



ALUM TREATMENTS TO CONTROL PHOSPHORUS IN LAKES

March 2003

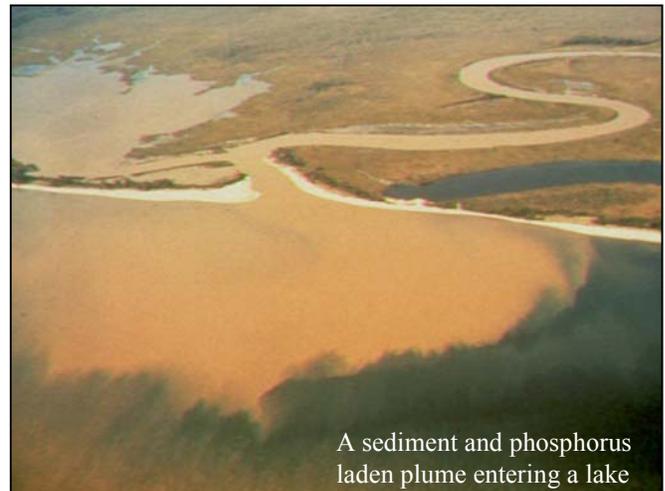
What is alum and how does it work?

ALUM (aluminum sulfate) is a nontoxic material commonly used in water treatment plants to clarify drinking water. In lakes alum is used to reduce the amount of the nutrient **phosphorus** in the water. Reducing phosphorus concentrations in lake water can have a similar clarifying effect by limiting the availability of this nutrient for algae production. Phosphorus enters the water either **externally**, from run-off or ground water, or **internally**, from the nutrient rich sediments on the bottom of the lake. Phosphorus is released from the sediments under anoxic conditions that occur when the lake stratifies and oxygen is depleted from the lower layer. Even when external sources of phosphorus have been curtailed by best management practices, the internal recycling of phosphorus can continue to support explosive algal growth. Alum is used primarily to control this internal recycling of phosphorus from the sediments of the lake bottom. On contact with water, alum forms a fluffy aluminum hydroxide precipitate called **floc**. Aluminum hydroxide (the principle ingredient in common antacids such as Maalox) binds with phosphorus to form an aluminum phosphate compound. This compound is insoluble in water under most conditions so the phosphorus in it can no longer be used as food by algae organisms. As the floc slowly settles, some phosphorus is removed from the water. The floc also tends to collect suspended particles in the water and carry them down to the bottom, leaving the lake noticeably clearer. On the bottom of the lake the floc forms a layer that acts as a phosphorus barrier by combining with phosphorus as it is released from the sediments.

Why treat a lake with alum?

Increased nutrient loading, particularly phosphorus has accelerated eutrophication of lakes and consequently reduced their ecological health and recreational value. Frequent and pervasive algal blooms, low water transparency, noxious odors,

depletion of dissolved oxygen, and fish kills frequently accompany cultural eutrophication. External sources of phosphorus delivered in run-off from the watershed are often the main contributor of excessive phosphorus to lakes.



A sediment and phosphorus laden plume entering a lake

Typically, the first steps taken in a lake rehabilitation effort target the control the external sources of phosphorus and can include: encouraging the use of phosphorus free fertilizers; improving agricultural practices, reducing urban run-off; and restoring vegetation buffers around waterways.

Lake researchers have learned that lakes are very slow to recover after excessive phosphorus inputs have been eliminated. Furthermore, it's extremely difficult to achieve recovery of lake conditions without additional in-lake management. This is due to the fact that lake sediments become phosphorus rich and can deliver excessive amounts of phosphorus to the overlying water. When dissolved oxygen levels decrease in the bottom waters of the lake (anaerobic conditions), large amounts of phosphorus trapped in the bottom sediments are released into the overlying water. This process is often called **internal** nutrient loading or recycling.

Is alum toxic to aquatic life?

Some studies have been conducted to determine the toxicity of aluminum for aquatic biota. Freeman and Everhart (1971) used constant flow bioassays, to determine that concentrations of dissolved aluminum below 52 $\mu\text{g Al/L}$ had no obvious effect on rainbow trout. Similar results have been observed for salmon. Cooke, et al (1978) adopted 50 mg Al/L as a safe upper limit for post-treatment dissolved aluminum concentrations. Kennedy and Cooke (1982) indicate that: Since, based on solubility, dissolved aluminum concentrations, regardless of dose, would remain below 50 $\mu\text{g Al/L}$ in the pH range 5.5 to 9.0, a dose producing post treatment pH in this range could also be considered environmentally safe with respect to aluminum toxicity. Guidelines for alum application require that the pH remain within the 5.5-9.0 range.

According to Cooke et al (1993) the most detailed study of the impact of alum treatments on benthic insects was that of Narf (1990). He assessed the long term impacts on two soft water and three hardwater Wisconsin lakes. He found that benthic insect populations either increased in diversity or remained at the same diversity after treatment. The treatment of lakes with alkalinities above 75 mg/L as CaCO_3 are not expected to have chronic or acute effects to biota. Fish related problems associated with alum treatments have been primarily documented in soft water lakes. However, many softwater lakes have been successfully treated with alum, when the treatments are pH buffered.

Health concerns for people?

Concerns about a connection between aluminum and Alzheimer's have been debated for some time. More recent research points to a gene rather than aluminum as the cause. In addition, aluminum is found naturally in the environment. Some foods, such as tea, spinach and other leafy green vegetables, are high in aluminum. Use of aluminum cookware has not been found to contaminate food sources.

How much does an alum treatment cost?

Costs of alum application are primarily dependent on the form of alum used (wet or dry), dosage rate, area treated, equipment rental or purchase, and labor. Liquid alum has been used when large alum doses were needed. Treatment costs range from \$280/acre to \$700/acre (\$450=approximate average) depending on the dosage requirements and costs to mobilize equipment.

How effective are alum treatments, and how long do they last?

A number of case studies have been conducted on lakes that have undergone nutrient inactivation with alum. Eugene Welch and Dennis Cooke (1995) evaluated the effectiveness and longevity of treatments on twenty one lakes across the United States. They concluded that the treatments were effective in six of the nine shallow lakes, controlling phosphorus for at least eight years on average. Applications in stratified lakes were highly effective and long lasting. Percent reduction in controlling internal phosphorus loading has been continuously above eighty percent. The study did however find that alum treatment of lakes with high external loading was not effective.



References

- Cooke, Dennis G. Restoration and Management of Lakes and Reservoirs, Second Edition. Lewis Publishers, 1993.
- Cooke, G.D., R.T. Heath, R.H. Kennedy, and M.R. McComas. 1978. Effects of diversion and alum application on two eutrophic lakes. EPA-600/3-81-012.
- Freeman, R.A. and W.H. Everhart. 1971. Toxicity of Aluminum Hydroxide Complexes in neutral and basic media to rainbow trout. Transactions of the American Fisheries Society 100: 644-658.
- Kennedy, R. and Cooke, G. 1982. Control of Lake Phosphorus with Aluminum Sulfate: Dose Determination and Application Techniques". Water Resources Bulletin 18:389-395.
- Narf, R.P. 1990. Interaction of Chironomidae and Chaoboridae (Diptera) with aluminum sulfate treated lake sediments. Lake Reserv. Manage. 6: 33-42.
- Welch, E.B. and G.D. Cooke. 1999. Effectiveness and longevity of phosphorus inactivation with alum. J. Lake and Reserv. Manag. 15:5-27.