ALUM CHEMICAL FACT SHEET

Formulations

Alum (aluminum sulfate, $Al_2(SO_4)_3$ or aluminum hexahydrate, $Al(H_2O)_6^{+3}$) is a material used in a variety of applications from baking goods to drinking water treatment. In lake management, alum is used to deactivate the internal load, or cycling, of the nutrient phosphorus that has accumulated in lake sediments. In some situations, alum is used to treat incoming flow from storm sewer systems and other external sources. Alum can be applied as a liquid or solid. A buffer (sodium aluminate, $Na(AlO_2)$) is often applied in conjunction with alum to stabilize pH.

Aquatic Use and Considerations

Alum is used to reduce the amount of the nutrient phosphorus available in the water column and prevent further phosphorus leaching from sediment. Phosphorus is a limiting nutrient in Wisconsin lakes, meaning that plant and algae growth are limited by the amount of phosphorus in the water. Reducing phosphorus concentrations in lake water limits algae production, which leads to clearer water.

Phosphorus enters the water externally (from run-off or ground water) and internally (from the sediments where it has accumulated over time). Internal phosphorus release occurs when the lake undergoes thermal stratification and oxygen is depleted from the lower layer. Even when external sources of phosphorus have been curtailed by best management practices, the internal cycling of phosphorus can continue to support extensive algal growth. Alum is used primarily to control this internal cycling of phosphorus from the sediments of the lake bottom; it may not be effective at reducing phosphorus long-term in waterbodies with continuous high external phosphorus loads.

Alum has been used to reduce internal phosphorus loading in lakes for over 50 years. Treatments typically result in an average reduction in internal phosphorus loading of 60 to 90% lasting for five to 20 years. Restoring impaired or eutrophic lakes can require up to an 80% reduction or more in internal phosphorus loads; repeated applications may be necessary to achieve management goals. Increased water clarity in lakes following alum applications leads to increased light availability, which can increase the area and abundance of rooted aquatic plant growth.

Post-Treatment Water Use Restrictions

There are no post-treatment restrictions on treated water use for swimming, fishing, drinking water or irrigation.

Dissolved aluminum concentrations after treatment vary based on the initial application rate and the chemistry of the treated waterbody. Wisconsin has a secondary drinking water standard for aluminum of 0.05 to 0.2 parts per million (ppm). Concentrations above the standard are not hazardous to human health but may affect the cosmetic quality of drinking water. Aluminum concentrations may persist above the Wisconsin secondary drinking water standard for months after treatment.

Chemical Degradation, Persistence and Trace Contaminants

On contact with water, alum ($Al_2(SO_4)_3$) forms aluminum ions which combine with water ($Al(H_2O)_6^{3+}$) and undergo chemical hydrolysis to form a precipitate commonly referred to as floc (aluminum hydroxide, $Al(OH)_3$). Aluminum hydroxide binds with phosphorus to form an aluminum phosphate compound. This compound is insoluble in water under most

conditions so the phosphorus can no longer be used by algae. As the floc slowly settles over the course of a few hours to a few days, some phosphorus is removed from the water column. The floc also tends to collect suspended particles in the water and carry them down to the bottom, resulting in increased water clarity. 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, disrupting the internal cycling of phosphorus.

The alkalinity and pH of a waterbody can affect the efficacy and toxicity of alum treatments, and alum treatments can conversely affect the pH of a treated waterbody. The chemical reaction that forms aluminum hydroxide also releases hydrogen ions, which lower the pH of water. If the pH of a lake declines to 6 or less, toxic free aluminum ions may persist in the water column rather than form aluminum hydroxide. Soft water lakes, which are common in northern Wisconsin, are more sensitive to changes in pH than hard water lakes, which are common in southern Wisconsin. Alum treatments on soft water lakes (i.e., lakes with alkalinities below 75 mg/L calcium carbonate ($CaCO_3$)) may cause toxic effects if the pH is not buffered. However, many soft water lakes have been successfully treated with alum when the treatments are pH buffered with sodium aluminate.

Impacts on Fish and Other Aquatic Organisms

Alum is not expected to cause significant short- or long-term toxic effects on biota when pH remains between 6.5 to 8.0 during treatment. Impacts to fish after alum treatments have been primarily documented in soft water lakes with low alkalinities and can be mitigated with pH buffering. And although laboratory studies have shown that fish can suffocate from aluminum hydroxide precipitation on gills at pH 5.5 to 6.0, in real-world applications fish are likely to avoid settling floc particles. Floc accumulation on the lake bottom can cause hypoxia and habitat disruption to aquatic invertebrates if alum dosing is very high. Most aluminum ingested by fish and aquatic invertebrates is readily excreted, so the potential for bioaccumulation (the process by which chemicals in the environment or in a food source are taken up by plants or animals) is low.

Birds are primarily exposed to aluminum through their diets and are therefore at low risk of toxic effects from alum treatments. However, aluminum can bind with phosphorus in the gut and lead to phosphorus deficiency.

Previous studies have found that elevated sulfate levels can negatively impact wild rice growth, but the extent to which aluminum sulfate treatments may impact this plant is currently not well documented. Sulfate monitoring on a whole lake basis pre, during and post alum treatment is recommended in waterbodies where wild rice is present.

Human Health

Chemical applicators are primarily at risk of short-term health effects from alum treatments. Alum can cause irritation and/or damage to the eyes, skin and respiratory tract. Wear proper personal protective equipment and follow label instructions while handling.

Aluminum is not known to cause birth defects, cancer, or genetic mutations. The primary product of alum treatments, aluminum hydroxide, is an active ingredient in many over-the-counter antacids. Concerns about a connection between aluminum and Alzheimer's have been debated for some time and are not supported by current scientific research. In addition, aluminum is found naturally in the environment. Some foods, such as tea, spinach and other leafy green vegetables are high in aluminum.

For Additional Information

U.S. Environmental Protection Agency (EPA)
Office of Pesticide Programs
epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
datcp.wi.gov/Pages/Programs_Services/ACMOverview.aspx

Wisconsin Department of Natural Resources
608-266-2621
dnr.wi.gov/lakes/plants

Wisconsin Department of Health Services
dhs.wisconsin.gov

National Pesticide Information Center
1-800-858-7378
npic.orst.edu