LAKE AND POND TREATMENT BY NUTRIENT INACTIVATION

First Draft Authors: A. Lo Porto, B. Kronvang and B. Braskerud

Description

Chemical substances can be used to bind soluble reactive phosphorus (SRP) and precipitate it as an insoluble compound not available to plant organisms' metabolism.

Rationale, mechanism of action

Phosphorus-enriched sediments can release phosphorus to the water through a process known as internal loading. When sediments are contributing phosphorus to the lake, lake managers can use nutrient inactivation techniques to remove phosphorus from the water column (called precipitation) and to retard its release from the sediments (called inactivation).The aim of this practice is to prevent eutrophication or rehabilitate those bodies of water considered eutrophic due to high concentrations of soluble phosphorus binding and settling it in the river bed.
Lake managers use aluminum, iron, or calcium salts for phosphorus inactivation of lake sediments. The chemical substance that is most commonly used is Aluminium sulphate (alum) Al2(SO4)3 that is frequently used as a flocculating agent in the purification of drinking water and in waste water treatment plants. When dissolved in neutral - alkaline water, aluminium sulphate produces a gelatinous precipitate of aluminium hydroxide, Al(OH)3.
In this practice the alum is dispersed in controlled amounts in the water body. The addition of alum helps in reducing SRP concentration in surface water following three mechanisms:
1) the aluminium reacts with the SRP to form aluminium phosphate that is insoluble and not bio-available at pH values between 3 and 9;
2) a hydrolysis converts the aluminium in aluminium hydroxide Al(OH)3 flocks that clarifies the water column and adsorbs additional phosphorus P while settling down;
3) the aluminium hydroxide flock settle on top of the bottom sediment of the lake or pond, covering sediment with a film that decreases P (but also other chemicals) release and recycling from bottom sediments, unless some resuspension happens.

Algal levels decline after alum treatment because alum addition reduces phosphorus levels in the water.
The application can be done as a single dose or alum can be injected proportional to stormwater inflow. Large water bodies are typically treated with liquid alum spread using vessels, while smaller lakes and ponds can be treated with dry alum.

Applicability

Nutrient inactivation is only appropriate where internal loading is a significant phosphorus source. If most phosphorus comes through external sources, alum treatment will not be effective. For appropriate nutrient inactivation projects, the length of treatment effectiveness varies with the amount of alum applied and the depth of the lake.

The size and volume of the pond or lake must be accurately determined together with sediment and influent water quality and volume to ensure accurate dosage of the chemical agent.

Effectiveness, including uncertainty

Welch and Cooke (1995) evaluated the effectiveness and longevity of treatments on several lakes in the USA concluding that alum treatment in shallow lakes for phosphorus inactivation is effective in most of the cases Applications in stratified lakes were highly effective and long lasting. Percent reduction in controlling internal phosphorus loading has been over 80 percent. The study did however find that alum treatment of lakes with high external loading was not effective.
Lakes with large, uncontrolled external nutrient inputs may need routine re-treatment in addition to attempts to decrease P inputs.

Time frame

The same study demonstrated that that the phosphorus inactivation by flocculants may last for eight or more years. In deeper lakes, alum treatment may last far longer. Some lakes treated in 1980s are still clear.

Environmental side effects

Freeman and Everhart (1971), Cooke et al (1978), Kennedy and Cooke (1982) concluded that dissolved aluminium concentrations, regardless of dose, below 50 µg Al/l in the pH range 5.5 to 9.0 could be considered environmentally safe with respect to aluminium toxicity. Guidelines for alum application require that the ph remain with the 5.5-9.0 range.
Narf (1990) assessed the long term impacts on some lakes and found that benthic insect populations either increased in diversity or remained at the same diversity after treatment.
No adverse effects on human health have been considered since some foods, such as tea, spinach and other leafy green vegetables have high levels in aluminium.

Relevance, potential for targeting, administrative handling, control

Water treatment by flocculants can be used when P inflow is rather low and controlled while P release from bottom sediment is high in static water bodies. Application is relatively simple and cost-effective and effects can last for many years making this practice quite appealing. Furthermore machinery needed consists mainly in pumps used in disinfectant applications quite commonly used in dairy factories.
Maintenance of inactivation programs mostly consist in water quality monitoring to make sure additional SRP inputs are controlled. Periodic tests for pH, alkalinity, total and soluble P, chlorophyll a and turbidity/transparency will aid the assessment of effectiveness and longevity of treatment.

Costs: investments, labor

The cost of a nutrient inactivation program will depend on the size of the water body; degree of pollution; water chemistry and need for buffering agents; Of course also site access and consulting needs can make the difference.
For complex applications, costs for chemicals and application may vary from a few hundred dollars per hectare to around two thousand dollars per hectare.

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