BioAugmentation in Force Mains, Gravity Sewers and Pumping Stations
Presentation Outline

- Collection Systems Basic Chemistry/Biology
- Industry Studies, Videos and Tests
- DC Water Main Pumping Station Project
- WERF CAPS Study
- Path Forward
How does it happen?

\[ \text{H}_2\text{S} + 2\text{O}_2 \rightarrow \text{H}_2\text{SO}_4 \]

Courtesy of Z. Yuan, UQ
What is BioAugmentation

The addition of:
- Microorganisms
- Oxygen, Hydroxyl Radials (Ozone)
- Surfactants

In to the flowing sewage to eliminate bio-slime on sewer walls, FOG above the water in particular and the formation of toxic gases
How They Work - Microbes

- Micro Organisms Eat Organic Matter
- Tiny – Trillion Can sit on the Head of a Pin
- Are Cultured by Manufacturer to Destroy Typical Organic Matter
- Safe to Humans, Effective Against FOG and BioSlime
How They Work – Microbes Cont’d

Aerobic Organisms
• Require Oxygen
• Bi-products are
  • Water
  • Carbon Dioxide
  • Ammonia

Anaerobic Organisms
• Environment Free of Oxygen
• Bi-Products
  • Hydrogen Sulfide
  • Methane
  • Water
  • Carbon Dioxide
How They Work – Oxygen, Hydroxyl Radicals Addition

Increasing Dissolved Oxygen Provides Life Sustaining Oxygen to normally Oxygen Depleted Sewage.

- Aerobic Organisms Multiply
- Convert Organic Matter to Water, Carbon Dioxide

Adding Ozone Oxidizes Organic Matter
How They Work – Oxygen cont’d

ECO₂ Technology

Nano Air Bubbles Aeration System (NABAS)
How They Work – Hydroxyl Radical

Parkson-OHxy Phogg

NABAS Bubble System

STX Catalytic – Source Technologies delivers Hydroxyl Radicals
Not Shown
How They Work – Hydroxyl Radical

- Free Radicals oxidize organic matter by removing electrons from the compound to achieve stoichiometric balance, therefore, reduction/oxidation is the result.
- This method can be mixed directly into the water or introduced as a ‘fog’ on top of the water.
How They Work - Surfactants

- Surfactants make water wetter and break up dirt, grease, grime, etc.
- Generally are chemically based such as soaps, dishwashing liquids, etc.
- In early 70's generally banned from use in sewers when the contained phosphorous.
How They Work – Surfactants - Accell

Gulf Oil Spill Demo          Sao Paulo Brazil – River Test
How Is Chemical Addition Different From BioAugmentation

- Chemicals maybe toxic – Ozone is only Biological product that can be hazardous if inhaled
- Chemicals are not easily portable
- Require Frequent Tanker Truck Deliveries
- Difficult to Locate in Cities
Key Collection Systems Terms

- **pH** – if pH is above 8.5 $H_2S$ will not be generated
- **Interfacial Tension (IFT)** measures the spreading effect between water and anything floating on the top
- **O.R.P.** – Oxidation Reduction Potential measures the effectiveness of water to oxidize or “clean” itself or in case of treated wastewater assist in cleaning the body of water it has entered.
Leading Industry Studies

- WERF Nov 8, 2007
  Minimization of Odors and Corrosion in Collection System, Phase 1
- Studied science of BioSlime
- Reviewed 4000 papers on subject
- Defined ORP (oxidation reduction potential) as key element to overcoming hydrogen sulfide
Leading Industry Studies – cont’d

American Water Co WEFTEC 2010 – Sioux Falls Study

- Introduced Microbes in Collection System
- Reduced BioSolids by 15%
- Increased BOD
- Speculated BOD Easier to Treat
Thanks to Howard University’s Charles Glass, PhD and his students
Add Accell3 at a different rates at Main Pumping Station – 0.1, 0.2 and 1.9 ppm
Track Performance at 6 Sites on the East Outfall Sewer
Take Samples
Measure ORP, DO, pH, TSS, VSS, H$_2$S, COD, NH$_3$, PO$_4$
Location of Sites

Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Average Hydrogen Sulfide Concentration at Six Sites
Data Analysis

- Reduction in TSS and VSS during the summer may have been due to the uncoupling of microorganism reproduction from energy use.
ORP Results: All Locations

- H₂S gas is produced at -50 to -250 mV.
- ORP values reached -300mV during 100+ weather
WERF Manuscript: DC Water’s Sewer-Methane Carbon Footprint

- John Willis¹, ²*, Haydee DeClippeleir³, Walter Graf⁴, Akshay Kumar⁵, Barry Lucas³, Sudhir Murthy³, Chris Peot³, Pusker Regmi¹, Abhiram Satyadev⁶, Charles Sweeney³, Keshab Sharma², Hiram Tanner³, and Zhiguo Yuan²

- ² The University of Queensland
- ³ DC Water
- ⁴ Water Environment Research Foundation (WERF)
- ⁵ RK&K Engineers
- ⁶ Arcadis
- * JWillis@BrwnCald.com
DC Water’s Potomac Interceptor

- **Location of Chemical Addition Facilities** (when employed)
- **Orange Segments** Represent the 10 to 12 Miles of PI Exhausted by MH 17 Fan
- **Green Segments** Represent PI not served by MH17 Fan during Tests
- **MH17 Exhaust Fan** used for CAPS Sample Collection
- **District of Columbia**
- **Potomac Pumping Station**
- **Potomac Forcemain**
- **Blue Plains AWTP**
Results – Summer Baseline

Flow (mgd); Temperature (deg C); H2S Gas-Phase Conc. (ppm)

- Flow (mgd)
- H2S (ppm)
- Sewage Temp (C)
- CH4 (ppm)
- CO2 (ppm/10)

Day and Time:
- 9/15/14 12:00 PM
- 9/16/14 12:00 AM
- 9/16/14 12:00 PM
- 9/17/14 12:00 AM
- 9/17/14 12:00 PM
- 9/18/14 12:00 AM
- 9/18/14 12:00 PM
- 9/19/14 12:00 AM
- 9/19/14 12:00 PM

Courtesy of J. Willis, Brown and Caldwell
CO₂ Emissions suggest Significant Aerobic Activity in the PI

- Atmospheric CO₂ should be ~400ppmv
- Observed headspace CO₂ values averaged 5,200ppmv; for an increase of 4,800ppmv
- Would expect ~1-to-1 CO₂ to CH₄ ratio
- Suggests >20 times aerobic than anaerobic
- CO₂ is more soluble in water than CH₄

Courtesy of J. Willis, Brown and Caldwell
Chemical Addition of FeSO$_4$ Did Not Effectively Control H$_2$S
Path Forward

- Addition of Microbes to remediate FOG blockages
- BioAugmentation best used for Routine Maintenance of Mains & Pumping Stations to avoid FOG, Corrosion and Hydrogen Sulfide and to Protect Workers
- To Track Benefits/Need for BioAugmentation Test for O.R.P.
- Perform Additional Research to Enhance Collection Systems Natural Aerobic Activity.