Watershed Wisdom – What's the deal with phosphorous?

This time of year, I go to a lot of lake association and road association annual meetings to talk about water quality. One question I get frequently is some variant of, "**What's the deal with phosphorous**?" We have previously discussed the concept of "eutrophication," or nutrient enrichment. Even with fully intact upland forests and vegetated wetland buffers to control sediment erosion, some sediment and nutrients are going to enter the lake. These are natural processes and a certain level of nutrients is necessary to support aquatic life. The problem comes when nutrient loading exceeds what the lake really needs to maintain a healthy aquatic ecosystem. The situation is analogous to maintaining a healthy diet and active lifestyle. If you consistently overeat, you will gain weight and suffer other health problems including premature aging. To remain healthy, you need to limit your caloric input to what your metabolism requires. It is the same with lakes. A lake will normally exist in a relatively clean state for tens of thousands of years with the healthy nutrient loading provided by Mother Nature. But if the nutrient load is excessive, that clean stage of life (the stages limnologists refer to as "oligotrophic" or "mesotrophic") can be reduced to less than 100 years. To keep our lakes from premature aging, we need to put the lakes on a diet. Most freshwater water quality programs attempt to limit degradation of water quality by limiting phosphorous. This week I thought I would further discuss the process of eutrophication and explain the concept of a "limiting nutrient."

Aquatic ecosystems vary in complexity but are all based on a food chain that has phytoplankton and other plants at the bottom. Phytoplankton are minute floating plant cells that create biomass through the process of photosynthesis. Using energy from sunlight, algae form plant cells by combining carbon dioxide (CO_2) and water (H_2O) with some nitrogen (N) and phosphorous (P). In the 1950s, an oceanographer named Redfield studied marine algae and determined that on average they were comprised of carbon, nitrogen, and phosphorous in a C:N:P ratio of 106:16:1. For freshwater algae, the ratio is 113:15:1. This means that for every 113 molecules of carbon dioxide the plant uses, it needs 15 molecules of nitrogen and 1 molecule of phosphorous to create plant biomass. Since light, carbon dioxide and nitrogen are in ample supply in most freshwater systems, the amount of plant growth that can take place is limited by the amount of phosphorous available. Phosphorous is the "limiting nutrient" in the system. Think of a car manufacturer who needs a ton of steel and 4 tires to manufacture a car. Even with twenty tons of steel, if he only has four tires, he can only make one car until he gets more tires. He is limited by his tire supply. In the same way, the productivity of freshwater aquatic systems is generally limited by the amount of phosphorous available.

Phosphorous is not especially soluble in water so precipitation percolating or filtering through the soil will not dissolve much phosphorous even if it is relatively abundant in the soil, as it is around here. Most of the phosphorous in the soils is bound to iron minerals in the soil under normal oxygenated conditions. The key to controlling phosphorous is to keep the soil from being eroded and transported into the lake. ***In simple terms, erosion control equals phosphorous control.***

Once in the lake, some phosphorous rich sediments settle to the bottom but soluble, available phosphorous in the water column is quickly taken up by some type of algae, either green or blue-green, or perhaps by macrophyte (large) plants. These algae will be grazed by zooplankton, which in turn will be eaten by fish, transferring the phosphorous up the food chain. Some will be returned to the water through excretion, starting the cycle again, but some will be washed downstream, be removed by human or other fishermen, or settle to the bottom where it is at least temporarily not “bioavailable.” Limnologists refer to these various places phosphorous can be as “compartments” and phosphorous is always cycling between compartments. The bottom line is that some phosphorous is always coming into the lake, some is being stored as biomass, and some is always leaving. If more is coming in than going out, phosphorous will accumulate and plants and algae will thrive. It’s a bit like tracking the amount of money in your check book. Some cash is always coming in and some is leaving and the actual amount in your account will vary over time. If you have more coming in than going out, your account will grow and you can afford to spend more.

The actual fate of phosphorous in the water is even more complex than described here due to its chemical properties and the seasonal cycle of lakes. In future columns we discuss some of these a bit as well as ways of taking advantage of Mother Nature’s natural systems to reduce phosphorous loading.