MAR/APR 2021

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Wastewater odour
& corrosion control

Paul Turgeon and **Greg Bock** of **Anue Water Technologies** show how sustainable oxygen and ozone help improve safety and decrease costly equipment damage.

Wastewater systems have long been subject to issues with odour and corrosion, which is understandable, given the nature of what they convey. Odour is the driving force behind implementing controls in these systems. Corrosion, however, is the issue with the greatest potential for environmental harm and real systemic and economic damage.

This damage can arise in the form of burst pipes and other equipment and system failures. Failures of this type require the repair and replacement of system materials and equipment, and they have the potential to expose the environment to unpredictable releases of hazardous waste that are difficult, if not impossible, to contain or recover.

Corrosion caused by H_2S

A major contributor to odour and corrosion in industrial systems is hydrogen sulfide (H_2S) and its associated compounds. Some industrial wastewater contains sulfur compounds, which provide the molecular basis for the generation of H_2S.

H_2S is a colourless gas that has a characteristic rotten egg odour, is highly toxic and is corrosive to certain metals. It is heavier than air, meaning it can accumulate in wells, manholes and other similar locations that do not have much ventilation. Table 1 shows the effects it can have on humans, at varying concentrations relative to ambient air.

H_2S arises from the combination of anaerobic conditions and the presence of sulfites and sulfates in conjunction with colonies of microorganisms on the inner walls of all collection systems, referred to as the slime layer. Sulfate-reducing bacteria (SRB) will use these compounds in the absence of free oxygen (O_2) for metabolism. These bacteria do not use the sulfur component, and it is available to react with water, specifically free protons (H+).

This process generates H_2S, which can then be released into the atmosphere and find its way to receptors through junctions of the atmosphere and collection system, at which point it is an odour concern. It also becomes a corrosion issue when it contacts moist concrete or steel, among other metals, in the presence of oxygen, even at very low gaseous concentrations.

Conditions such as these are common in the headspace of some pipes and other areas where the collection system has easy access to atmospheric oxygen. Bacteria in these areas convert the H_2S into sulfuric acid, which then begins a destructive reaction with the infrastructure.

Concentration (ppm)	Physiological effect
0.1 - 3	- Odour threshold
3 - 10	- Offensive odour
10 - 50	- Headache - Nausea - Throat & eye irritation
50 - 100	- Eye injury
100 - 300	- Conjunctivitis - Respiratory tract irritation - Olfactory paralysis
300 - 500	- Pulmonary oedema - Imminent threat to life
500 - 1,000	- Strong nervous system stimulation - Apnoea
1,000 - 2,000	- Immediate collapse with respiratory paralysis - Risk of death

Table 1 – H_2S health effects at different concentrations

Historically, odour and/or corrosion have been treated either through vapour-phase techniques, where the headspace of a system is treated, or liquid-phase techniques, where treatments target the liquid flow. Some of the former, like scrubbers, do not provide corrosion control, while some of the latter do.

The most common method of inducing liquid-phase treatment inside the collection system has been by dosing chemicals. A constant and continuous dose of chemical is fed from a large reservoir with a small pump into the collection system, typically at a manhole or pump station. These are meant to react with the odour-causing compounds in the wastewater or cease their formation and/or release from solution.

Control options

The conventional classes of reactions used to control H_2S are:

- **Chemical oxidation through the use of a compound with a high oxidation potential, called an oxidant, such as hydrogen peroxide or sodium hypochlorite (bleach)**
- **Using sulfide scavengers (iron salts), which interact with H_2S and sequester the sulfur into a relatively insoluble form, such as ferric or ferrous chloride, thus removing it from the cycle entirely**
- **Adjusting the pH: because of the way that its ions dissociate in the aqueous phase, H_2S will not be released from wastewater if the pH is at 9 or above**

A common alternative is to use an oxygen source and sulfate substitute. In an anaerobic environment, the microbiology in a collection system will use oxygen from a nitrate (NO_3) molecule more readily than from a sulfate (SO_4) molecule. As a result, benign nitrogen is released rather than H_2S.

Chemicals like calcium or sodium nitrate are commercially available ➤

and can be used for this purpose. They can be expensive, though, and they feed and grow the SRB layer, potentially requiring a higher volume for treatment over time. And, upon cessation of treatment, H_2S levels can be even worse than before.

Excess wet well build-up, requiring increased clean-out cycles because of the addition of the waxes used to stabilise the nitrate molecules, can be encountered downstream in the collection system. In addition, emerging regulations are beginning to include nitrate concentrations on discharge limitations.

Real-time, active monitoring of wastewater H_2S levels is seldom carried out, so enough chemical to control peak values is typically added on a constant basis. By treating for peak values with chemicals such as these, excess nitrate will probably be present, requiring additional and expensive denitrification processes or fines.

An issue with all chemicals is the need to store them in bulk nearby in order to introduce them to a collection system. To ensure that they are always available for treatment, continued deliveries to the bulk storage tank must be made. And to avoid adverse effects to the environment, engineered controls, such as secondary containment and leak monitoring, must be designed, implemented and maintained.

Oxygen & ozone

Ideally, a successful treatment of wastewater odour and corrosion would, in addition to being cost-effective:

- **End sulfide production**
- **Quickly eliminate any sulfides present**
- **Bring about no additional hazard to life or the environment**
- **Do no harm to the collection system**
- **Create no additional challenges downstream**

One answer is introducing ozone and oxygen into wastewater systems to control odour and corrosion. Ozone (O_3) is a naturally occurring form of atmospheric oxygen that has been used in water treatment since at least the late 19th century, primarily to disinfect drinking water.[4] Its use is common in Europe.[5]

The controlled use of ozone as a treatment does not produce harmful by-products that could contaminate or damage the environment. Typically, the only by-products here are O_2 and inert oxides. In recent years, interest in using ozone to treat wastewater has led to the development of new and sustainable (green) technology for odour and corrosion control in wastewater collection systems.

Ozone has three oxygen atoms. This makes it a highly reactive molecule with the highest oxidation potential of any commercially available molecule and the fourth highest overall with an oxidation potential of 2.07 volts. Only atomic fluorine, the hydroxyl radical and atomic oxygen are higher.

Ozone can be generated by exciting a flow of oxygen with sufficient electrical or optical energy, causing some oxygen atoms to split and recombine with others nearby. Under typical treatment conditions, using a relatively pure oxygen stream and a corona discharge chamber with a high-voltage electrical arc, this reaction can produce up to 9-12wt% ozone, although 1-9 wt% is more typical.[6,7]

As ozone concentrations rise above this concentration, the destruction reaction becomes more frequent, returning greater quantities to oxygen and maintaining this equilibrium. This instability is also the reason why ozone cannot be stored and must be generated immediately before application.

Because of its extreme instability and high oxidation potential, ozone is both powerful and indiscriminate in terms of reactivity with other chemical species. It has been shown to be an effective treatment for the destruction of volatile organic compounds; removal of metals, total suspended solids and organic carbon; and significant reductions to chemical oxygen demand.

Anue's new headquarters and main facility at Alpharetta, Georgia

In freshwater, the half-life of ozone is typically 10-20 minutes, but in wastewater, it is entirely consumed within 8.6 seconds because of the extreme amount of potential reactants present in wastewater including H_2S.[8] The simple structure of H_2S makes it an easy target for oxidation by ozone.

In addition, ozone's unique structure tends to create free radicals, making them highly reactive, especially in water. As part of these reactions, additional free radicals form, which can be even more reactive than ozone. These tend to create additional radicals as they react, in what is termed a free radical chain reaction.

The current technology for producing ozone has benefitted from more than 45 years of ongoing development, resulting in cost-effective and robust operation. Using little more than an oxygen separator, a corona discharge chamber and some compressors and other electrical components, onsite generation of ozone is relatively simple and safe, unlike most other commercially available treatments.

Because of the way ozone is produced, oxygen is necessarily going to be part of the treatment gas cocktail when using it. This is beneficial because oxygen is also an oxidiser. With an oxidation potential of 1.23 V, oxygen reacts slower than ozone but is an excellent complement to it.

Oxygen's other primary benefit is increasing the dissolved oxygen (DO) concentration of the wastewater, encouraging the growth of aerobic bacteria, which do not create compounds that are odorous, corrosive or otherwise harmful to collection systems. It also eliminates the ability of SRB to produce sulfides, either by removing it entirely or promoting the growth of aerobic species that will oxidise any sulfides before they enter the wastewater stream.[3]

Combined use for treatment

The combined forces of oxygen and ozone are at the top of the list of robust and green methods to treat and prevent of odour and corrosion in collections systems. The generation and infusion of these two gases into wastewater collection systems has proven to be clean, safe and cost-effective.

The first method of action is the powerful destructive effects of ozone on H_2S, quickly converting it to sulfites and sulfates on contact. In addition, ozone's antimicrobial properties can help to reduce the presence of SRB and other microorganisms present on pipe walls.

As a product of its reaction, oxygen is generated. This in turn adds more power to the oxygen portion of the treatment gas cocktail, which is providing secondary treatment by significantly increasing DO, and allows for more complete utilisation of infused treatment gases.

Oxygen will also oxidise H_2S, though at a much slower rate. Because of these indiscriminate and powerful oxidising characteristics, concerns are sometimes raised about ozone attacking the wastewater infrastructure itself. However, this is unlikely to occur in application, especially in wastewater where liquid-phase infusion is implemented, due to the high ratio of liquid volume compared to pipe surface area per unit pipe length and the extreme availability of reactants in the liquid portion. ●

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