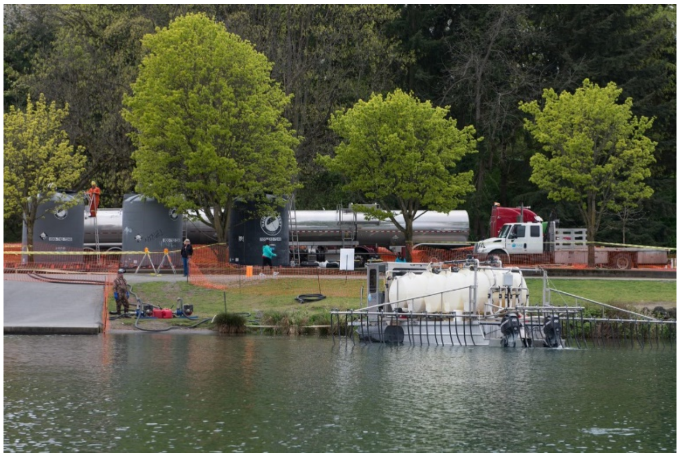
Stormwater Best Management Practice

Alum Injection

Minimum Measure: Post Construction Stormwater Management in New Development and Redevelopment
Subcategory: Other

Description

The process of adding aluminum sulfate salt—otherwise known as alum—to stormwater is called alum injection. Alum combines with fine particles to merge into larger particles. Alum injection is particularly effective at reducing concentrations of soluble and particulate phosphorus, but the process is also applicable to other pollutants, particularly those associated with sediments. When stormwater professionals inject alum into stormwater, it forms precipitates of aluminum phosphate and aluminum hydroxide. These precipitates can combine with suspended solids, heavy metals and some microorganisms to settle into the sediment in a highly stable, inert state (Harper, 2007). A common term for the collected mass of alum precipitates, pollutants and sediments is floc.



Three on-shore alum storage tanks are being filled from tanker trucks in the background. On the water, there is a barge with alum distribution tanks and lines.

Credit: Dan Bennett, 2016

Applicability

The primary use of alum injection is to reduce phosphorus concentrations, though alum injection can also be a pretreatment step to reduce turbidity, total suspended solids and bacteria (Kurz, 1998).

The most common application method is in-line alum injection, which is adding alum to stormwater within an existing storm sewer system before discharging it into a downstream basin. Due to high installation and operating costs, alum injection is most effective for large volumes of water that a system either conveys from a large drainage area or stores in a large basin. If the design requires floc recovery and disposal, adding a settling basin can allow for easy draining or dredging.

While the most common use of alum is as an in-line treatment of stormwater, another use is as an in situ treatment of surface waters such as lakes (Welch and Cooke, 1999; Harper, 2007), reservoirs and combined sewer overflow storage areas. In some cases, such as in combined sewer overflow storage areas, design engineers should develop a floc management plan to allow for the regular retrieval and disposal of accumulated floc. However, in lakes and reservoirs, floc generally settles to the bottom, where it combines with the natural sediment.

Operators may have to adjust pH levels before or after alum dosing because the addition of alum makes water more acidic. Ferric chloride, which behaves similarly to alum but does not impact pH to the same extent, may be a suitable option for pH-sensitive waters (Pitt et al., 2004).

Siting and Design Considerations

In-Line Injection

Alum injection treatment systems generally consist of three parts: a flow-weighted dosing system that often fits inside a storm sewer manhole; remotely located storage tanks that provide alum to the dosing device; and a downstream basin with low flow velocities that allow the alum, pollutants, and sediments to settle out.

Operators determine dosage rates, which range from 5 to 10 milligrams of alum per liter, on a flow-weighted basis during storm events (Harper, 2007). The operator can add other chemicals, such as sodium hydroxide or lime, to adjust the pH before or after the injection

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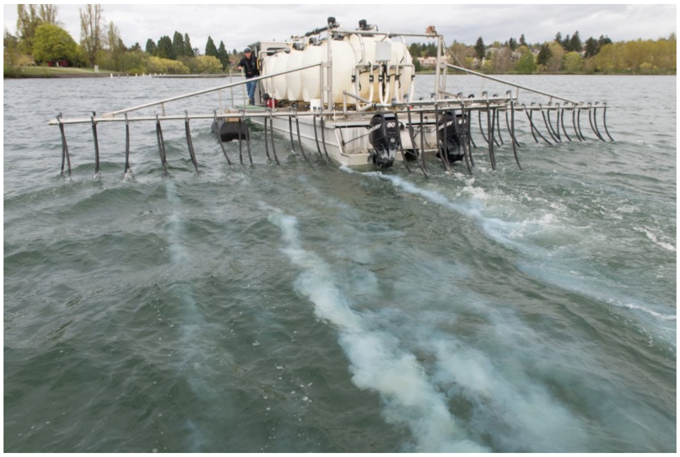
process to maintain the optimal pH range. For the alum floc itself, a pH range of 5.5 to 7.5 allows for minimum solubility of aluminum and thus maximum stability of the floc. Where receiving waters are subject to water quality standards for pH to protect aquatic biota, it is important that this stability range does not conflict with any standards. Chemical storage tanks should be large enough to minimize the frequency at which it is necessary to refill them.

In addition to a settling pond, operators may install a separate floc collection pump-out facility to reduce the chance of resuspension and transport of floc to receiving waterbodies. Incorporation of a sump or containment area may also make floc disposal easier (Harper, 2007). Proper disposal of the floc that settles in downstream basins is important because it may contain high concentrations of dissolved chemicals, metals, or viable bacteria and viruses (Kurz, 1998). Floc disposal can occur via a sanitary sewer system or a sludge drying bed with subsequent landfill disposal though prior approval is needed from the publicly owned treatment work. The publicly owned treatment work will typically require a permit for floc disposal, as the quantity of sludge a site produces can be as much as 0.5 percent of the volume of water the system treats (Gibb et al., 1991).



A barge fitted with specialized equipment (tanks and distribution lines) can evenly distribute alum in large surface water bodies.

Photo Credit: Dan Bennett, 2016

In Situ Application

In situ alum applications generally address internal phosphorus loading from lake or reservoir sediments. Phosphorus loading within a waterbody occurs when a waterbody receives stormwater with high phosphorus concentrations over a long period of time, causing sediments to develop equally high phosphorus concentrations. Some sediments, such as clays, can also be naturally high in phosphorus. Water quality fluctuations can temporarily reduce phosphorus concentrations in the water, causing phosphorus that has bound to sediments to leach into the water (NALMS, 2004). In situ alum application can bind sediment phosphorus and reduce this leaching effect. However, consideration of in situ alum application should only occur after other types of stormwater controls have reduced stormwater loadings.

To design an in situ alum treatment plan, there should be preliminary water quality investigations to identify potential reactants, targeted pollutants and the degree of treatment desired. Dosing generally occurs via boat-mounted mechanical sprayers over the course of one to several days, depending on the size of the waterbody.

Limitations

While alum injection has shown effectiveness as a stormwater treatment method, it has several limitations, including the following:

- Limited information is available about the long-term effects of alum injection on downstream biota.
- Alum injection requires much greater levels of ongoing operation and maintenance than most other post-construction stormwater treatment controls.
- Operators should carefully monitor and adjust chemical additions during the alum injection process to prevent negative effects on downstream waters, including toxic effects of aluminum or other heavy metals.
- Operators may need to dispose of the precipitates from the alum in a particular manner, depending on local regulations.
- Alum injection is typically not cost-effective for drainage areas less than 50 acres.

Maintenance Considerations

Proper operation and maintenance of an alum treatment system is critical. Typical actions include:

- Routine inspection and repair of equipment, including the dosing device and pump-out facility.
- Adjusting the dosage of alum and other chemicals by a trained operator to maintain consistent operation if flows through the basin vary.
- Regular disposal of floc stored on-site in drying beds.
- Periodic dredging of the settling basin to dispose of accumulated floc.

Effectiveness

When its designs are correct, alum injection can result in total phosphorus reductions of 85 to 95 percent, total suspended solids reductions in excess of 95 percent and bacteria reductions in excess of 99 percent. Alum injection can reduce total nitrogen concentrations by around 50 percent, though results vary and highly depend on nitrogen speciation (Harper, 2007; Pinellas County, 2017). There have been reports of lower rates of total phosphorus removal, with influent total phosphorus values of 0.2 to 0.3 milligrams per liter being reduced to around 0.1 milligrams per liter or fewer (approximately 40 percent reductions), but these were likely due to an undersized settling basin (Carr, 1998). For information regarding cost per kilogram of pollutant removed, refer to the “Cost Considerations” section below.

For in situ lake and reservoir applications, a single application can be effective for 5 to 15 years, using sustained reductions in phosphorus and algal concentrations as a metric (Welch and Cooke, 1999). In some cases, such as areas where high stormwater loadings continue or areas with unique sediment chemistry, operators may want more frequent applications (NALMS, 2004).

Cost Considerations

Alum injection is a relatively expensive practice. A 2007 life cycle cost analysis of four large-scale stormwater treatment facilities found total costs—including capital, operation and maintenance costs over a 20-year period—to be between $1 and $4 million (Harper, 2007). However, when considering the cost versus weight of nutrients that alum injection facilities removed, these facilities performed better than standard wet detention facilities. Moreover, alum injection facilities generally require less space than their conventional post-construction control counterparts. In terms of cost per kilogram of pollutant removed, alum injection is an affordable option for removing total suspended solids, with a cost between $30 to $79 per kilogram removed. Nitrogen and phosphorus removal costs vary between $314 and $4,166 per kilogram and $1,736 and $10,496 per kilogram removed, respectively (Harper, 2007).

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA’s National Menu of Best Management Practices (BMPs) for Stormwater website

References

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