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WATER AND SEWERAGE

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Treating bacterial concrete corrosion

Microbiologically induced corrosion (MIC) is a biochemical process through which sulphur compounds present in wastewater are transformed, through a complicated, multiple-step process, into sulphuric acid (H_2SO_4). This H_2SO_4 generation takes place directly over the surface, above the wastewater level, and can quickly lead to serious structural damage.

MIC takes place naturally over any wastewater facility where hydrogen sulphide (H_2S) is released from the wastewater. If the amount of H_2S is small, the effects can be negligible throughout the entire designed lifespan of the sewer system, but under certain circumstances, MIC can also lead to critical structural damage in periods as short as four years.

MIC is a bigger problem in warm and humid climates, so the UK is much better off than, for example, Florida. Nevertheless, MIC is acknowledged in areas as cold as Canada.

The MIC process can be divided into four steps:

1. In wastewaters with dissolved oxygen levels under 0.1 mg/l, sulphur-reducing, anaerobic bacteria convert sulphates into H_2S. Warm wastewater temperatures favour a high conversion rate.

2. Under certain circumstances, H_2S gas can massively migrate into the sewer's atmosphere. The main factors that favour H_2S release from the wastewater into the atmosphere are high temperature, the pH of the wastewater and turbulence.

3. Bacteria and fungi naturally form a biofilm over the (non-submerged) surfaces of a wastewater facility. Among the microorganisms that thrive in this biofilm is the main contributor to MIC, a breed of aerobic bacteria called *Thiobacillus*. These bacteria transform H_2S into H_2SO_4 in their digestion process.

4. The H_2SO_4 reacts with concrete's calcium hydroxide, producing gypsum, a material with poor mechanical properties, especially when wet.

MIC is a durability problem which is difficult to address because protecting the entire system using traditional methods would be unnecessary and finding the spots that could be affected is not an evident task. However it is very important: replacement or rehabilitation of the facilities that can be affected is expensive and troublesome.

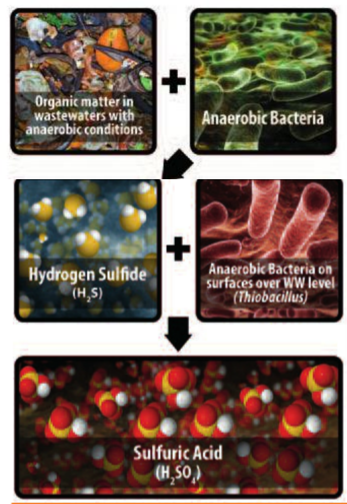
There are several guidelines that can be considered to locate spots with high MIC corrosion potential. For example, high H_2S concentrations are likely to be found at:

- sections downstream of intakes where the wastewater temperature is warm due, for example, to industrial process water
- sections downstream from locations where the water does not move or moves very slowly
- pressure mains, pumping stations, siphons

Spots with high H_2S concentrations in the atmosphere are probably downstream of those previously mentioned, in spots with turbulence in the wastewater such as:

- manholes (especially if there is a change in direction or slope or an intake with a difference of height)
- changes in direction or slope
- pressure main intakes, pumping stations, siphons

H_2S is denser than air, and therefore extends around the sewer's atmosphere, affecting an area that typically extends 7.5 to 15 metres from the release point, at both sides.



The MIC lifecycle

For in-depth evaluation, there are several computer-aided corrosion prediction models that enable engineers to locate sections of a sewer system that have a high MIC potential, to predict the expected damage rate and to choose the best solution for each particular case. Some examples are 'HS', from the American Concrete Pipe Association and 'Sulfide Works', from MicroCorpSystems.

To prevent/minimise MIC, several approaches can be adopted:

Design

- Ensure that the sewage velocity is high enough to enable air entrainment to replenish the oxygen consumed by aerobic microorganisms in the wastewater
- Avoid pressure mains, pumping stations and siphons whenever possible. These favour anaerobic conditions in the wastewater and

MIC delamination of coated manhole

thus, high hydrogen sulphide (H_2S) generation.

- Minimise the points of the system where turbulence is generated. The (H_2S) generation and release points can be distant from each other.

Chemical treatment

Wastewaters can be dosed with chemicals that cause H_2S to react and, generally, produce a precipitate before the H_2S can migrate into the atmosphere. This has to be done on a regular basis and is expensive.

Surface protection

Another option is coating the exposed surface with epoxy coatings or plastic liners, which is often done when the strength of a concrete pipe is required but the environment has high corrosion potential for concrete. While costly, these coatings provide resistance to sulphuric acid. However, both the fuel for the biochemical reaction (H_2S) and the microorganisms involved are microscopic; any pinhole or crack can enable MIC to take place between the substrate concrete and the coating/liner. Thus, the lifespan of these protective measures can be limited, due to the exacting quality control required for *in-situ* remedial operations.

Antimicrobial additives

Another option is the incorporation of polymer-based antimicrobial additives into the concrete during batching as part of the pipe manufacturing process.

Once added, these additives cover the surface of each concrete particle while it hardens. The strong covalent bonds that each monomer creates, both with each neighbouring monomer and the concrete particle that it covers, and the fact that the killing mechanism involves no electron exchange, makes the antibacterial effect permanent.

The cell wall of *Thiobacillus* and other potentially dangerous microorganisms is negatively charged. As the bacteria are attracted to the treated surface, where each of the monomers has a positive charge, they are destroyed.

Using concrete prepared in this way, it could be possible to have an MIC-free pipeline system. Antimicrobial additives are usually a more cost-effective option due to the fact that no extra operation is required. The potential increase in cost effectiveness is magnified in terms of a sewer asset's whole life cost.

About the author

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