world water

Volume 41 / Issue 2
March / April 2018

Ocean plastics:
New energy source

Water Environment Federation
the water quality people®

A Supporting Publication of
weftec®
the water quality event™

Sustainable odor and corrosion control using oxygen, ozone

Sustainable oxygen and ozone help improve safety and decrease costly equipment damage. Paul Turgeon and Tonya Chandler of Anue Water Technologies explain how the introduction of oxygen and ozone into wastewater collection systems can cost effectively reduce odors and corrosion.

Wastewater systems have long been subject to issues with odor and corrosion, which is understandable given the nature of what they convey. The odor is the driving force behind implementing controls for 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 odor 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 H_2S generation. H_2S arises from the combination of anaerobic conditions and the presence of sulfites and sulfates in conjunction with colonies of microorganisms present 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. Since these bacteria do not use the sulfur component, it is available to react with water, specifically with free protons (H+), which results in the generation of H_2S.

Following its generation, H_2S can be released into the atmosphere and find its way to receptors through junctions of the atmosphere and collection system, at which point it becomes an odor concern. H_2S is a colorless gas that has a characteristic rotten egg odor; it is also highly toxic and corrosive to certain metals.

H_2S 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.

Historically, control of odor and corrosion has been implemented through either vapor phase techniques, where the headspace of a system is treated, or liquid phase techniques, where treatments target the liquid flow. Vapor phase treatments such as scrubbers do not provide corrosion control. Some of the liquid phase techniques offer corrosion control.

The most common method of inducing liquid phase treatment, or directly treating the wastewater inside the collection system, has been by dosing chemicals into the systems. 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 chemicals are meant to react with the odor-causing compounds present in the wastewater or cease their formation and/or release from solution.

Conventional control options

The conventional classes of reactions used to control H_2S are:

- *Oxidation* – Chemical oxidation of H_2S is accomplished through use of a compound with a high oxidation potential, called an oxidant, such as hydrogen peroxide or sodium hypochlorite (bleach)
- *Sulfide scavengers (iron salts)* – Chemicals that interact with H_2S and sequester, or scavenge, the sulfur into a relatively insoluble form, such as ferric chloride and ferrous chloride, can be used to remove sulfur from the cycle entirely
- *pH adjustment* – Because of the way that its ions dissociate in the aqueous phase, the release of H_2S from wastewater will not occur if the pH is at 9 or above.

Anue's Phantom Ozone/ Oxygen Injection System is a small, compact unit used to inject ozone/ oxygen into smaller lift stations and other wastewater facilities. Photo by Anue

Alternate oxygen source/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, and as a result, benign nitrogen is released rather than H_2S. Chemicals such as calcium or sodium nitrate are commercially available and can be used for this purpose. They can be expensive, however, and they feed and grow the SRB layer, potentially requiring a higher volume for treatment over time.

Upon cessation of treatment, the amount of H_2S can be even worse than before. Excess wet well build-up resulting from the addition of the waxes used to stabilize the nitrate molecules can be encountered

Municipal wastewater technician uses Anue digital monitoring system to control oxygen/ozone injection and view key measures remotely. Photo by Anue

downstream in the collection system and requires increased clean-out cycles. Additionally, emerging federal and state 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 H_2S values is typically added on a constant basis. By treating for peak values with chemicals such as these, the likelihood is very high that excess nitrate will be present and actively added to the wastewater, requiring additional denitrification processes or fines, both of which can be very expensive.

An issue with all chemicals is that a bulk quantity must be stored nearby for introduction into a collection system. To ensure that chemicals are always available for treatment, continued deliveries to the bulk storage tank must be made. To avoid adverse effects to the environment, engineered controls, such as secondary containment and leak monitoring, must be designed, implemented, and maintained.

Ideally, a successful treatment of wastewater odor and corrosion would:

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

The treatment solution must also be cost effective. One viable option involves introducing ozone and oxygen into wastewater systems to control odor and corrosion. Ozone's environmental sustainability and relative safety versus chemical systems has established it as a favored current and future technology. The controlled use of ozone as a treatment does not produce harmful byproducts that could contaminate or damage the environment or ecology.

Typically, the only byproducts from its reaction are O_2 and inert oxides. In recent years, interest in its use to treat wastewater has led to the development of new and sustainable technology for odor and corrosion control in wastewater collection systems.

Because of its extreme instability and high oxidation potential, ozone is powerful and indiscriminate in terms of reactivity with other chemical species. Ozone has been shown as 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.

In freshwater, the half-life of ozone is typically 10 to 20 minutes, but in wastewater, ozone has been documented as being entirely consumed within 8.6 seconds. This occurs because of the extreme amount of potential reactants present in wastewater, including H_2S. The simple structure of H_2S makes it an easy target for oxidation by ozone. In addition to its high oxidation potential, ozone's unique structure tends to create free radicals, chemical species having unbonded electrons that make them highly reactive, especially in water. In effect, the benefit of ozone's direct reaction with different chemical species is realized and, as part of these reactions, additional free radicals, which can be even more reactive than ozone, can form. These radicals also tend to create additional radicals as they react to create what is called a free radical chain reaction.

These additional reactions are indirect effects of ozone. With the source of ozone generation being ambient air, ozone is the ultimate in sustainable and green chemical treatment. 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, in sharp contrast to most other treatments that are currently commercially available.

Because of the way ozone is produced, oxygen is necessarily a part of the treatment when using ozone, which is beneficial because oxygen is also an oxidizer. With an oxidation potential of 1.23 Volts (V), oxygen reacts slower than ozone but is an excellent complement. Aside from its ability to assist in oxidation, its 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

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Events 2018

May

3-5 Shanghai, China
IE expo Trade Fair for Environmental Technology Solutions: Water, Waste, Air, and Soil
www.ie-expo.com

8-10 May Brisbane, Australia
OZWATER '18, Australia's International Water Conference & Exhibition, organized by Australian Water Association
Includes WEF International Pavilion
www.ozwater.org

14-18 Munich, Germany
IFAT 2018, Trade Fair for Water, Sewage, Waste and Raw Materials Management. Includes WEF International Pavilion
www.ifat.de

15-18 Munich, Germany
6th Joint Conference on Resilience of the Water Sector, organized by European Water Association, Japan Sewage Works Association, and Water Environment Federation in cooperation with IFAT, Messe München
www.resilience-conference2018.com

15-18 Phoenix, Arizona, USA
Residuals and Biosolids Conference 2018, organized by Water Environment Federation
www.wef.org

May

27-31 Nanjing, China
15th IWA Leading Edge Conference on Water and Wastewater Technologies, organized by International Water Association and Nanjing University
www.iwa-let.org

31 – 2 June Shanghai, China
Aquatech China, International Exhibition for Process, Drinking Water and Wastewater in Asia
www.aquatechtrade.com

June

6-8 Grange-over-Sands, England, UK
Protections 2018, 3rd International Conference on Protection Against Overtopping. Held in Lake District National Park, organized by HR Wallingford
www.protections2018.org

18-21 Raleigh, North Carolina, USA
WEF Specialty Conference on Nutrient Removal and Recovery, organized by Water Environment Federation
www.wef.org

June

25-28 Ramallah, Palestine
First Palestine International Water Forum on Integrated Water Resource Management: Best Practices and Technology Transfer, organized by Palestinian Water Authority
Email: PIWF@pwa.ps

27-28 Milwaukee, Wisconsin, USA
11th Annual Water Leaders Summit, "Global Industries Revving Up Water Tech Demand," organized by The Water Council
www.thewatercouncil.com

July

8-12 Singapore
Singapore International Water Week 2018, organized by Ministry of the Environment & Water Resources, National Water Agency (PUB). Includes Water Leaders Summit, Water Expo, Industrial Water Solutions Forum
www.siww.com.sg

29-31 Portland, Oregon, USA
Disinfection & Reuse Symposium 2018, organized by Water Environment Federation
www.wef.org

August

26-31 Stockholm, Sweden
SIWI World Water Week 2018: Water, Ecosystems and Human Development, organized by Stockholm International Water Institute
www.worldwaterweek.org

September

4-6 Mexico City, Mexico
Aquatech Mexico Exhibition, co-located with Global Resources Environmental & Energy Exhibition and Congress. WaterMex Conference held in cooperation with CONAGUA
www.aquatechtrade.com

9-12 San Antonio, Texas, USA
33rd Annual WateReuse Symposium
www.watereuse.org

16-21 Tokyo, Japan
World Water Congress & Exhibition 2018, organized by International Water Association
www.worldwatercongress.org

29-October 3 New Orleans, Louisiana, USA
WEFTEC 2018, 91st Annual Technical Exhibition & Conference, held with Stormwater Congress. Organized by Water Environment Federation. www.weftec.org

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collection systems. It also eliminates the ability of SRB to produce sulfides, either by removing the SRB entirely or promoting the growth of aerobic species that will oxidize any sulfides before they are able to enter the wastewater stream.

The Anue Mobile Demonstration Unit is transported to customer sites where it is used to demonstrate how the Ozone /Oygen Injection Systems work to eliminate FOG, odor, and corrosion. Photo by Anue

Combined use of oxygen and ozone for treatment

In terms of a robust and green method of the treatment and prevention of odor and corrosion in collections systems, the combined forces of oxygen and ozone top the list. Oxygen is widely available, making up roughly 21 percent of the atmosphere, and it is easily converted to ozone, as has already been seen. The generation and infusion of these two gases into wastewater collection systems has proven to be a clean, safe, and cost-effective treatment. The first method of action involves the powerful destructive effects of ozone on H_2S, quickly converting it to sulfites and sulfates on contact. Additionally, ozone's antimicrobial properties can help to reduce the presence of SRB and other microorganism present on pipe walls. As a product of its reaction, oxygen is generated. This generation in turn adds more power to the oxygen portion of the treatment, which provides secondary treatment by significantly increasing DO and allows for more complete utilization of infused treatment gases.

Oxygen will also oxidize H_2S, but at a much slower rate than ozon-eecause of the indiscriminate and powerful oxidizing characteristics of ozone, the concern is sometimes raised regarding the possibility of ozone attacking the wastewater infrastructure itself. This result is unlikely to occur in application, especially in wastewater where liquid phase infusion is implemented.

Authors' Note

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