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Technical Bulletin:
Ferrous Salts for H_2S and Phosphorus Removal

Hydrogen Sulfide Removal

Sulfides are the primary agent of odor and corrosion issues in wastewater treatment systems, and are usually present in the form of hydrogen sulfide (H_2S).

Hydrogen sulfide is produced by sulfate-reducing bacteria (SRB) in anaerobic environments such as wastewater. This accounts for the rotten smell associated with such systems. In the headspace above wastewater, moisture from sewage condenses on non-submerged sewer walls and mixes with oxygen from air, forming a habitat for sulfur-oxidizing bacteria (SOB). As hydrogen sulfide gas diffuses from wastewater into the headspace, these bacterial colonies convert hydrogen sulfide into sulfuric acid.

Since most SOB colonies form on sewer crowns, the corrosive nature of sulfuric acid has disastrous consequences, including sink-holes as the crown cannot bear the load above it. This occurs as sulfuric acid corrodes concrete and steel. Specifically, sulfuric acid converts the primary component of concrete, calcium hydroxide, into calcium sulfate, destroying concrete's polymeric strength and structural integrity.

The solution is to apply ferrous salts to the wastewater stream. Ferrous salts remove hydrogen sulfide by precipitation of ferrous sulfide, which is caused by the reaction of an iron ion and a sulfide ion.

$$Fe^{+2} + HS^{-} \rightarrow FeS_{(solid)} + H^{+}$$

The resulting ferrous sulfide is a fine black powder that settles and aids in TSS reduction. Stoichiometrically, one ppm of HS^{-} is removed for every ppm of ferrous metal. Accordingly, ferrous salts are widely used for odor and corrosion control.

View the chart on the following page indicating the effects of hydrogen sulfide exposure.

Phosphorus Removal

Phosphorus is the limiting nutrient for growth of many organisms and usually exists in nature as orthophosphate (PO_4^{+3}). Eutrophication, an algal bloom, occurs as orthophosphates promote algal growth at the effluent of wastewater treatment plants. This is known to decrease the oxygen content in water, inhibiting aquatic life. Due to eutrophication, other environmental factors, and possible toxicity, the EPA has criteria for effluent phosphate concentrations.

Application of iron salts to a water or wastewater stream effectively removes phosphorus. Ferrous ions can also oxidize to ferric ions if oxygen is present in the stream, precipitating phosphate.

$$3Fe^{+2} + 2PO_4^{+3} \rightarrow Fe_3(PO_4)_{2\,(solid)}$$
$$Fe^{+3} + PO_4^{+3} \rightarrow FePO_{4\,(solid)}$$

Stoichiometrically, for every 3 ppm ferrous metal, 2 ppm orthophosphate is removed; similarly, for each ppm ferric metal, 1 ppm orthophosphate is removed.

Another benefit of reducing phosphate concentration is that it decreases struvite formation that causes scaling problems.

Table 1. Effects of Hydrogen Sulfide Exposure at Specific Concentrations

Concentration (ppm)	Effect	Comment
0.0005	Odor Detection Threshold	Minimum odorant concentration required to perceive the existence of the pollutant.
0.0047	Odor Recognition Threshold	Minimum odorant concentration required to identify the pollutant, normally described as “a rotten egg”.
10	8 hours (Time Weighted Average)	An employee should be able to work for eight hours without problems.
15	15 minutes (Short Term Exposure Limit)	Should not occur more than 4 times a day and at least 60 minutes between exposures. Can result in irritation.
50-100	Feel noticeable physical health problems	Exhibit sub-acute poisoning symptoms such as eye and respiratory tract irritations.
150-250	Loss of Sensory and Mental Awareness	The olfactory nerve is paralyzed after a few inhalations, the sense of smell disappears, often together with awareness of danger.
320-530	Loss of Consciousness	30 minute time frame. Pulmonary edema with possibility of death.
530-1000	Can be Fatal	Strong stimulation of the central nervous system and rapid breathing, leading to loss of breath.
800	Lethal Concentration	Lethal for 50% of humans with 5 minutes of exposure.
1000+	Fatal	Immediate collapse with loss of breathing, even after a single breath.