



# Hydrogen Sulfide Control in Wastewater Collection Systems

### Introduction

Hydrogen sulfide (H<sub>2</sub>S) is a dense, colorless, strongly odorous toxic gas that corrodes infrastructures and impairs the performance of wastewater treatment operations.

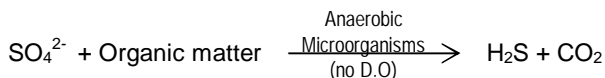
Hydrogen sulfide is naturally converted to sulfuric acid which is corrosive towards steel and concrete. Control of H<sub>2</sub>S will result in increased life and lower maintenance cost for facilities and piping. In addition, worker safety is of concern as hydrogen sulfide is extremely toxic at levels above 500 ppm, which can be reached in confined spaces.

A number of sulfide control strategies are available depending on the system design and treatment goal.

### Application Description

Sulfide exists in wastewater in three forms; hydrogen sulfide gas (H<sub>2</sub>S), non-volatile ionic species hydrogen sulfide (HS<sup>-</sup>) and sulfide (S<sup>2-</sup>). The ratio of each of the three species H<sub>2</sub>S, HS<sup>-</sup> and S<sup>2-</sup> is dependent on the pH. At pH 6, 90% of the sulfide will be present as H<sub>2</sub>S, and the higher the H<sub>2</sub>S concentration the greater the tendency for it to volatilize. Conversely at pH 10, 100% of the sulfide will be present as S<sup>2-</sup>.

Hydrogen sulfide occurs naturally through the anaerobic decay of organic matter and is recognized by its characteristic rotten egg odor. In typical domestic wastewater, microbial reduction of the sulfate ion is the dominant mechanism for sulfide formation. In the absence of dissolved oxygen (DO) and in the presence of soluble Biological Oxygen Demand (BOD), *Desulfovibrio desulfuricans* (SRB) and other sulfate-reducing bacteria (SRB's) convert the sulfate ion to sulfide.



Hydrogen sulfide formation in wastewater systems occurs primarily in the gelatinous slime layer that accumulates on pipe walls and in the sludge blankets of clarifiers and other solids processing units. The rate of sulfide production is dependent upon the concentrations of sulfate ions, organic matter, and dissolved oxygen, as well as other factors such as pH, temperature, retention time, stream velocity, and surface area.

### Treatment Alternatives

There are two basic ways to control hydrogen sulfide:

- Prevent sulfide formation
- Remove the sulfide after its formed

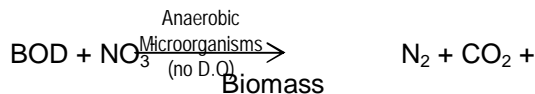
### Preventing Sulfide Formation

Inhibiting bacterial action or moderating the variables affecting hydrogen sulfide generation is often the basis for controlling hydrogen sulfide in wastewater treatment systems. Treatment options include the following chemicals.

- Chlorine dioxide
- Nitrate

**Chlorine dioxide (ClO<sub>2</sub>)** is applied at or near the source of hydrogen sulfide. Chlorine dioxide, when fed at doses higher than the minimum required to destroy hydrogen sulfide will remove the biofilm layer, which contains the bacteria creating the sulfide. Chlorine dioxide reacts more rapidly and completely than other available oxidizers and does not form colloidal sulfur.

**Sodium nitrate (NaNO<sub>3</sub>)** is applied to retard septicity and promote bio-oxidation of organic odors in systems with a retention time greater than four hours. Sodium nitrate is a biological approach to controlling odors in wastewater, providing naturally occurring facultative anaerobic denitrifying bacteria with a source of bound oxygen which is metabolized preferentially over other sources of oxygen like sulfate. This results in the production of nitrogen gas via intermediates like nitrite (NO<sub>2</sub><sup>-</sup>), nitric oxide (NO), nitrous oxide (N<sub>2</sub>O) and other metabolic byproducts rather than sulfide.



Typical field applications require a minimum of 1.5 pounds of nitrogen-oxygen (N-O) per pound of BOD.

## Removing Sulfide After its Formation

Removing the sulfide after it has been formed can be achieved using a variety of chemicals either alone or in combination. The treatment mechanism generally employed is oxidation of the hydrogen sulfide to either sulfur or the sulfate ion. In some cases, the chemical treatment program also promotes bio-oxidation of organic odors. Common treatment options include:

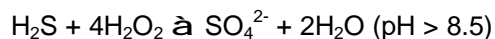
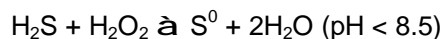
- Sodium chlorite
- Hydrogen peroxide
- Sodium or calcium nitrate
- Iron salts

**Sodium chlorite (NaClO<sub>2</sub>)** is applied at or near the source of hydrogen sulfide. It is also applied in wastewater systems where a retention time of greater than 3 hours is encountered, such as remote sites for long duration control. Sodium chlorite selectively oxidizes sulfide and related organic odors. Unlike hypochlorite, sodium chlorite does not react with ammonia, and does not form chlorinated organics.



Typical field applications require a minimum of 3 mg/L of sodium chlorite per 1 mg/L of sulfide.

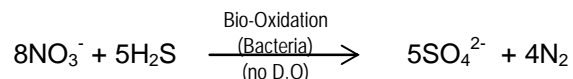
**Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>)** is applied to the wastewater system usually where there is a retention time of less than 5 hours and at least 30 minutes prior to the point where the hydrogen sulfide is released. Hydrogen peroxide is a stronger oxidant than either chlorine or potassium permanganate. Hydrogen peroxide will oxidize the hydrogen sulfide present and promote bio-oxidation of organic odors. Hydrogen peroxide decomposes into oxygen and water, environmentally harmless byproducts.



Typical field applications require 1 to 3 mg/L hydrogen peroxide per 1 mg/L sulfide. The reaction with sulfide is rapid with 90% of the hydrogen peroxide typically consumed within 10 to 15 minutes.

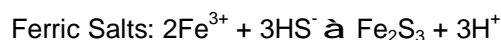
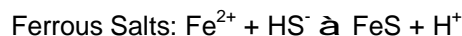
**Nitrate (NO<sub>3</sub>)** may also be effective for the removal of existing sulfide in the presence of bacteria that can utilize the nitrate for the oxidation of sulfide to

sulfur or sulfate. Examples of such bacteria include *Thiobacillus denitrificans*, *Thiomicrospira denitrificans* and *Thiosphera pantotropha*<sup>1</sup>. Bacteria able to utilize nitrate for the bio-oxidation of sulfide are naturally present in sewage systems.



Typical field applications require 3-10mg/L of N-O per 1 mg/L of sulfide.

**Iron Salts** are applied to wastewater systems for long-duration control. Both ferrous and ferric salts react with dissolved sulfide to form metal sulfide precipitates that are removed at the treatment plant.



Typical field applications require 3-5 mg/L as Fe per 1 mg/L of sulfide.

## Further Information

For more information, contact your OxyChem representative or our Technical Services Department at 1-800-733-1165 option #1.

## References

1. Bentzen, G., et. al., "Controlled Dosing of Nitrate For Prevention of H<sub>2</sub>S in a Sewer Network and The Effects On The Subsequent Treatment Processes", *Wat. Sci. Tech.*, Vol. 31, No. 7, pp 293-302, (1995).

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