

**ENGINEERING LETTER A-214
APPLICATION OF BIOXIDE®
SULFIDE PREVENTION VS. SULFIDE REMOVAL (BIOXIDE PROCESS®)**

Introduction

It is known that bacteria commonly present in wastewater collection systems will use dissolved oxygen, nitrate, and sulfate as oxygen sources for respiration, in that order of preference. Dissolved oxygen is usually present in "fresh" wastewater, but is rapidly depleted by biological activity. There is typically very little nitrate present in the wastewater, while sulfate is typically abundant. Since little or no nitrate is available, the bacteria begin utilizing sulfate when the dissolved oxygen is depleted. The byproduct of the sulfate uptake process is dissolved sulfide. The dissolved sulfide combines with hydrogen ions to form hydrogen sulfide, causing odor and corrosion problems.

Nitrate can be added to wastewater to control dissolved sulfide. There are two mechanisms by which nitrate can be used to provide this control. It can be used as a substitute oxygen source to prevent sulfate uptake and thus the formation of sulfide. This mechanism is known as "sulfide prevention". Nitrate can also be used to remove existing sulfide via the "removal" mechanism, which is also known as the Bioxide® Process.

It has been well established that the Bioxide® Process is effective for continuous removal of existing dissolved sulfide in wastewater systems. The stoichiometric nitrate requirement for the Bioxide® Process is 2.4 pounds NO₃-O per pound of sulfide removed (Hunniford, 1990). There is no direct relationship between the amount of sulfide treated and the amount of nitrate applied for the prevention mechanism, however empirical data indicate a nitrate to sulfide mass ratio of ten-to-one (Bowker, et al, 1985). The following information is presented as a comparison of the processes and an explanation for the differences in application rates.

Process Description and Comparison

Prevention: The prevention mechanism uses oxygen-source substitution to prevent the formation of dissolved sulfide. Under "untreated" conditions a carbon source (BOD) is consumed by bacteria in the wastewater in the presence of sulfate-oxygen, producing sulfide. If a single carbon source (methanol) is assumed for simplicity, the resulting reaction is as follows:



In this process 0.25 moles sulfate are used and 0.25 moles of dissolved sulfide are produced for every mole of carbon consumed.

This process is prevented when nitrate is added to the wastewater. In the presence of nitrate the carbon source is consumed via an anoxic denitrification reaction, producing no sulfide. Again assuming a single carbon source (methanol) for simplicity, the reaction is as follows:



In this process 1.2 moles of nitrate are used and zero moles of sulfide are produced for every mole of carbon consumed.



Expressing the nitrate requirement on an amount of sulfide prevented basis for these assumed reactions: (1.2 moles nitrate/mole carbon)/ (0.25 moles sulfide/mole carbon) = 4.8 moles nitrate required per mole sulfide prevented. On a mass basis, 9.3 pounds NO₃, or 7.2 pounds NO₃-O, are required per pound of sulfide.

The above analysis shows a "best-case" scenario for the prevention mechanism. In actual field applications higher carbon consumption (BOD reduction) rates are typically observed under anoxic conditions than under anaerobic conditions, therefore the nitrate-oxygen used is typically somewhat higher than the amount predicted here.

Removal: The removal mechanism (Bioxide® Process) uses naturally occurring bacteria to biochemically oxidize dissolved sulfide in the presence of nitrate. This mechanism takes place when Bioxide® is applied in wastewater that contains dissolved sulfide. The sulfide is typically either 1) generated upstream of the Bioxide® injection point, where no nitrate exists in the wastewater, or 2) is contributed downstream via a septic lateral flow. Then nitrate is injected in sufficient quantities to biochemically oxidize the sulfide via the following reaction (Hunniford, 1990):



This reaction takes place in the bulk flow and in the upper zones of the slime layer. Nitrate is not added in sufficient quantities to fully saturate the slime layer; therefore sulfide production continues to occur in the lower zones of the slime and is removed in the upper zones or in the bulk flow.

In this process 1.6 moles of nitrate are used for every mole of sulfide removed. On a mass basis, 2.4 pounds NO₃-O is required per pound of sulfide.

Summary

In this comparison it is readily observed that the amount of nitrate required to achieve a sulfide-free condition is at least three times greater for the prevention mechanism than for the Bioxide® Process. An application rate of 2.4 pounds NO₃-O per pound of sulfide (0.7 gal. Bioxide® per lb. sulfide) is necessary for the Bioxide® Process while at least 7.2 pounds NO₃-O per pound of sulfide (2.1 gal. Bioxide® per lb. sulfide) are required for the prevention mechanism

This analysis and comparison shows the advantages of maximizing the use of the removal mechanism when applying Bioxide®. Maximizing this mechanism can usually be achieved through careful selection of the application point for the Bioxide® solution. Each wastewater collection system is unique and presents its own set of environmental conditions which affect the injection point selection.

For a free analysis and review of your collection system followed by a Bioxide® application point recommendation, consumption rate prediction, and no-risk product demonstration, please contact the Siemens's Representative in your area by calling 1-800-345-3982.

References:

Hunniford, David J., (1990), Control of Odors and Hydrogen Sulfide Related Corrosion in Municipal Sewage Collection Systems Using a Biochemical Process: Bioxide®, WPCF 63rd Annual Conference, Washington D.C.

Bowker, Robert P. G., and John M. Smith, (1985), Design Manual, Odors and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants, U.S. Environmental Protection Agency, Cincinnati, OH.

The purchase of Bioxide® from Evoqua constitutes an implied license to practice the process of "Removal of Dissolved Hydrogen Sulfide and Reduction of Sewage BOD in Sewers and Other Waste Systems", as described in U.S. Patent No., Re #36,651, Re #37,181 and 7,087,172