Disinfection Alternatives for Water and Wastewater

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Purpose of Disinfection

- Most Basic Requirement for Sanitation and Protection of Public Health
- Prevent the Spread of Waterborne Disease – Typhoid, Salmonella, Cholera, Hookworm, etc.
- Kills or Inactivates Most Disease Sources - Bacteria, Protozoa, Parasites, and Viruses
- Used Widely Since Around the Turn of the Century with Huge Public Health Benefits
- Reduced Infant Mortality & Increased Longevity
History of Water Disinfection
Purpose of Disinfection

Water Treatment and Distribution

- Surface Source – Must Treat to Render it Potable and Insure Potability at the Point of Usage
- Ground Source – May Not Be Required for Treatment, but Generally Required for Distribution

Wastewater Treatment

- Surface Discharge – Required in NPDES Permit to Protect Downstream Users
- Ground Discharge – May not be required
Common Disinfection Options

Sodium Hypochlorite – Liquid Solution

Ultraviolet Light Disinfection

Chlorine – Elemental Gas or Liquid

Other Chemicals
Disinfection Mechanism

**Chemicals**
- Breaks organism cell walls for kill
- Chemically oxidize organic matter

**Ultraviolet Light**
- Disrupts organism reproduction
- Inactivates viruses
**Sodium Hypochlorite**

### Dosing

- \( \text{NaOCl} + \text{H}_2\text{O} = \text{HOCL} + \text{NaOH} \) (alkaline soln.)
- 1 lbs chlorine gas = 1 gallon 12.5% NaOCl
- Comparable performance to Chlorine gas
- OCl is a powerful disinfectant and oxidant

### Storage/Generation

- Bulk storage of liquid – Larger Volume than Pure Cl
- Requires secondary containment in case of leak or spill
- Must have 30 – 60 days supply in heated storage
- Degrades over time (dilute in tank)
- Safety issue if mixed with other chemicals!
Sodium Hypochlorite Only
(Bleach)
UN1791

WARNING: MIXING SODIUM HYPOCHLORITE WITH ANOTHER CHEMICAL MAY CAUSE A DANGEROUS SITUATION

GUIDANCE TO AVOID ACCIDENTAL MIXING

1. Verify that the shipping papers are in order
2. Verify that the tanker is loaded with sodium hypochlorite solution (UN1791)
3. Verify that the receiving tank has sufficient capacity
4. Verify that the drain sump is empty, rinsed, and isolated prior to unloading
5. Verify that the unloading connections/piping are correct (check labels, routing, etc.)
6. Verify correct connections by a second person
7. Monitor tank level during the unloading process
8. Follow applicable regulations for monitoring/attendance
Tankage for Sodium Hypochlorite Solutions
Sodium Hypochlorite Solution Alternative: On site generation from salt

- Must maintain 1 – 3 days supply of liquid solution
- 30 – 60 days supply of salt
- Must keep it dry

No containment required
Sodium Hypochlorite Feed Equipment

Pump Styles

- Diaphragm
- Solenoid
- Peristaltic
Sodium Hypochlorite

Performance Issues

- Taste/odor
- Disinfection by-products
- Gas binding
- Peristaltic pumps
- Scaling concern
- May need to feed phosphate
Ultraviolet Disinfection - Wastewater

Disrupts organism reproduction

Technology of choice for most WWTPs due to inherent safety advantages, simple operation

Won’t work well if WW effluent is “cloudy” or excessive solids

- Check effectiveness for industrial uses
- Check for fixed film treatment
- CSO – too dirty; not a good option
- Transmittance testing/Collimated beam testing
UV – Wastewater System Configurations

- **Closed Pipe**
- **Automatic Cleaning**
UV – Wastewater

- Equipment removal
- Flow pacing
- Level control requirements (2” +/- light travel)
- Open channel - Convert existing chlorine contact basins to UV channels
UV – Wastewater Flow Channels
Ultraviolet Disinfection - Water

Primarily used in difficult or large applications

Still need chemical feed for distribution system protection – maintain chlorine residual

Closed pipe configuration

Courtesy Water-Technology.net
Chlorine - Liquid or Gas

Low Cost to Operate

Reliable and Effective Under Most Conditions

Safe with Proper Use, but Many Safety Concerns

- Respiratory Irritant – 2 ppm limit for 8-hour exposure
- 10 ppm immediately dangerous to health
- Heavier than air – Can Accumulate in Low Areas
- Regulatory Burden - Process safety management - MIOSHA
- Scrubbers and Gas detection equipment required
- Homeland security concerns
Flint’s Liquid/Gas WWTP Chlorination System - 2012

Green lines are under pressure
Flint’s WWTP Chlorination System - 2015

Conversion to GAS ONLY

All lines are under vacuum

Chlorine Feed Regulators
Chlorine Gas

Vacuum System – safer than liquid chlorine feed, smaller leak potential

System Operates under Vacuum

500 lb/day Capacity per Drum
Gas-Only Chlorine System
Drum with Pressure Regulator Mounted
Chlorine Feed Regulators
Rate of Liquid Chlorine Evaporation – Very Sensitive to Temperature

Much Heat Energy Needed for Chlorine Evaporation
Gas-Only Chlorine System
Multiple Drum Installation – Increased Capacity
Chlorine Gas - Wastewater

Gas Dissolved in Water; Solution To Contact Tank

Dosing:

- Effectiveness of kill depends on:
  - Effluent quality
  - Contact time (15 minutes at peak flow)
  - Mixing efficiency, and
  - Temperature
  - 1-2 ppm residual, 3-10 ppm overall
  - Requires dechlorination
Chlorine is most soluble in Cold Water
Chlorine Gas – Potable Water

Effective kill, though not as effective as other options

Disinfection by-products concerns

Excellent for system residual
### Chlorine Costs

#### Elemental Gas/Liquid
- **Ton cylinder** = $320 - $900.00 (depending on quantity)
- **150 lbs cylinder** = $198.00 (only one)

#### NaOCl Solution
- **Bulk** = $0.82/gal (4,000+ gallons)
- **55 gallons** = $128.00 (only one)
Other Chemicals

Mixed Oxidant

- On site generation
- Disinfection by-products/Taste and Odor concerns (water)
Other Chemicals

**Peracetic Acid (Wastewater)**
- Powerful - Less concentration & time required
- No dechlorination needed
- New technology; Cost?

**Chlorine Dioxide (Water)**
- Strong oxidant, few (regulated) by-products
- Generate on-site
- Can be difficult to operate
Other Chemicals

Ozone (Water)
- Generate on site
- Contact basin required
- Very strong oxidant
- No residual

Hypochlorite pellet system
- No liquid storage needed
- No safety issues with gas
- Typically smaller applications
Chloramines (Water)

- Can be used where disinfection by-products are a concern
- Not as strong of an oxidant
### Relative Disinfectant Strengths of Selected Chemicals

CT Values of Selected Disinfectants for Water Treatment at 5⁰ C

(higher value indicates weaker disinfectant)

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Giardia Cysts (3 log removal)</th>
<th>Viruses (3 log removal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Chlorine</td>
<td>200</td>
<td>6</td>
</tr>
<tr>
<td>Chloramines</td>
<td>2,200</td>
<td>1,423</td>
</tr>
<tr>
<td>Chlorine Dioxide</td>
<td>26.0</td>
<td>17.1</td>
</tr>
<tr>
<td>Ozone</td>
<td>1.9</td>
<td>0.9</td>
</tr>
</tbody>
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