasant swimming conditions, objectionable odors, blooms of toxic and nontoxic organisms, interference with boating, and "polluted appearances." The economic implications are significant for many communities.

Phosphorus may accumulate in bottom sediment, both in deposited clays and silts and deposited organic matter. In such cases, phosphorus and other nutrients may be released from the sediment in the future. This results in an internal phosphorus loading. Because of this phenomenon, a reduction in phosphorus inputs may not be effective in reducing algal blooms for a number of years.

Phosphorus enters surface waters from both point and nonpoint sources. The primary point source of phosphorus is sewage treatment plants. A normal adult excretes 1.3 - 1.5 g of phosphorus per day. Additional phosphorus originates from the use of industrial products, such as toothpaste, detergents, pharmaceuticals, and food-treating compounds. Primary treatment removes only 10% of the phosphorus in the waste stream; secondary treatment removes only 30%. Tertiary treatment is required to remove additional phosphorus from the water. The amount of additional phosphorus that can be removed varies with the success of the treatment technologies used. Available technologies include biological removal and chemical precipitation.

Nonpoint sources of phosphorus include both natural and human sources. Natural sources include 1) phosphate deposits and phosphate-rich rocks which release phosphorus during weathering, erosion, and leaching, and 2) sediments in lakes and reservoirs which release phosphorus during seasonal overturns. The primary human nonpoint sources of phosphorus

include runoff from 1) land areas being mined for phosphate deposits, 2) agricultural areas, and 3) urban/residential areas.

Because phosphorus has a strong affinity for soil, little dissolved phosphorus will be transported in runoff. Instead, the eroded sediments from mining and agricultural areas carry the adsorbed phosphorus to the water body. An additional source is the overboard discharge of phosphorus-containing sewage by boats.

Phosphate itself does not have adverse health effects. However, phosphate levels greater than 1.0 may interfere with coagulation in water treatment plants. As a result, organic particles that harbor microorganisms may not be completely removed.

Water Quality Standards for Phosphorus

Rule 60 of the Michigan Water Quality Standards (Part 4 of Act 451) limits phosphorus concentrations in point source discharges to 1 mg/l of total phosphorus as a monthly average. The rule states that other limits may be placed in permits when deemed necessary. The rule also requires that nutrients be limited as necessary to prevent excessive growth of aquatic plants, fungi or bacteria, which could impair designated uses of the surface water.

Phosphorus Limitations in NPDES Permits

Phosphorus limits are placed in NPDES permits for all discharges which have the potential to contain significant quantities of phosphorus. The limit of 1 mg/l is contained in permits for discharges to surface waters which do not have substantial problems with high levels of nutrients. More stringent limits are required for discharges to surface waters which are very sensitive to nutrient inputs. Many of these surface waters are in developed areas with substantial point source and nonpoint source phosphorus inputs. In such areas, a waste load allocation may be necessary. The DEQ must determine the total amount of phosphorus (in pounds per day) which can be assimilated into the particular surface water. The DEQ then works with the dischargers to decide on appropriate phosphorus limits for each permit, without exceeding the total assimilative capacity of the surface water.