Evoqua Water Technologies - Overview

Municipal Services Group
• Provide products and services for the treatment of water and wastewater
  -- Wide variety of equipment and chemistries for odor and corrosion control
  -- Full Service Odor Control Programs
  -- Capital Equipment Sales
• Started in 1978 with ferrous sulfate (Odophos) for collection system odor control
• Nitrate products, oxidizers, pH shift, iron salts
• Over 700 municipal and industrial accounts nationwide
• Employ over 150 engineers, sales representatives, technicians, and support staff

Wastewater Odor Compounds

<table>
<thead>
<tr>
<th>Mercaptans</th>
<th>Amines</th>
<th>Sulfur Dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulfide (H₂S)</td>
<td>Ammonia</td>
<td>Skatole</td>
</tr>
<tr>
<td>Dimethyl Sulphides</td>
<td>Indole</td>
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</tbody>
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Hydrogen Sulfide - Odor and Toxicity

<table>
<thead>
<tr>
<th>Odor Threshold</th>
<th>Offensive Odor</th>
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<tbody>
<tr>
<td>Headache, Nausea</td>
<td></td>
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<tr>
<td>Throat and Eye Irritation</td>
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<tr>
<td>Eye Injury</td>
<td></td>
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<tr>
<td>Conjunctivitis, Respiratory Tract Irritation, Olfactory Paralysis</td>
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<tr>
<td>Pulmonary Edema</td>
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<td>Strong Nervous System Stimulation</td>
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<tr>
<td>Apnea</td>
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<td>Death</td>
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Background – H₂S Formation & Concrete Corrosion

Step 1 – Aerobic bacteria deplete available oxygen
Step 2 – Anaerobic bacteria convert sulfite to sulfide
Step 3 – Sulfide combines with wastewater acidity to form hydrogen sulfide
Step 4 – Insoluble hydrogen sulfide escapes to headspace
Step 5 – Hydrogen sulfide is biologically oxidized to sulfuric acid
Step 6 – Sulfuric acid weakens the concrete structure

Acid reacts with calcium hydroxide matrix.

Concrete Pipe

Biologically Active Slime Layer

H₂S

H₂SO₄

SO₄²⁻

O₂

H⁺
The Sewer Sulfide Cycle

**Formation Factors**
- Temperature
- Long Force Mains/RT
- High BOD
- Debris/Solids

**Release Factors**
- pH
- Turbulence
- Pressure

Potential Problem Areas
- Pump stations/Force Mains
- Inverted siphons
- Full-flowing gravity lines
- Slope change – decrease
  - Forces air out
- Slope change – increase
  - Sucks air in
- Drop shafts
- Air release valves

Sewer Ventilation Study

Until recently, sewer ventilation has not been carefully studied. Today the Water Environment Research Foundation (WERF) has an ongoing project studying sewer ventilation and models.
- May help in design of sewers
- May help in design of odor and corrosion control measures

Corrosion Impacts

Collapse Impacts:
1. System Outage
2. Pollution Release
3. Danger to Public
4. Expensive and Disruptive to Fix
5. Headline News

Infrastructure Failure is Unacceptable

Concrete Corrosion Study - Overview
- Deploy samples at two similar locations in the wastewater collection system
  - Allow H2S exposure in one sample
  - Remove H2S in second sample
- Expose samples in an operating collection system for 2 years
  - Sanitation District 1 located in Northern KY
- Measure exposure conditions in both samples
  - Long Term Hydrogen Sulfide Monitoring
- Quantify concrete corrosion – loss of mass over time
- Measure compressibility before and after exposure
- Quantify effect of atmospheric hydrogen sulfide on a concrete sample

Methodology – Sample Concrete Coupons

Concrete coupons
Fabricated by third party contractor.
Fabricated of Type II Portland cement in accordance with specifications outlined in ASTM C150
Testing and curing was performed in accordance with ASTM C192

Data – Atmospheric Sulfide

Airport PS – Untreated
- 68.5 ppmv average H2S
- 148.5 ppmv peak

Centerplex PS – Treated
- 3.6 ppmv average
- 32.3 ppmv peak
Results of Samples Treated to Prevent H₂S

- Exposure to an average of 3.5 ppmv over a two year period resulted in:
  - No loss in compressive strength
  - 6.2% reduction in weight of samples

Results of Untreated Samples

Exposure to an average of 68.5ppmv over a two year period resulted in:

- 13% reduced compressive strength of samples
- 5.4% reduction in weight of samples
- Most pipe materials at risk

Full study will be presented at NJWEA conference in AC in May.

So you know you don’t want this to happen in your system...so now what?

Initial Evaluation

- Take all contributing factors into account:
  - Flow
  - Retention Times
  - Temperatures
  - BOD Loadings
  - pH
  - Industrial Contributors
  - Current Issues & Treatment Goals

- Collect Data
  - Liquid Sampling
  - Continuous Vapor Phase Monitoring

What are the Technologies?

**Vapor Phase**
- Biological
- Adsorption
- Wet Scrubbing (Chemical)

**Liquid Phase**
- Nitrate Salts
- pH Adjustment
- Iron Salts
- Oxidizers
  - Hydrogen Peroxide
  - Sodium chloride
- Others

**COMBINATIONS**

Nitrate – Prevention Mechanism

The end product of microbial respiration:
1. Oxygen → Carbon Dioxide and Water
2. Nitrate → Nitrogen gas
3. Sulfate → Hydrogen Sulfide

The presence of Nitrate in anoxic wastewater prevents the formation of hydrogen sulfide by providing the microbiology with an “easier to breathe” terminal electron acceptor

Without Nitrate:
\[
\text{SO}_4^- + 6 \rightarrow \text{S}^- + \text{H}_2\text{O} + \text{CO}_2
\]

With Nitrate:
\[
2\text{NO}_3^- + 3\text{C} \rightarrow 3\text{CO}_2 + \text{N}_2
\]

IT TAKES 2.1 GALLONS OF BIOXIDE TO PREVENT THE FORMATION OF 1 POUND OF HYDROGEN SULFIDE
Nitrate – Removal Mechanism

If hydrogen sulfide is already present at the location where Nitrate is added, the microbiology can remove the hydrogen sulfide.

\[ \text{NO}_3^- + 5\text{H}_2\text{S} \rightarrow 5\text{SO}_4= + 4\text{N}_2 + 4\text{H}_2\text{O} + 2\text{H}^+ \]

The reaction requires about 90 minutes of contact time to complete.

Nitrate is best used:
- At pump stations and along forcemain injection points
- For retention times ranging from 1.5 to 12 hours
- Where chemical safety is important
- Hydrogen sulfide goal is very strict

IT TAKES 0.7 GALLONS OF BIOXIDE TO REMOVE 1 POUND OF HYDROGEN SULFIDE

Oxidizers – Hydrogen Peroxide - Mechanism

Hydrogen peroxide works by direct oxidation of dissolved sulfides:

\[ \text{H}_2\text{O}_2 + \text{H}_2\text{S} \rightarrow \text{S} + 2\text{H}_2\text{O} (\text{pH} < 8.5) \]

\[ 4\text{H}_2\text{O}_2 + \text{S}^= \rightarrow \text{SO}_4= + 2\text{H}_2\text{O} (\text{pH} > 8.5) \]

NOTE: hydrogen peroxide is 4 times more effective at lower pH than higher.

It takes 1 pound of \( \text{H}_2\text{O}_2 \) to oxidize 1 pound of \( \text{H}_2\text{S} \) under ideal conditions.

90 percent of hydrogen peroxide is used in 10-15 minutes, reaction complete in 30 minutes.

Excess hydrogen peroxide left over decomposes, providing dissolved oxygen to the system:

\[ 2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2 \]

Iron Salt – Mechanism

Iron Salts remove sulfide from solution by combining with them and forming a solid.

\[ \text{Fe}^{2+} + \text{HS}^- \rightarrow \text{FeS} + \text{H}^+ \]

\[ \text{Fe}^{2+} + 2\text{Fe}^{3+} + 4\text{HS}^- \rightarrow 2\text{Fe}_3\text{S}_4 + 4\text{H}^+ \]

Iron sulfide arriving at the treatment plant with the wastewater may be oxidized to ferric iron where it can be used in secondary clarifiers for phosphorous removal.

Iron Salts are best used:
- At pump stations and along forcemain injection points
- For low retention times
- Dissolved sulfide goal = 0.5 mg/L
- Economic option in high flow systems
- Secondary benefits at the treatment plant may be realized

pH Shift – Mechanism

pH shift chemicals work by changing to the sulfide type to the non-volatile sort.

\[ \text{S}^- \rightarrow \text{non-volatile} \]

\[ \text{HS}^- \rightarrow \text{non-volatile} \]

\[ \text{H}_2\text{S} \rightarrow \text{volatile, can off-gas to cause corrosion and odors.} \]

pH shift technology is best used:
- Economical solution for flows in the range of 0.5 – 3.0 MGD
- High BOD lines
- When point source and downstream odor control is needed
- Good for retention times up to 8 hours

Oxidizers – Application Guideline

Oxidizers are best used:
- Where fast reactions times are needed
- Very Low RTs or sludge lines
- Peroxide is suitable for RTs from 30 min to 3 hours
- Other organic odors may be present
- Treatment goals are very strict
- No chemical residual is permitted downstream

Care must be taken when using Oxidizers:
- Hazardous chemicals requiring strict handling and storage procedures.
- Contact with organics or other incompatible substances can lead to violent reactions.
- Moderate to High chemical and equipment costs
- Site must be secured

Oxidizers – Sodium Chlorite – Mechanism

\( \text{NaClO}_2 \) works by direct oxidation of dissolved sulfides:

\[ 2\text{H}_2\text{S} + \text{NaClO}_2 \rightarrow 2\text{S} + \text{NaCl} + 2\text{H}_2\text{O} (\text{pH} < 7) \]

\[ 2\text{NaClO}_2 + \text{S}^= \rightarrow \text{SO}_4= + 2\text{NaCl} (\text{pH} > 7) \]

NOTE: sodium chlorite is 4 times more effective at lower pH than higher.

It takes 1.4 pounds of \( \text{NaClO}_2 \) to oxidize 1 pound of \( \text{H}_2\text{S} \) under ideal conditions.

\( \text{NaClO}_2 \) reacts within seconds.

Other Oxidizers - Potassium Permanganate and Sodium Hypochlorite– Also can be used where fast reaction is needed.

Oxidizers – Application Guideline

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Others...

- **Oxygen Injection**
  - Good for short retention time applications.
  - Higher the operating pressure the more O2 allowed in solution.

- **Bio-Augmentation**
  - Have heard of good results for plant performance (BOD, VS destruction, etc.)
  - Have seen limited success in straight up odor control applications.

- **Air Stripping**
  - Intentional agitation or stripping of wastewater by mechanical means.
  - Either Vent or Treat.

Next Steps...

- You know what H2S is and how it's formed...
- You know where to look for it in your collection system...
- You have looked at contributing factors and performed modeling/collected data to determine severity of issue...
- You have taken all available information and determined the best treatment technology...
- Now a program must be developed for your particular situation to treat safely and efficiently.

Treating safely and efficiently

- Regardless of Technology Chosen, Dosing Control and Monitoring are Important.
- Appropriate Sampling, Monitoring, & Maintenance for Application.
- Advanced Odor Control Utilizes:
  - Hardware
  - Applications Expertise
  - Control Functions
  - Remote System Monitoring and Data Collection
  - Alarm Notifications

Dosing Technology Comparison

AOC – VersaDose – Hardware

AOC – VersaDose – Control Functions

- Capabilities of the advanced dosing systems:
  - Temperature
  - Dose Curve
  - Rain Curve
  - Dose in proportion to flow
  - Results
Internet Enabled Hydrogen Sulfide Data Loggers

- Cellular modem enabled hydrogen sulfide data-loggers
- Deployed at the compliance point
- Report hydrogen sulfide data to web
- Instantaneous call-out alarms

Web Based Interface

Customizable trending graphs
Historical data permanently available

AOC – VersaDose – Efficiency – Temperature

- Biological activity increases with a rise in temperature
  - Typically 7% per degree Celsius
- Microbial activity may reach negligible levels below certain thresholds
  - Values of 15-13 degrees Celsius have been validated
  - Higher oxygen solubility at lower temperatures
  - Reduced aerobic activity results in less time for SRBs to create sulfide.

AOC – VersaDose – Flow – Rain Compensation

- Rain, I&I, Snowmelt
  - Increase in flow
  - Reduced retention time
  - Increased scouring velocity reduces slime layer thickness
  - Reduced BOD
  - Reduced chemical demand
- Program 50% reduction during high flow monitor results.
  Repeat as necessary.
- Spring Creek PS: 61 days with a total of 415 hours of rain, ~$4,000 in chemical savings

CONCLUSIONS

- There are many different factors that contribute to sulfide generation
- H2S is common, it can be dangerous, and it can cause severe damage to your collection systems/treatment plants
- A comprehensive approach in pinpointing the sources, the issues and determining how to treat these sources should be used.
- There are a broad variety of treatment technologies out there that can be utilized
- Different applications will require varying degrees of technology, monitoring, and maintenance. Choose accordingly.
- Some simple treatment programs can go a long way to prevent major maintenance and repair issues