Confronting Corrosion

Biological corrosion control method succeeds at treatment plants

By Rich Schici

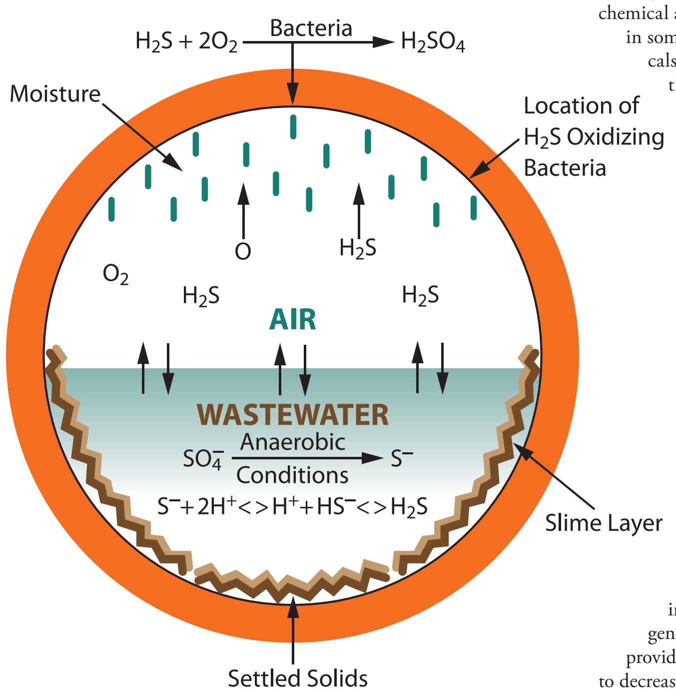
The presence of hydrogen sulfide (H_2S) can lead to rapid and extensive damage to concrete and metals used in the construction of wastewater collection and treatment systems. H_2S corrosion in wastewater often results in costly, premature replacement or rehabilitation of systems used in the transport and treatment of wastewater. Sewers designed to last 50 to 100 years have failed due to H_2S corrosion in as little as 10 to 20 years.

ARTICLE SUMMARY

Challenge: H_2S corrosion in wastewater collection and treatment systems is costing U.S. communities millions of dollars—perhaps more than the cost to prevent infrastructure corrosion in the first place.

Solution: Investigating a wastewater system's H_2S sources and problem areas allows operators to reduce dissolved sulfide levels through biological treatment, thus preventing corrosion.

Conclusion: With the proper H_2S corrosion controls in place, wastewater infrastructure operates more efficiently and over a longer lifetime, saving owners time and money.



Consequences of extensively damaged sewers have prompted the U.S. Environmental Protection Agency (EPA) to conduct a national assessment of the problem, resulting in reports to Congress and technical handbooks for municipalities throughout the country. EPA reports conclude that the costs to repair or replace pipes, equipment and structures deteriorated by H_2S corrosion may exceed the cost several times over to control the corrosion and avoid infrastructure damage. Nationally, the cost to repair corrosion damage by H_2S is in the billions of dollars, and many communities will spend millions of dollars in coming years to correct corrosion problems.

It is evident that a means to detect, control and correct H_2S corrosion in existing wastewater systems is the preferred alternative to premature replacement of system components. Several methods available to control the rate of H_2S corrosion focus on chemical injections. The most common chemical alternatives are costly and, in some cases, hazardous. Chemicals are fed at limited locations where the problems are generally the most severe; however, within a network of sewers that transports wastewater over thousands of square feet of collection system infrastructure, only a small portion of the sewer is protected.

As wastewater is transported, sewage velocity, wastewater characteristics, detention time and temperature provide dissolved oxygen such that the concentrations of organic material and nutrients increase the rate of sulfide generation. One technology provides a biological alternative to decrease H_2S emission in sewers. It includes regular additions of a highly concentrated formulation of facultative soil bacteria at multiple strategic locations throughout the entire collection system in accordance with an engineered treatment plan.

The technology enhances the microbial community in the sewer such that more reactions occur in the sewer biofilm, a community of microorganisms similar to a trickling filter, a rotating biological contactor or rocks in natural streams that contribute to increased metabolism of wastewater compounds. The biofilm is composed of extracellular polymeric substance or exopolysaccharide, which is the sticky organic matter or slime produced by microbes and responsible for cell adhesion in biofilms.

By reducing the quantity of H_2S available to be biologically converted to sulfuric acid, the rate of corrosion is controlled. Municipalities use this technology in the outreaches of the collection system to provide greater system coverage and extend the life of existing infrastructure.

What Causes H_2S Corrosion?

H_2S is an odorous, toxic gas. In the absence of dissolved oxygen and in the presence of soluble biological oxygen demand, *Desulfovibrio desulfuricans* and other sulfate-reducing bacteria (SRB) convert the sulfate to sulfide. Sulfate is biologically reduced to sulfide in the sewer biofilm, which accumulates on pipe walls and in wet wells. H_2S corrosion can occur by two mechanisms: acid attack resulting from the biological conversion of H_2S gas to sulfuric acid in the presence of moisture and direct chemical reaction with metals. The first mechanism is the principle cause of internal sewer corrosion.

SRB generate H_2S in the anaerobic parts of the wastewater system using sulfate as the final electron acceptor. In the absence of sulfate, certain strains of SRB can use a single carbon compound as both the electron donor and an electron acceptor by a process called dismutation. The SRB generally are thought to be obligate anaerobes, but recently it has been determined that they can tolerate oxygen for short periods of time and proliferate in the presence of oxygen. Several of these types of bacteria are commonly found in the human colon, such as *Desulfovibrio* and *Desulfobacter*.

Each year, deaths result from municipal workers' exposure to H_2S gas in confined spaces. Odor complaints result from neighbors living near wastewater systems who are exposed to low levels of the gas. Atmospheric H_2S levels can be reduced by controlling the amount of dissolved sulfide available in the wastewater. The basic goals and treatment levels must be developed individually for each system, but EPA guidelines target dissolved sulfide levels below 0.3 mg/L to control H_2S corrosion.

Biological Process Description

Far upstream in the collection system, where conditions are optimal for sulfide generation, H_2S corrosion takes place. Miles of existing sewer piping contain various layers and amounts of biofilm. The added facultative bacteria grow throughout the interior surface of the sewer pipes and dominate the sewer biofilm through the microbiological principal of competitive exclusion. By out-competing the SRB for nutrients, the high concentrations of beneficial microbes grow and populate the sewer pipes and lift station wet wells to optimize the entire infrastructure.

Over time, the added facultative bacteria convert the biofilm on the interior surface area of the infrastructure into a controlled, beneficial microbiological population. Organisms in the biological formulation are heterotrophic facultative anaerobes that can grow quickly in either anoxic conditions using nitrate as a final electron acceptor or aerobically using oxygen as the final electron acceptor and at any stage in between using fermentation. The added bacteria have a competitive advantage over the SRB, but only if they are added at a higher level than occurs in normally untreated conditions.

Performance History & Discussion

In a study of In-Pipe Technology Co., LLC conducted by Dr. Eberhard Morgenroth of the University of Illinois, a molecular analysis was performed on biofilm with In-Pipe bacteria using terminal-restriction fragment length polymorphism. The study identified a shift in the dominant populations of microorganisms that decreased dissolved sulfides 50% after continuous addition for 20 days from 0.45 mg/L to 0.23 mg/L. The reason is due largely to bacteria that are more flexible to convert organic matter, allowing gradual repopulation of the biofilm and preventing the proliferation of SRB.

At the 0.5-million-gal-per-day (mgd) Riverwood Community Wastewater Treatment Plant and collection system in Port Charlotte, Fla., In-Pipe service began in October 2009 with goals to remove deposits of fats, oils and grease (FOGs) and control corrosion. After an engineering review of the collection system, In-Pipe installed 13 dosing points throughout the system to dispense microorganisms into the sewer. The results after 30 days demonstrated that atmospheric H_2S decreased 80% from 605 ppm to 123 ppm and solution sulfides decreased to levels at or below 0.3 mg/L.

At a 15-mgd plant in Sioux City, Iowa, In-Pipe service began in May 2007 with goals to control corrosion and FOGs in the collection system and reduce the influent organic load. In-Pipe installed 80 dosing points throughout the collection system and introduced high concentrations of additional microbial formula at select locations over 28 months. The results demonstrated significant improvements at several locations in the collection system; solution sulfides decreased 90% from 5 mg/L to 0.5 mg/L, and atmospheric values decreased 80% from 146 ppm to 29 ppm.

The In-Pipe approach identifies existing and potential corrosion problems by reviewing collection system maps, odor complaint logs and specific sewer appurtenances at many locations within the system. Field service technicians conduct inspections and H_2S surveys at potential problem areas by measuring atmospheric and solution sulfides at locations upstream. This provides a matrix of corrosion rates at known problem areas in addition to discovering sources of H_2S, allowing the company to engineer a custom plan for biological treatment in the outer reaches of the collection system to control H_2S corrosion and protect as much as 80% of the existing infrastructure.

It is essential that corrosion problems be identified early, while the corrosion can still be controlled. Establishing biological treatment to decrease H_2S emission in sewers by reducing the quantity of H_2S available to be biologically converted to sulfuric acid controls the rate of corrosion. Lowering dissolved sulfide levels will control H_2S corrosion. The end result will be collection systems and treatment facilities that last longer and operate more efficiently. WWD

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