Interception and Inactivation of Phosphorus in Lakes and Ponds (Stopping the Problem at the Source)

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OVERVIEW

A common problem with many lakes and ponds is excessive weed and/or algae growth. The root of this problem is quite often overlooked, high nutrient levels. Plants require nutrients to thrive and the two most essential nutrients for plant growth are nitrogen and phosphorus. Phosphorus (P) is the most limiting nutrient for aquatic plant growth. If the amount of nutrients, phosphorus in particular, in an aquatic system can be controlled, then excessive plant growth can be avoided. However, if nutrients are available in high concentrations and growing conditions are favorable, then plant growth is inevitable.

Once plants grow to nuisance proportions they can ruin a water body both aesthetically and recreationally. A couple of ways to treat excessive plant growth is through mechanical harvesting or chemical control. Harvesting can be effective, but is often costly and can be harmful if used on such species as Eurasian Watermilfoil. Milfoil fragments can actually re-root and grow back into new plants, thus increasing the problem. Chemicals offer an effective means of control, but often have to be applied a couple of times per season. Ultimately, the only way to solve the problem is to attack the source. The nutrients must be intercepted or inactivated.

The first step in the right direction is identifying and controlling your watershed. This can often be difficult, especially when dealing with non-point source pollution. Once the entire watershed has been determined, steps can be taken to intercept the phosphorus before it reaches your lake or pond. Unlike nitrogen, phosphorus is transported mainly by runoff. This occurs because phosphorus has a high affinity for soil particles and does not leach through the soil column. From this fact, it's easy to see why rainy weather in an agricultural area can pose a major problem for surrounding bodies of water.

Fertilizer application rates and timing are very important in trying to control the amount of phosphorus in the landscape. Leaving buffer zones around farmland and waterways is also a very significant part of the interception process. The task of controlling the entire watershed is tough to achieve. But with the cooperation farmers, foresters, developers, and everyone else in between, an effective management plan can be derived. The key is to look at the land with a holistic view, as everything within the ecosystem is linked in one way or another.

INTERCEPTION

External phosphorus loading occurs as nutrients from the surrounding landscape is transported to various water bodies within the watershed, promoting weed growth and algal blooms. Reducing this external loading will help improve the trophic status of the lake, if this is the primary source of nutrients in the system. The most practical approach to this problem is to leave a buffer zone around the shoreline. Buffer zones provide a way of intercepting the nutrients before they can reach the water. Many people make the mistake of mowing their lawn right up to the water's edge, leaving a clear path for runoff to enter the lake or pond. Leaving tall grass, bushes, and trees at the water's edge slows down runoff from precipitation and allows the terrestrial plants to take up the existing nutrients. This will not prevent all the nutrients from reaching the water but it will reduce it significantly.

Stormwater runoff is a major source of phosphorus in urban areas. One way to intercept this P is to add Alum to the stormwater. The Alum will bind up the phosphorus before it reaches the receiving water body. Another way to intercept this nutrient supply is to create a detention pond upstream from the receiving water body. By slowing down the flow of water, many suspended particles are allowed to settle out. Phosphorus is often associated with suspended particles and can be filtered out of the system if these particles settle out in the detention pond. Plants within the pond can then utilize the available nutrients, using them up before they reach your lake or pond. These are major projects and would have to be discussed in detail by your subdivision, town, or lake association.

Wetlands are an important part of any landscape. These complex systems are able to withstand large inflow and nutrient fluctuations. Some wetlands can remove up to 90% of the incoming suspended solids, nutrients, and BOD. However, not all wetlands are the same and some can handle nutrient loads better than others. Detouring stormflow through these systems will reduce nutrient loading in your lake or pond, but will also degrade the wetland over time. The best solution here is to construct an artificial wetland. By constructing your own wetland, you can control flow patterns, substrate, and vegetation within the system. This is an effective tool at reducing nutrient loading, while preserving natural wetlands in the process.

INACTIVATION

Once in the water column, phosphates can be utilized by aquatic macrophytes and algae. The only way to combat the problem from here is to inactivate the phosphorus or introduce microbial populations to compete with the plants for the nutrients. Alum is widely accepted and used as a means of inactivating phosphorus. This aluminum based product comes in a variety of forms, depending on the situation or severity of the problem. The Alum is effective because it binds up the phosphates, making them unavailable for plants to take up. With less P available in the water column, less plant growth can occur. Alum treatments can last a long time as studies have indicated based on phosphorus testing years after treatment. In recent years, biologists have leaned towards natural methods of aquatic management using enzymes and bacteria. Two such products on the market are Algae-Tron and Waste & Sludge Reducer. Algae-Tron acts upon the algae growing in the water and also competes with aquatic plants for essential nutrients. By reducing the amount of phosphorus in the water the algaetron reduces excessive plant growth and algal blooms. Waste & Sludge reducer acts upon the soft sediments, reducing the sludge depth up to 60%. A test pond in Wisconsin showed a 51% decrease in soft sediment depth over a three month period, in which waste & sludge reducer was added every two weeks. In conjunction with aeration, this is a very effective tool at reducing soft sediments. Besides reducing the unappealing muck along the bottom, the secondary effect here is the elimination of a natural sink for nutrients (N,P), hydrogen sulfide (H2S), methane (CH4), and other anoxic gases.

Even if external phosphorus loading is controlled there still may be a problem. The P in the sediments play a major role in the total amount of phosphorus present in the water column. If a large concentration gradient is present between the water and the sediments, P will be released from the sediments (figure 1). Most of this phosphorus is bioavailable and can be utilized by plants. This internal loading is common in many lakes and ponds. The most widely recognized method to control this internal loading is treating the lake or pond with aluminum-sulfate (Alum). Aluminum from the aluminum-sulfate binds up phosphorus, taking the usable P out of solution. Not only does the alum take care of the P in solution, but an aluminum-hydroxide floc forms and seals up the sediments as it sinks to the bottom. The seal prevents the future release of P from the sediments. During it's descent to the bottom, this floc also removes particulate matter from the water, producing a clarifying a effect. Adversely, the benthic community can be effected as the bottom is manipulated. Also, the pH can become a factor if too much Alum is applied. If the lake or pond has a low buffering capacity then the pH may decrease to harmful levels. Lime can be added during the Alum treatment to account for this drop in pH. Obviously, factors such as these are analyzed before any Alum treatments are conducted.

As mentioned above, the precipitate formed from the aluminum-hydroxide complex can seal up the sediments. Even without adding Alum, if the external loading is controlled, it is possible a lake could eventually recover on it's own. Over time, through natural processes, low P containing sediments will cover up the old, existing "P" rich sediments. Studies show that about the first 5 centimeters of sediment contain P that can be actively released into the water column. Thus, it would take at least a few years for new sediments to cover up and seal the original nutrient rich sediments. This concept hasn't completely been proven, but is a theory that has been discussed by many biologists.

There are other alternatives to Alum in terms of inactivating phosphorus in the water column. If oxic conditions are present, iron (Fe) can be used to bind up phosphorus. Lakes with high Fe in the sediments can naturally neutralize P if oxygenated conditions are prevalent. Under oxic conditions Fe is present in an oxidized state and can successfully neutralize P being released from the sediments. Generally, iron is only effective in shallow unstratified lakes because the hypolimnion remains oxygenated. Under stratified conditions, anoxia results in the hypolimnion converting Fe to a reduced state. Hardwater lakes can be treated with calcium (Ca) to help reduce high P concentrations. Past studies have shown this method to be effective, but the longevity of these treatments is unknown at this time. The key to inactivating the P here is the formation of a complex called apatite. Much like the precipitate formed from Alum, this method binds up the P making it unobtainable to plants.

Regardless of the treatment used, aquatic macrophytes will have a profound effect on the amount of P transported from the sediments to the water. Eurasian water milfoil is a major contributor of P to the water column. Phosphorus is taken up from the sediments and released through the leaves of the plant by diffusion. This diffusion occurs because of the high concentration gradient between the plant and the surrounding aquatic media. This fact must be taken into consideration when evaluating the effectiveness of a particular treatment.

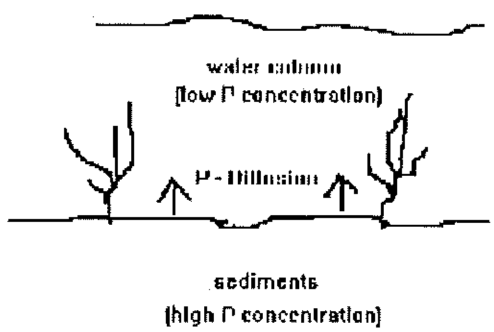

Figure 1. The diffusion of P from the nutrient rich sediments into the water column.

CONCLUSION

Phosphorus is the most limiting nutrient for plant growth. It is important to realize that this nutrient is the actual root of the problem. Visible weed and algae growth is merely a reflection of the problem. If phosphorus concentrations can be controlled, then excessive aquatic weed and algae growth will be suppressed. Using methods such as harvesting and chemical control to treat heavy weed growth may offer momentary relief to the problem, but these will not cure the situation. However, selective control of exotic species such as Eurasian Watermilfoil with 2,4-D based products may be a step in the right direction. By reducing this species, which has the ability to entrain P into the water column, some internal phosphorus loading can be curtailed. Excessive plant and algae growth are simply symptoms of the nutrient dilemma at hand. This is a big problem, but it can be reversed. By implementing a management plan and using various management techniques, this problem can be remedied. These changes won't appear overnight, but over time the improved health of the system will be observable.