Reducing Sludge Volume with Organic Polymers

The cost for handling, hauling, and disposal of hazardous waste sludge from an industrial wastewater treatment plant is high. Current costs are around $130.00 per cubic yard for hauling and disposal of hazardous waste sludges. Because federal, state and local hazardous waste disposal requirements are becoming more restrictive and because disposal sites are filling up, the cost of hazardous waste sludge disposal is likely to rise. For these reasons, it is important for an industrial wastewater treatment supervisor to minimize the amount of sludge that the plant generates. It is possible for some wastewater treatment plant supervisors to reduce hazardous waste sludge volume just by evaluating the materials used as coagulants in the wastewater treatment plant and replacing traditional treatment chemicals with organic polymers.

In some industrial wastewater treatment systems, alum, Al₂(SO₄)₃ · 14H₂O, is used as a coagulant. Alum disassociates in wastewater to form Al³⁺ and SO₄²⁻ ions. The trivalent aluminum cations (Al³⁺) neutralize negative electrical charges along the surface of a solid particle or along the surface oil droplet suspended in water. This allows the particles to come together, or to coagulate. In addition, at a pH range of about 6.0 to 8.5 alum hydrolyses to form an insoluble aluminum hydroxide complex as shown in Figure I.

In wastewater, this complex forms a gelatinous precipitate, which entraps fine suspended particles and oil droplets. This causes more rapid separation of the solid/water or oil/water phases. However, the gelatinous precipitate that alum produces is bulky; it entraps water and creates a larger volume of material, which is difficult to dewater. The
aluminum hydroxide complex contributes to the sludge volume by as much as 70%, which increases sludge haul out and disposal costs.

Replacing Alum:
Organic polymers can provide an alternate to alum, by avoiding the sludge handling problems caused by alum. Low molecular weight cationic polymers are most often used to replace alum and work in a manner that is similar to alum. They carry, or are able to develop a positive charge, which enables them to neutralize negative electrical charges along the surface of suspended particles or oil droplets. The chain-like structure of polymers (see Figure II) enables them to enmesh fine particles or oil droplets into faster separating phases.

Because of physical characteristics of the polymer floc, certain polymers create a sludge that is less voluminous and dewater's more easily than alum sludge. This cuts sludge volume as well as haul out and disposal costs.

For example, at a 500,000-gal/day-oil refinery wastewater treatment plant, alum was fed at a dosage of 30 ppm as a coagulant prior to dissolved air flotation. After careful jar testing, a high charge, low molecular weight cationic polymer was selected as a substitute for alum at a feed rate of 15 ppm. After one month on the polymer program, sludge production dropped from 500 gal/day to 160 gal/day. This saves the refinery $63,000 yearly in hazardous waste handling costs.

Replacing Calcium Chloride
Let's look at another, similar example. At an industrial laundry wastewater treatment plant, calcium chlorides along with sodium hydroxide were fed to coagulant soil, oil and grease prior to a dissolved air flotation cell. When mixed in a wastewater, calcium chloride reacts with sodium hydroxide to form a calcium hydroxide precipitate, which neutralizes and enmeshes suspended particles and oil droplets in a manner similar to alum. However, calcium hydroxide reacts farther to produce insoluble carbonates and hydroxides as follows:

$$2\text{NaOH} + \text{CaCl} \rightarrow \text{Ca} (\text{OH})_2 \downarrow + 2\text{NaCl}$$
2Ca (OH)$_2$ + Mg (HCO$_3$)$_2$ → 2CaCO$_3$↓

+ Mg (OH)$_2$↓ +2H$_2$)

These compounds contribute to sludge volume and haul out costs.

Organic polymers do not produce these insoluble compounds. By switching from a NaOH + CaCl$_2$ coagulant program to a polymer coagulant program, this industrial laundry cut its sludge product and haul out costs by 84%. Substituting a polymer for inorganic coagulants may cut sludge haul out and disposal costs, but this substitution is not possible in all wastewaters. For some waste waters, only an inorganic coagulant may be used. Also, before a substitution is made, jar testing should be done to select the most effective polymer and determine optimum dosage. Since a polymer-produce sludge is more dense than an inorganic-produced sludge, it is very important for a plant supervisor to realize that the plant’s dewatering equipment may have to be modified to handle the dense sludge.