EVOQUA WATER TECHNOLOGIES

The Science & Parameters Behind Odor Control Technology Selection

TRANSFORMING WATER. ENRICHING LIFE.

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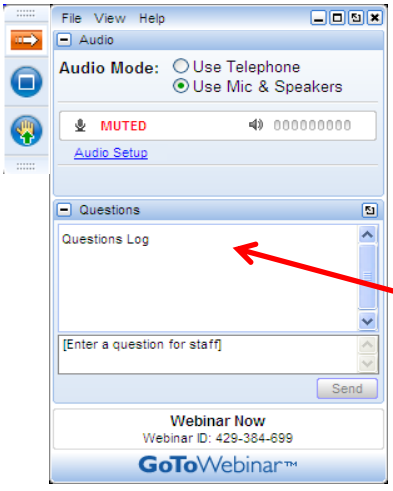
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Presenters

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Odor & Corrosion Treatment

Liquid Phase Odor Control (LPOC)
- Multiple point odor control.
- Generally lower capital cost, higher operating costs.
- Effective method for combined odor and corrosion control.

Geomembrane Covers
- Odor control by capture and treat (supported), or by surface coverage (floating).
- Generally higher capital cost, lower operating costs.
- Effective for 'containing' odors or significant reduction.

Vapor Phase Odor Control (VPOC)
- Point source odor control.
- Generally higher capital cost, lower operating cost.
- Treats odors very well, but limited corrosion control.

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Types of Odors

- Hydrogen Sulfide (H_2S)
  - Typically 100X higher concentration than other odors.
  - Masks other odors, which then become noticeable after H_2S is removed.
  - Relatively easy to remove.
- Organic sulfur compounds (Methyl Mercaptan, DMS, DMDS, COS, CS_2).
- Nitrogen compounds (Ammonia and Amines).
- Volatile organic compounds (VOCs).
  - Aldehydes
  - Ketones

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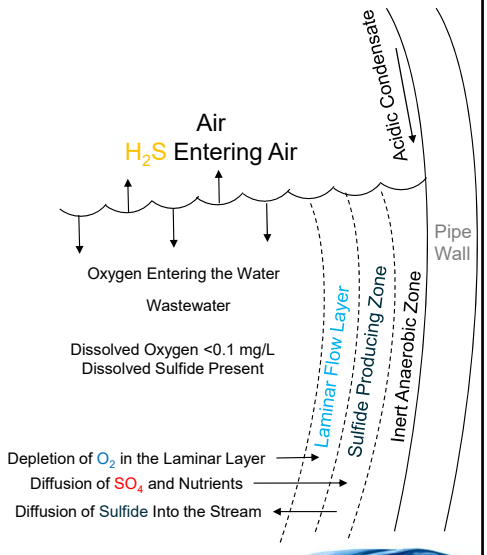
Liquid Phase Odor Control Solutions

Biological Oxidizers
- 1.5 hrs Minimum Reaction Time
- Prevents H_2S
- Removes H_2S

Chemical Oxidizers
- RT is Product Dependent
- Cost Scales with $S^=$ mass load

pH Shift
- RT is Product Dependent
- Cost Scales with WW flow rate

Iron Salts
- Quick Reaction Time
- Lower Limit of Treatment ~0.5 mg/L



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Biochemical Oxidizers

- Calcium Nitrate or Sodium Nitrate solutions.
  - BIOXIDE®
  - BIOXIDE® Plus 71
  - BIOXIDE® AQ
- Removes existing $S^=$ from wastewater
  - Requires 1 – 1.5 hr. reaction time
- Prevents the formation of $S^=$ in the wastewater
- Cost of treatment scales with $S^=$ mass load

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Chemical Oxidizers

- Hydrogen Peroxide, Sodium Chlorite, Hypochlorite, etc.
- Removes existing $S^=$ from waste water
  - Reaction time is product dependent
- Cost of treatment scales with $S^=$ mass load
- Generally considered hazardous
  - Added equipment cost due to hazard and handling requirements

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pH Shift products

- Calcium Hydroxide, Magnesium Hydroxide
- ↑ pH to trap $S^{=}$ in nonvolatile ionic form
  - Reaction time is dependent on solubility of product
    - $Mg(OH)_2$ - 30-45 minutes
    - $Ca(OH)_2$ - seconds
- Cost of treatment scales with wastewater flow
- Overfeed can cause plugging and scaling

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Iron Salt Solutions

- Ferrous/Ferric Sulfate, Ferrous/Ferric Chloride
- Binds $S^{=}$ as in soluble precipitate
- Quick reaction time seconds
- Cheap on a per gallon basis but cost of treatment ↑ with sulfide mass load
- Depresses wastewater pH
- Low limit sulfide removal ~ 0.5 mg/L

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Geomembrane Technologies™

an EVOQUA brand

- Customized cover solutions designed and installed by Evoqua's Geomembrane Technologies™.
- A wide selection of custom tank and lagoon cover types for demanding odor-control applications at wastewater treatment facilities.

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Geomembrane Technologies™

an EVOQUA brand

Retractable Structurally-Supported Covers

- Ideal for **municipal** wastewater treatment facilities, however there are some applications in the **industrial** market.
- **Retractable** cover tensioned over an aluminum arched frame that spans a tank opening.
- **Gas-tightness** better than FRP or aluminum; permits recovery for treatment.
- Design provides quick and **easy access** for inspection and maintenance.
- Limited to **rectangular tanks** with max 30ft +/- spans.

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Geomembrane Technologies™

an evoqua brand

Modular Covers

- Ideal for both **municipal** and **industrial** wastewater treatment facilities.
- **Floating** cover consisting of interconnected panels (modules).
- **Reduces odors** by preventing volatilization of odorous particles from the surface.
- Can be installed on tanks and lagoons of **all sizes and shapes**.
- Individual panels can be **removed or folded open for access.**
- **Walkable** surface sampling and maintenance activities.

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Vapor Phase Odor Control

Technology Selection

BIOLOGICAL

Use bacteria to metabolize (oxidize) odorous sulfur compounds.

CARBON

Use activated carbon or chemically enhanced media to physically adsorb and chemically react with odorous compounds.

CHEMICAL

Use chemicals to absorb and react with volatile odorous compounds.

HYBRID

A combination of technologies in series to achieve desired site conditions. Custom engineered solutions.

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Biological Odor Control

| BIOLOGICAL

Use bacteria to metabolize (oxidize) odorous sulfur compounds.

- Biofilters
- Bio-trickling Filters (BTF) / Bio-Scrubbers

- Biofilters
  - Organic media
  - Inorganic (engineered) media
- Bio-trickling Scrubbers
  - Inorganic media typ.
  - Single pass
  - Recirculation
  - Multi-stage
- Biological Hybrids

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Biological Odor Control (cont'd)

The Biological Process

- Use bacteria to metabolize (oxidize) odorous sulfur compounds.
- Bacteria require an energy and carbon source and various nutrients (N,P,K, etc.).
- Autotrophs (e.g., thiobacillus) oxidize H_2S.
  - $H_2S + O_2 \rightarrow H_2SO_4$
  - Gain energy from the sulfide bond.
  - Gain carbon from CO_2.
  - Tolerate acidic conditions (pH 1.5-2).
- Heterotrophs oxidize organic compounds.
  - Yields CO_2 and H_2O.
  - Gain both energy and carbon from the organic compound.

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Hybrid Biofiltration Zero Acclimation Biological Odor Control System (ZABOCS®)

- Integrates two proven technologies:
  - Biological first stage.
  - Carbon second stage.
- Air flow from 350 to 5,000 cfm.
- H_2S concentration between 5-100 ppm for standard systems. Higher concentrations possible.
- High efficiency odor removal.
- Low profile, ideal for residential areas.
- Factory assembled for plug-and-play installation and start-up.
- Lower operating cost.

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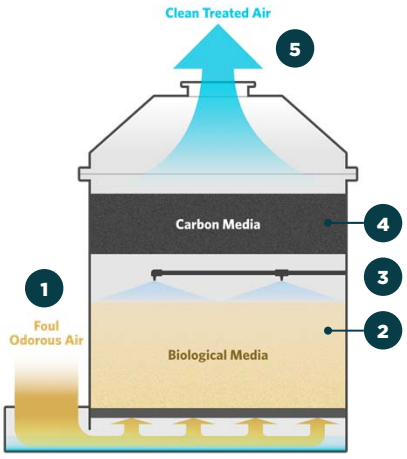
ZABOCS® (cont'd)

Process Flow Diagram

1. Odorous air enters system.
2. Bacteria metabolizes odorous compounds in the air stream.
3. Biological media irrigated w/ nutrient.
4. Carbon polishing stage.
5. Clean, treated air exits the system.



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Bio-trickling Filter (BTF)

(Bio-trickling Scrubber)

Features

- Inorganic media (plastic or mineral).
- Fabricated towers.
- Smaller footprint.
- Higher flow rates.
- Good removal of H_2S (8-10 sec).
- Good organic removal (15-20 sec).
- Low operating cost.
- Long media life.
- Emissions at stack, good odor dispersion.

Disadvantages

- Higher capital cost for large flow rates.
- Difficulty handling extreme odor spikes.
- Tall towers, obtrusive in residential area.
- Requires acclimation of biology.

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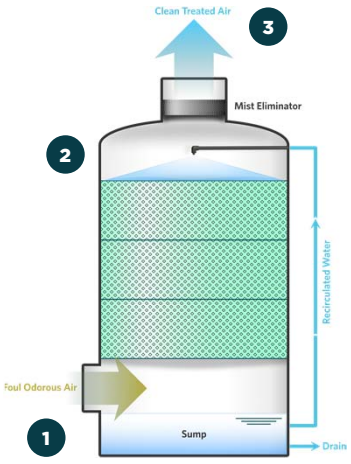
Bio-trickling Filter (cont'd)

Process Diagram – Single Stage

1. Odorous air enters system.
2. Continuous recirculation of biological beds for H_2S removal. Nutrient added intermittently.
3. Clean, treated air exits the system.



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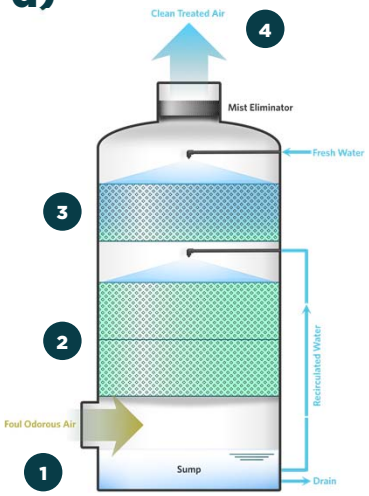
Bio-trickling Filter (cont'd)

Process Diagram – Two Stage

1. Odorous air enters system.
2. Continuous recirculation of lower beds for H_2S removal.
3. Intermittent spray of upper stage with fresh water and nutrient for VOC and RSC removal.
4. Clean, treated air exits the system.



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Chemical Odor Control

CHEMICAL

Use chemicals to absorb and react with volatile odorous compounds.

- LO/PRO® System
- Packed Tower

- Fast reaction (99% in < 1 s of contact time)
- Single Stage Packed Towers
  - Air flows up to 80,000 cfm.
  - Lowest capital cost for high flows.
  - Can be expensive to operate.
- Multi-stage Scrubbers
  - Air flows up to 30,000 cfm.
  - 2 and 3 stage designs.
  - > 99.5% H_2S & NH_3 destruction.
  - 50% lower chemical usage.
  - Handles H_2S and organic odors.
  - Ideal for dewatering and sludge drying odors.

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Chemical Odor Control (cont'd)

- Primarily H_2S is target contaminant as well as ammonia in solids handling.
- Typical odor control scrubbers utilize:
  - Absorption of H_2S into alkaline liquid (NaOH).
  - Oxidation of H_2S in solution (NaOCl).

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Low Profile Multi-stage Scrubbers (LO/PRO®)

Features

- Air flow rates up to 30,000 cfm.
- 2 or 3 stage designs.
- Polypropylene packing media.
- > 99.5% H_2S & NH_3 destruction.
- Handles H_2S and organic odors.
- 50% to 70% lower chemical cost with multi-stage design.

Disadvantages

- Higher operating cost for chemicals.
- Requires chemical storage and handling.
- More maintenance required.

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Activated Carbon Odor Control

- Simplest odor control process.
- No water*, no waste stream, no chemicals or nutrients.
- Specialty carbons have higher capacity.
- Some carbons can be regenerated.
- Carbon has limited capacity for H_2S and organics.
- Some organic odors breakthrough quickly.

*No water is required for the media manufactured by Evoqua.

CARBON

Use activated carbon or chemically enhanced media to physically adsorb and chemically react with odorous compounds.

- CAP Series
- RJC Series
- RJMC Series
- V-Bank

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RJC Bulk Carbon Odor Control System

- Air flows up to 20,000 cfm.
- Diameters up to 14 ft.
- 99.5% H_2S removal.
- Single bed or dual bed.
- Low capital and operating cost until carbon needs to be replaced.
- Best for low concentrations or as polishing stage.

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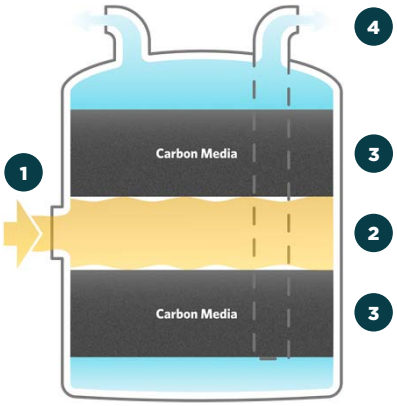
RJC (cont'd)
Process Flow Diagram

1. Odorous air enters the system.
2. Odorous air split between carbon beds (for dual bed option).
3. Odorous compounds are adsorbed by the carbon media.
4. Clean, treated air exits the system.



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Types of Carbon Media

- For 1-year media life:
  - Virgin Activated Carbon: ≈ 1 ppm
  - Midas® OCM: ≈20 ppm
- Pelletized carbon media used for low pressure drop.

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HYBRID ODOR CONTROL CASE STUDY

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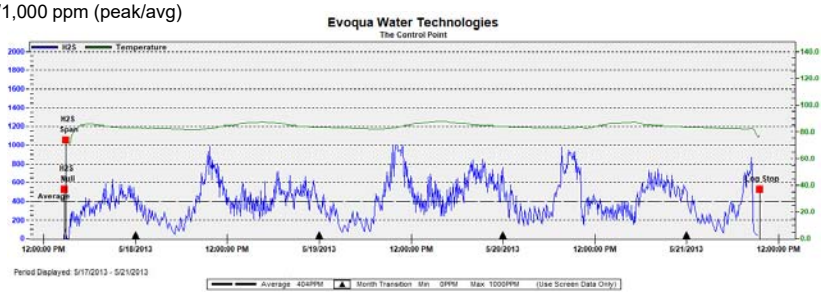
Case Study – Background

Target – Fugitive H_2S emission from Municipal pump station wetwell aka "The Control Point"
404/1,000 ppm (peak/avg)



Influent Streams – Six influent wastewater streams
- LS 1, aka "The Park"
- LS 2, aka "RV Resort"
- LS 3, aka "Long HRT"
- LS 4, aka Neighborhood
- LS 5, aka Restaurant
- Private PS's (6)

Bystanders – Three major centers for odor receptors
- The neighbor, ~25 feet
- The recreation area, ~ 500 feet
- The Shopping center, ~ 550 feet

Primary Objective – Eliminate odors at "The Control Point"
Secondary Objective – Eliminate odors at "RV Resort" resulting from emptying "blackwater" tanks

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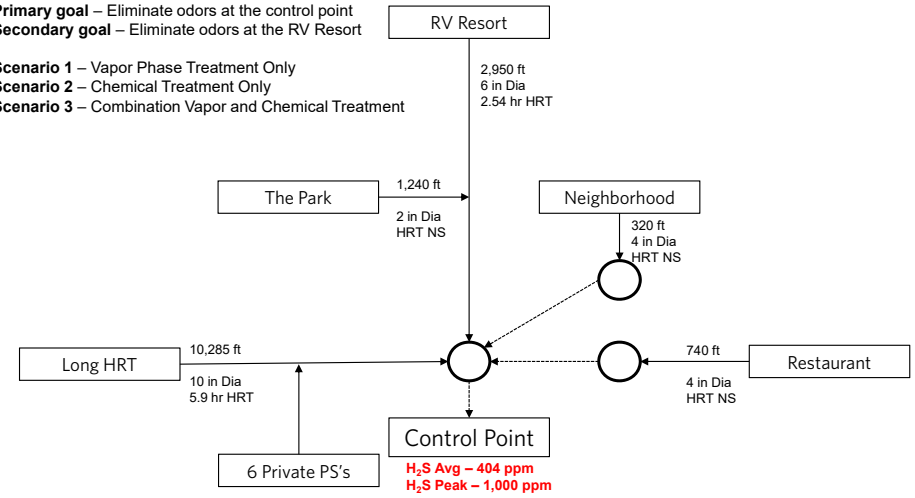
Case Study – Line Diagram

Primary goal – Eliminate odors at the control point
Secondary goal – Eliminate odors at the RV Resort

Scenario 1 – Vapor Phase Treatment Only
Scenario 2 – Chemical Treatment Only
Scenario 3 – Combination Vapor and Chemical Treatment



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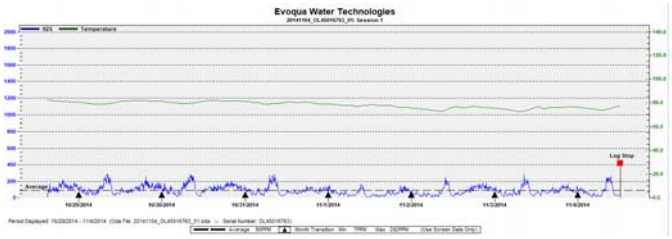
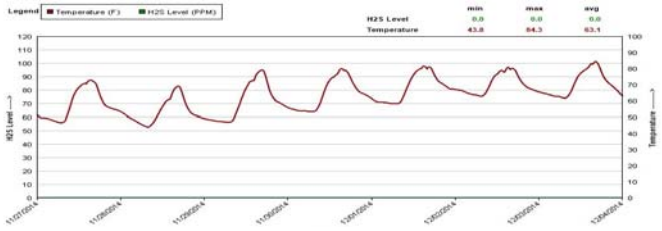
Case Study – Results

Primary Goal – Eliminate fugitive H_2S emissions at the "Control Point"

Biofilter Inlet:
- 90 PPM Avg
- 292 PPM Max



Biofilter Outlet:
- 0 PPM Avg
- 0 PPM Max



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Case Study – Economics

Scenario 1 – VPOC Only

Application point	Technology	Unit Cost	Unit	Dose Rate	Annualized Cost
Control Point	Whisper 96	$3,925	$/month	N/A	$47,100
				Total	**$47,100**

Scenario 2 – Chemical Feed Only

Application point	Technology	Unit Cost	Unit	Dose Rate	Annualized Cost
Long HRT	BP71	$3.48	Gallon	30	$38,106
RV Park	Odophos	$0.76	Gallon	36	$9,986
Restaurant	Bioxide	$2.35	Gallon	30	$25,733
				Total	**$73,825**

Scenario 3 – Combined Liquid and Vapor Treatment

Application point	Technology	Unit Cost	Unit	Dose Rate	Annualized Cost
Long HRT	BP71	$3.48	Gallon	13	$16,513
RV Park	Odophos	$0.76	Gallon	36	$9,986
Control Point	Whisper 48	$1,568	$/month	N/A	$18,816
				Total	**$45,315**

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Questions?

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