THE ROLE OF PHOSPHORUS IN LAKE ECOLOGY
FACT SHEET

Created by Progressive Companies / Water Resources Group

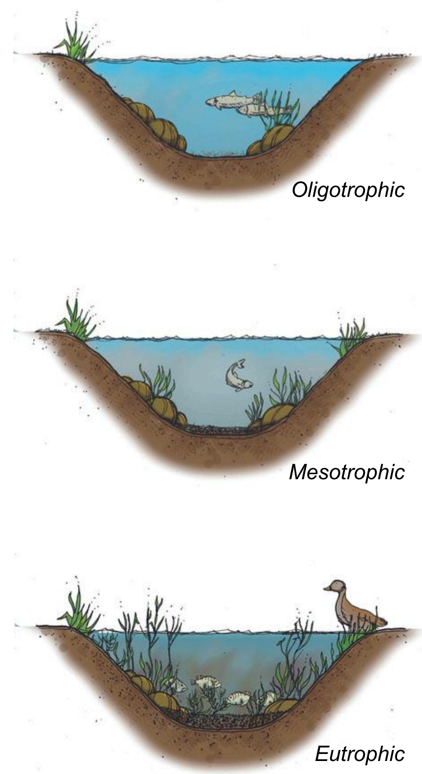
Lakes can be classified into three broad categories based on their productivity or ability to support plant and animal life. The three basic lake classifications are “oligotrophic,” “mesotrophic,” and “eutrophic”. Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two extremes are called mesotrophic lakes.

Lakes that receive large inputs of nutrients are susceptible to excessive plant and algae growth and an acceleration of the natural progression from an oligotrophic state to a eutrophic one. This process is called eutrophication. Phosphorus, the nutrient that most often drives aquatic plant and algae growth, can be introduced to a lake from both internal and external sources.

External phosphorus loading refers to the amount of phosphorus entering a lake from its watershed or directly from the atmosphere. Watershed inputs include phosphorus tied to organic material in surface water runoff, groundwater movement into the lake (often tied to septic seepage), or from a point source such as a river or stream flowing directly into a lake. Phosphorus that enters a lake from external sources is available for use by plants and algae and eventually ends up in the lake’s sediments, where, in the presence of oxygen, is bound to sediment particles. However, if a lake is mesotrophic or eutrophic, anoxic (oxygen-free) conditions often exist in water deeper than around 20-25 feet as a lake thermally stratifies (warm water near the surface overlays deeper, cooler water) in the late spring and summer. These anoxic conditions allow for the release of phosphorus from sediment particles, making it available again for use by plants and algae. This type of phosphorus loading that occurs within a lake where sediment-bound phosphorus is recycled back into the water column is called internal loading.

Lakes that experience internal loading often exhibit algae blooms during the summer and into the fall as some of the phosphorus from deeper water can leak into the warm upper waters of a lake through diffusion or mixing. One way to limit internal phosphorus loading is to make the available phosphorus inactive again by applying an aluminum or lanthanum-based salt to the lake. This binds the dissolved phosphorus into fine, solid particles that eventually sink to the deeper portions of the lake and are unavailable for algal growth.

Filamentous algae bloom



Trophic states

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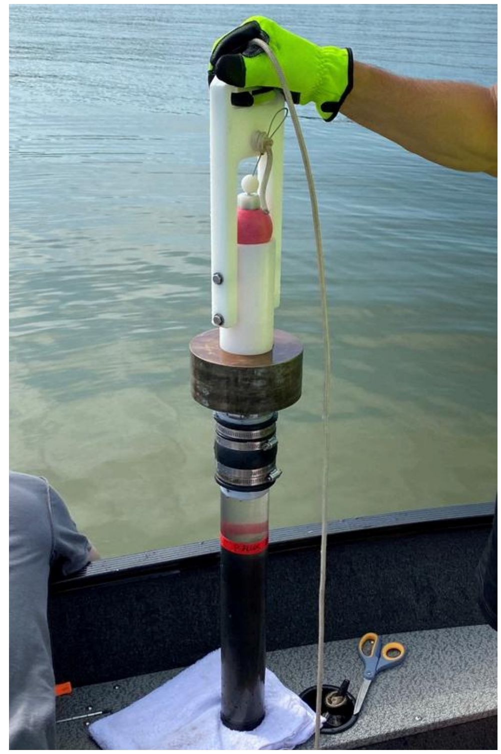
Phosphorus inactivation can provide long term control of nuisance algae due to the reduction of available nutrients that drive algal growth.[1] An added benefit to these treatments occurs when the precipitated solid material is sufficient enough to create a chemically impermeable barrier above the sediments that effectively inhibits future release of phosphorus – even under anoxic conditions. The duration of effectiveness can vary depending on the characteristics of the lake but generally lasts several years, in some cases, even decades.[2]

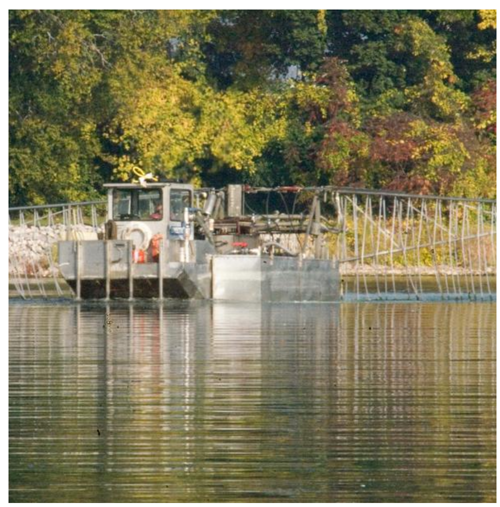
Typical management of algae involves the use of algicides which break down the structure of algal cells and are only effective for a very short duration (usually a few days). If favorable growth conditions persist in a lake, algae growth will follow. Additionally, some copper-based algicides do not break down completely and can build up in the sediments after repeated usage.

When evaluating whether a lake is a good candidate for nutrient inactivation, a thorough study of the lake's water chemistry and sediment characteristics should be undertaken by a qualified scientist to ensure that the treatments will be effective given the high potential cost of this management strategy. Current technology favors the use of either aluminum sulfate (Alum) or lanthanum carbonate[3] (Phoslock[4] or EutroSORB G[5]) as the most effective phosphorus inactivation treatments available and permitted for use in Michigan. Alum is commonly used to treat wastewater and drinking water and, over the last half-century, there have been hundreds of lake alum treatments. Alum treatments require special application equipment and can be quite costly. Although comparable in cost, application of currently available lanthanum-based products are more easily applied to lake waters than alum. Both treatments require a Rule 97 Certification of Approval from the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

When evaluating the best tool for nutrient inactivation, several factors will need to be assessed including a lake's physical, chemical, and hydrologic characteristics. These evaluations can best be conducted by an unbiased third-party consultant having no financial ties to either of these nutrient inactivation tools.



Sediment core sample



Alum application

References:
1 Cooke, G.D., E.B. Welch, S.A. Peterson, S.A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs, Third Edition. Taylor & Francis.
2 Progressive AE. 2023. Byram Lake Water Quality Report.
3 Zhang, S., et al. 2022. Adsorption of Phosphorus by Surface Precipitation on Lanthanum Carbonate Through In Situ Anion Substitution Reactions. Frontiers in Environmental Science Volume 10.
4 Phoslock is a trademark of PET Water Solutions, Victoria, Australia
5 EutroSORB G is a trademark of SePRO Corp., Carmel, IN