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Operational Challenges of a Leachate Pretreatment Plant

OWEA Plant Operations and Lab Analysis Workshop

October 2015

Presented By:

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Tasks in 14 Months

- **Leachate Flow & Characteristics**
- **Testing**
- **Design Plans**
- **Permitting**
- **Interim Plan**
- **Final Plan – Permit from POTW**
- **UV Transmissivity**
  - Reroute Effluent to larger POTW – New 6-mile Forcemain
  - Coordination with POTW and State for Forcemain
- **O&M Plan and Staffing Planning**
- **Training Staff and Startup**

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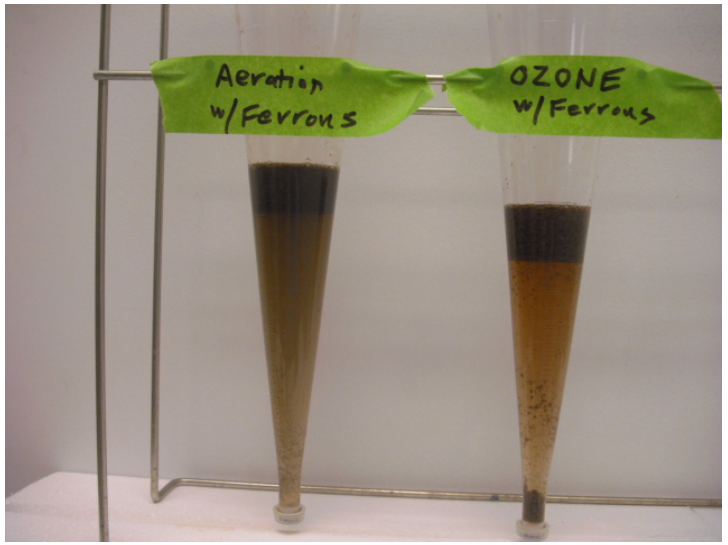
Treatment Investigation and Plan

- **Initially identified Storage Tanks to be converted to treatment**
  - 4 @ 1 MG Tanks – Glass Lined vs. Epoxy Coated
- **Bench Scale tests**
  - BOD: 30,000 mg/l
  - COD : 50 – 100,000 mg/l
  - Flow: 0.2 – 0.4 mgd
  - $CaCO_3$: 4,000 mg/l
  - Settling
  - Fly Ash for COD
  - Caustic – pH 5.5 to 10-11
  - Biological Treatment
  - Fenton's Reagent



Pilot Scale Test at Site

- **Clarification**
- **MBR**
- **Sludge Dewatering**
- **Electrocoagulation**
- **Reverse Osmosis**
- **Thermal Oxidizer**
- **Scrubber**
- **UV Investigation**

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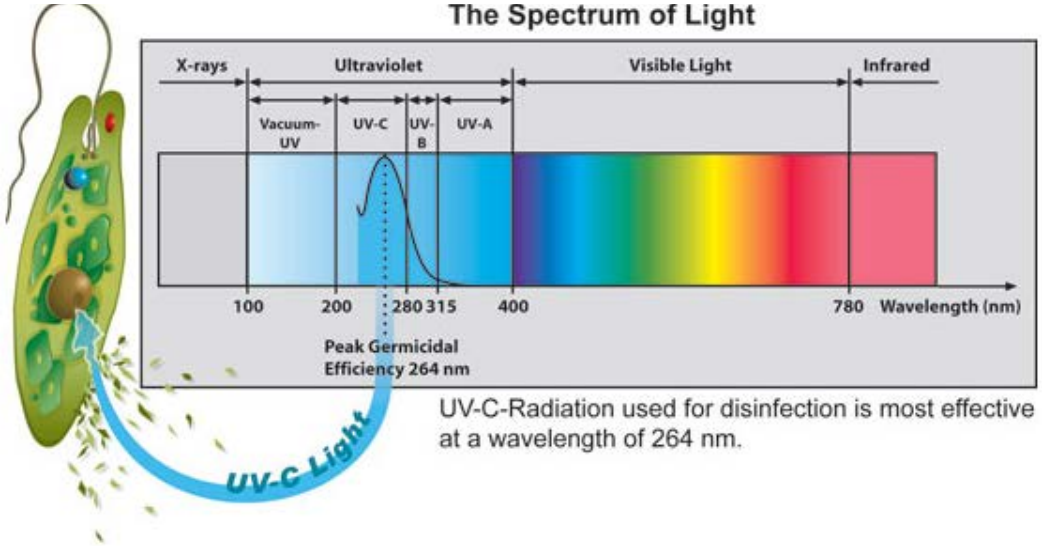
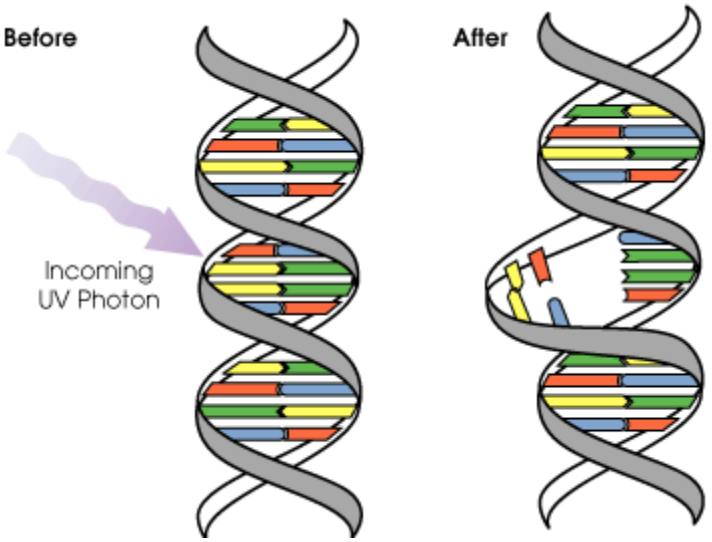
UV Disinfection at POTW



UV-C-Radiation used for disinfection is most effective at a wavelength of 264 nm.



Source:UVComparison.com

UV Interference Issues

- **Many POTW installing UV disinfection**
- **253.7 nm effective for bacterial kill, virus inactivation**
- **causes adjacent thymine molecules on DNA to dimerize.**
- **thymine dimer defects accumulate on a microorganism's DNA**
- **replication is inhibited,**
- **Dark recombination?**
  - Moderate Pressure UV reduces, but not a guarantee – WEF and EPA studies available

- **UV disinfection by rendering the microorganisms harmless.**
- **Leachate interferes with UV**
- **Turbidity/Iron**
- **Humic substances/Fulvic substances**
- **As UV absorbance increases, UV transmittance decreases:**
  %UVT = 100 x 10-A

Source:UVComparison.com

UV-T Removal Technologies

PHYSICAL TREATMENT PROCESSES

- **Powdered Activated Carbon**
- **Chemical Precipitation**
- **Nano-Filtration**
- **Reverse Osmosis**
- **Electrocoagulation**

ADVANCED OXIDATION PROCESSES

- **Ozonation**
- **TiO2 Photo-Catalytic Oxidation**
- **H2O2-O3 Treatment**
- **Ferrate**
- **Sulfate Radical Oxidation**

UV Transmittance Issues

- **65% required at POTW (some manufacturers claim disinfection at 15% UV-T)**
- **Biologically treated waste had 0% transmittance**
- **Activated sludge showed sub-65% UV-T**
- **Testing program to raise leachate to 65% UV-T**

Sample Date	No dilution	1:100 dilution	1:200 dilution
8/29/2013	0.00%	49.20%	70.20%
9/25/2013	0.00%	40.80%	64.80%
9/30/2013	0.00%	40.60%	64.50%

Testing Program

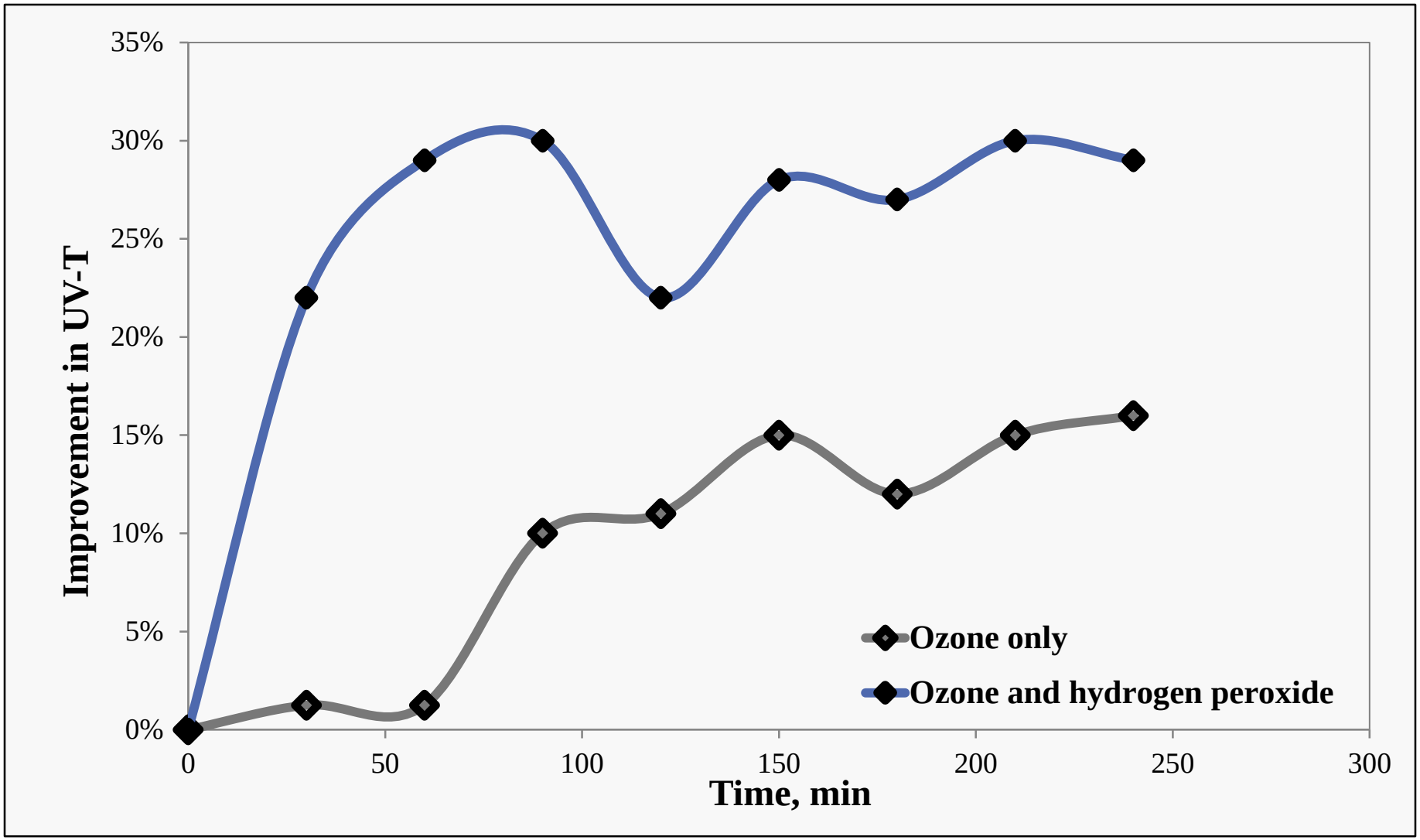
- **Bench scale**
- **Pilot scale treatment tests**
  - at CEC,
  - other treatability labs,
  - at landfills
- **Leachate contained recalcitrant organics**
  - leachate effluents are resistant to further biological treatment (BOD/COD < 0.1)
- **Test: ozone, ozone and hydrogen peroxide, Fenton's Reagent oxidation, Sulfate radical, Titanium catalyst AOP, and membrane nanofiltration**
- **Discarded carbon adsorption, reverse osmosis, and electrocoagulation**

Ozone & Ozone/Hydrogen Peroxide Tests

- **Ozone Only - 8 L reaction column**
  - 9.8 O_3 gm/hr Ozone Generator
  - 6 l/min rate at 98% pure delivered

- **Ozone & Peroxide**
  - 500 ml sample
  - 100 ml of 3% peroxide
  - Some ozone reacted with peroxide, less available for COD
  - Ozone & peroxide reacts better with UV-T absorbing compounds
  - Ozone alone reacts better with COD

UV-T after Ozone and Ozone/H2O2 Treatment



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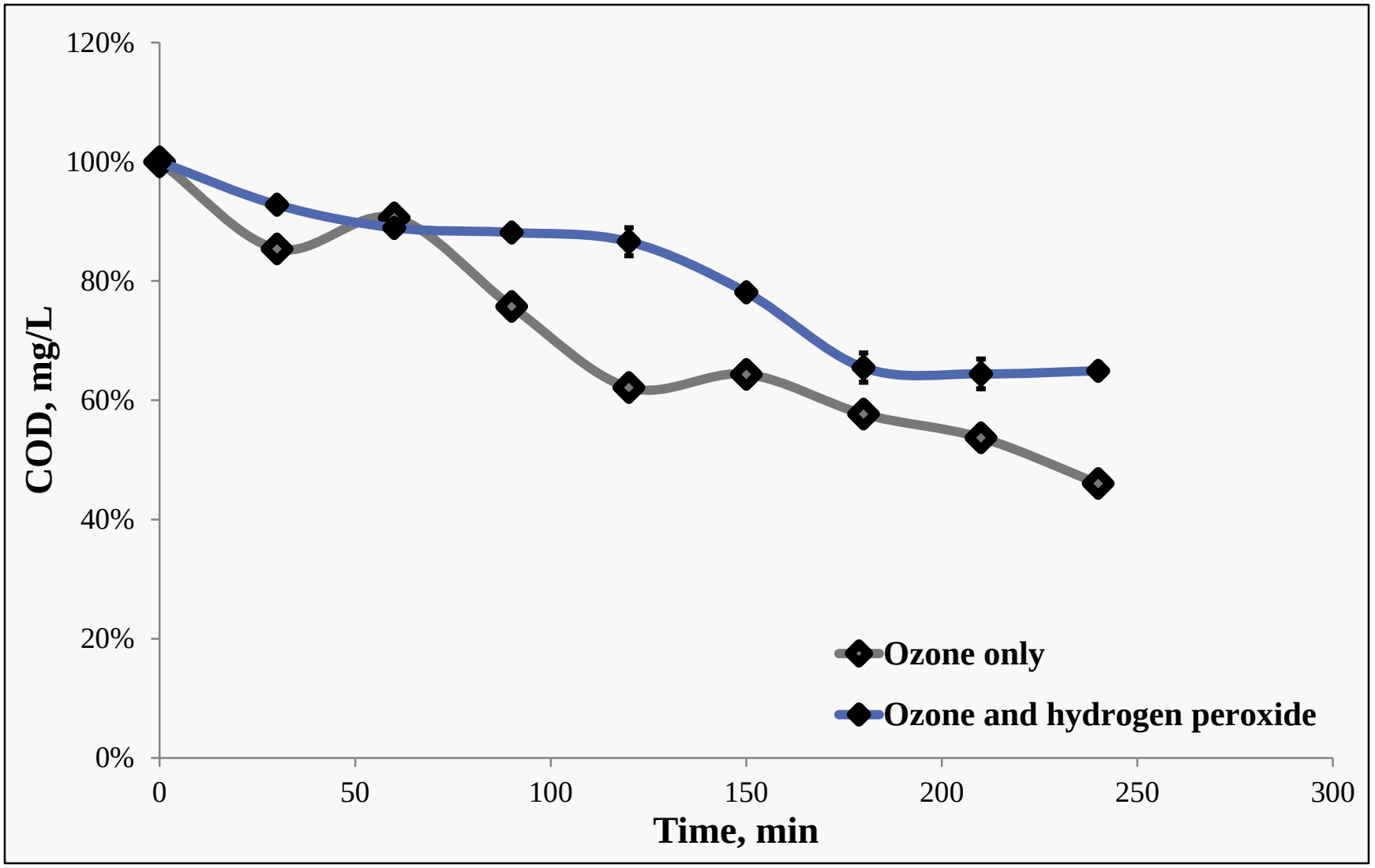
COD after ozone and ozone/H2O2 treatment



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Ozone and Ozone/Hydrogen Peroxide Color Change

Color change of biologically treated leachate with various oxidants (left to right: before oxidation, with ozone only, and with ozone and hydrogen peroxide)

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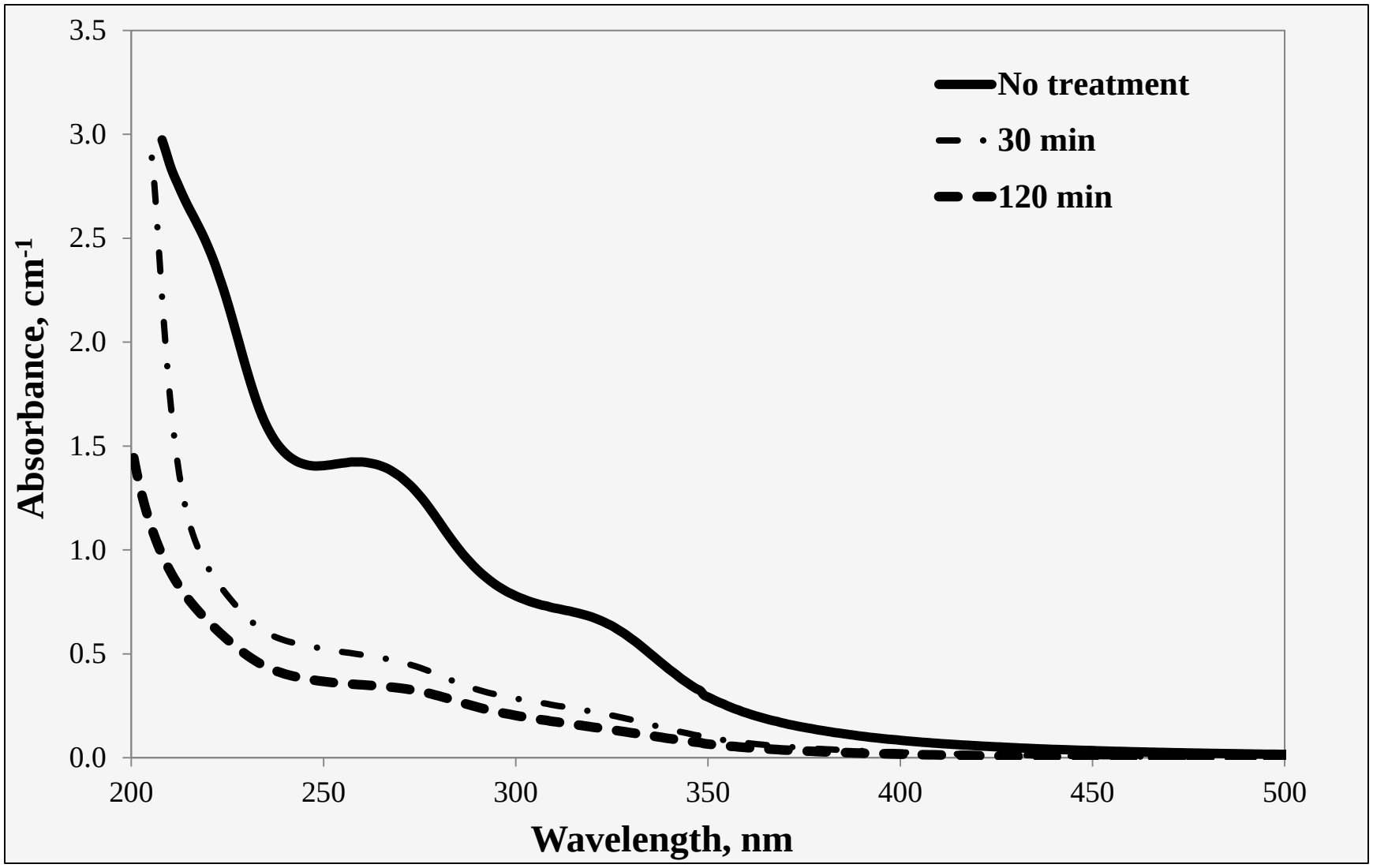
Fenton's Reagent Tests

- **Initial Application**
  - Added 1:1 peroxide to COD
  - pH 4 dropped to pH 3
  - Fast drop did not allow Fe^{+2} to change to Fe^{+3} by color – reaction stopped
  - Retested at lower peroxide (2.8 gm/l) – 90% consumed
  - Added caustic to raise pH to 11 & settled
  - Process would require additional settling/clarification/sludge removal

Fenton's Reagent



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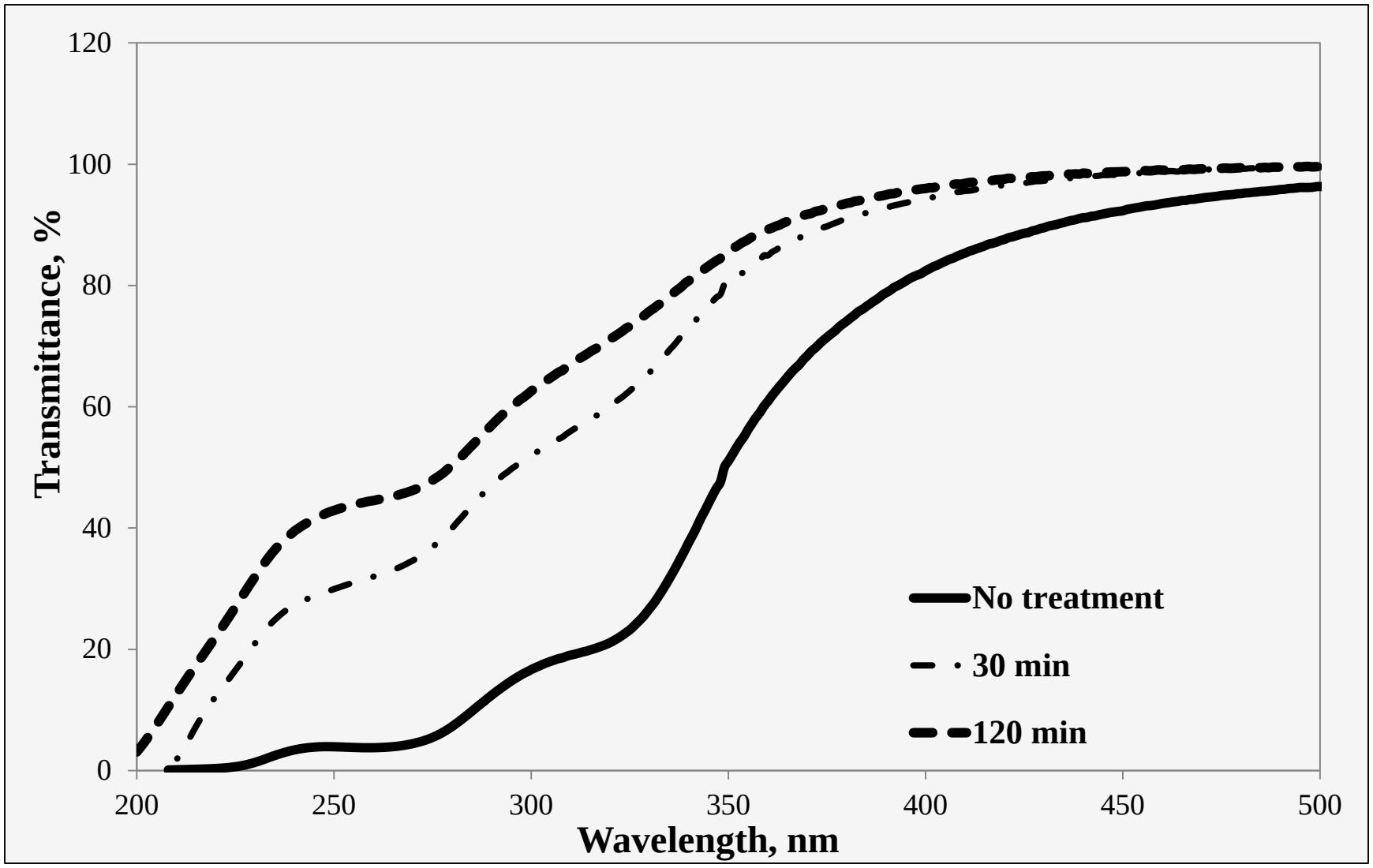
Fenton's Reagent



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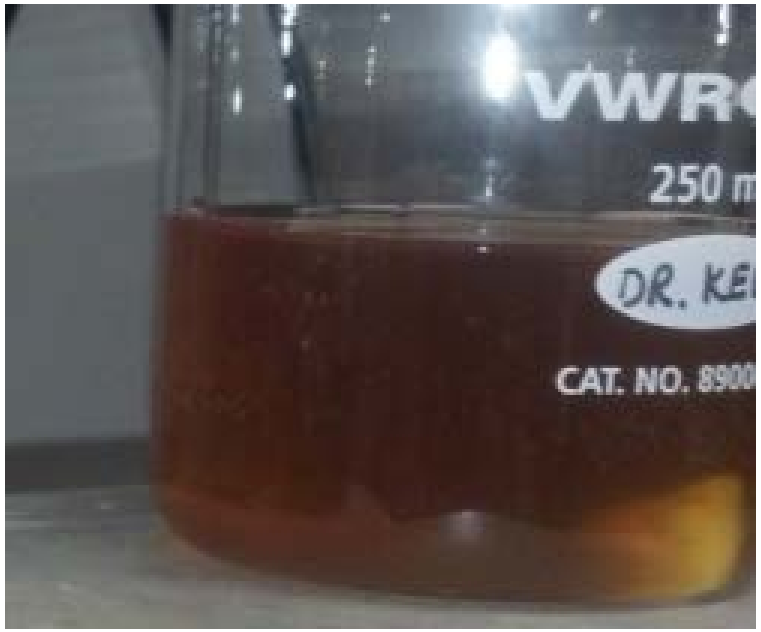
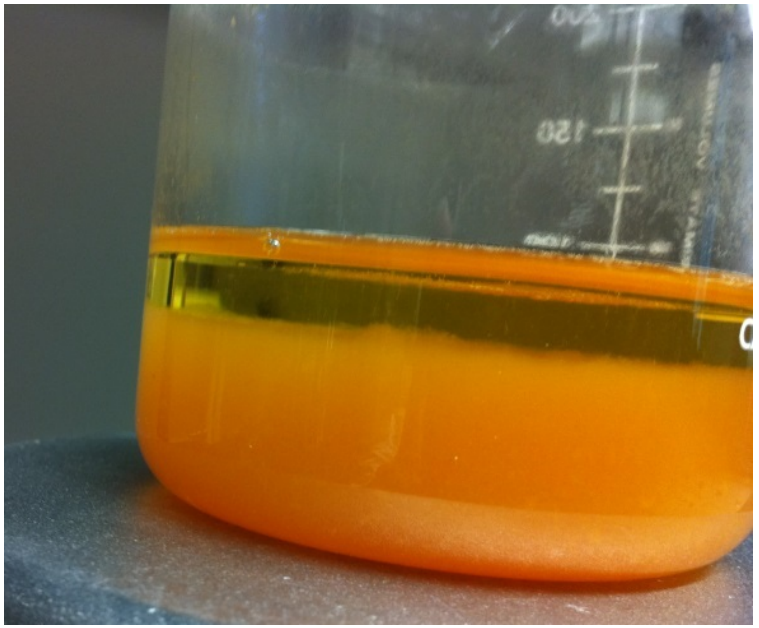
Fenton's Reagent Color Change

LEACHATE BEFORE FENTON'S



POST-FENTON'S LEACHATE (120 MIN REACTION TIME) AFTER 30 MINUTES OF SETTLING



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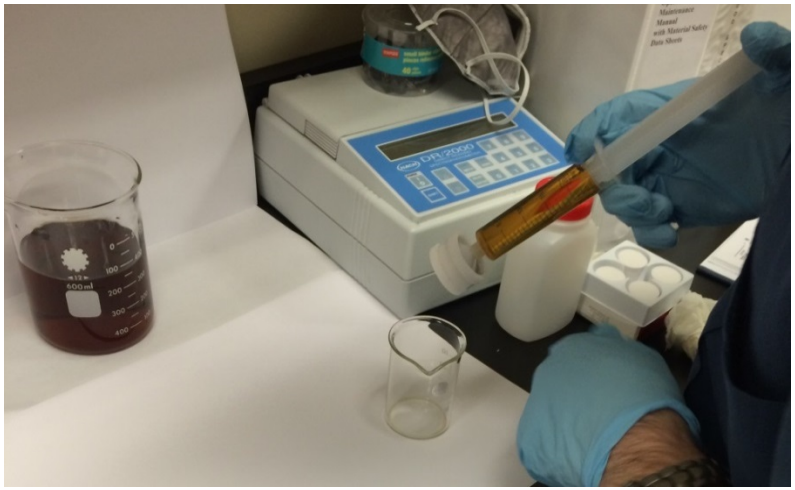
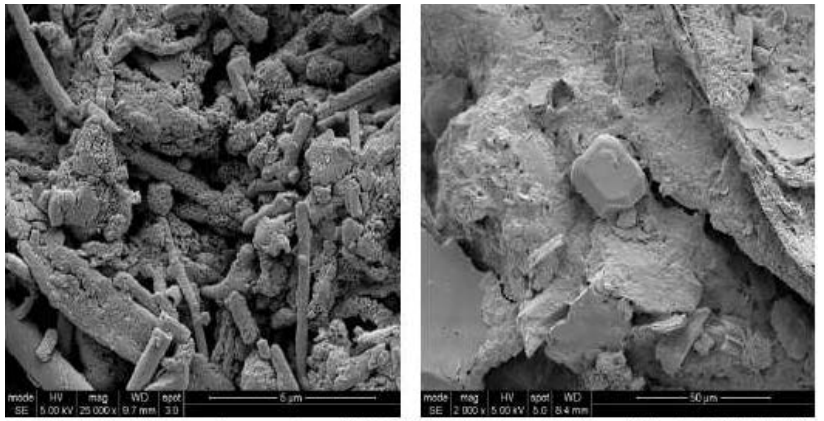
Nano Filtration Tests

- **Literature - < 1,000 dalton membrane pore size**
  - Several membranes tested
  - All sub 1,000 Da
  - UV-T improvement, but needs lower Da cut
  - Loose RO may be required
  - Reject flow and further treatment are issues
  - Added Ahlstrom Disruptor® membrane
    - Nonwoven zeolite/activated carbon fiber pad

The scanning electron microscope image on the left is of the surface of a new sample of Disruptor with the image on the right being of Disruptor fouled with polysaccharides.





Images courtesy of Ibrahim El-Azizi, and Robert J. G. Edyvean, University of Sheffield, UK.

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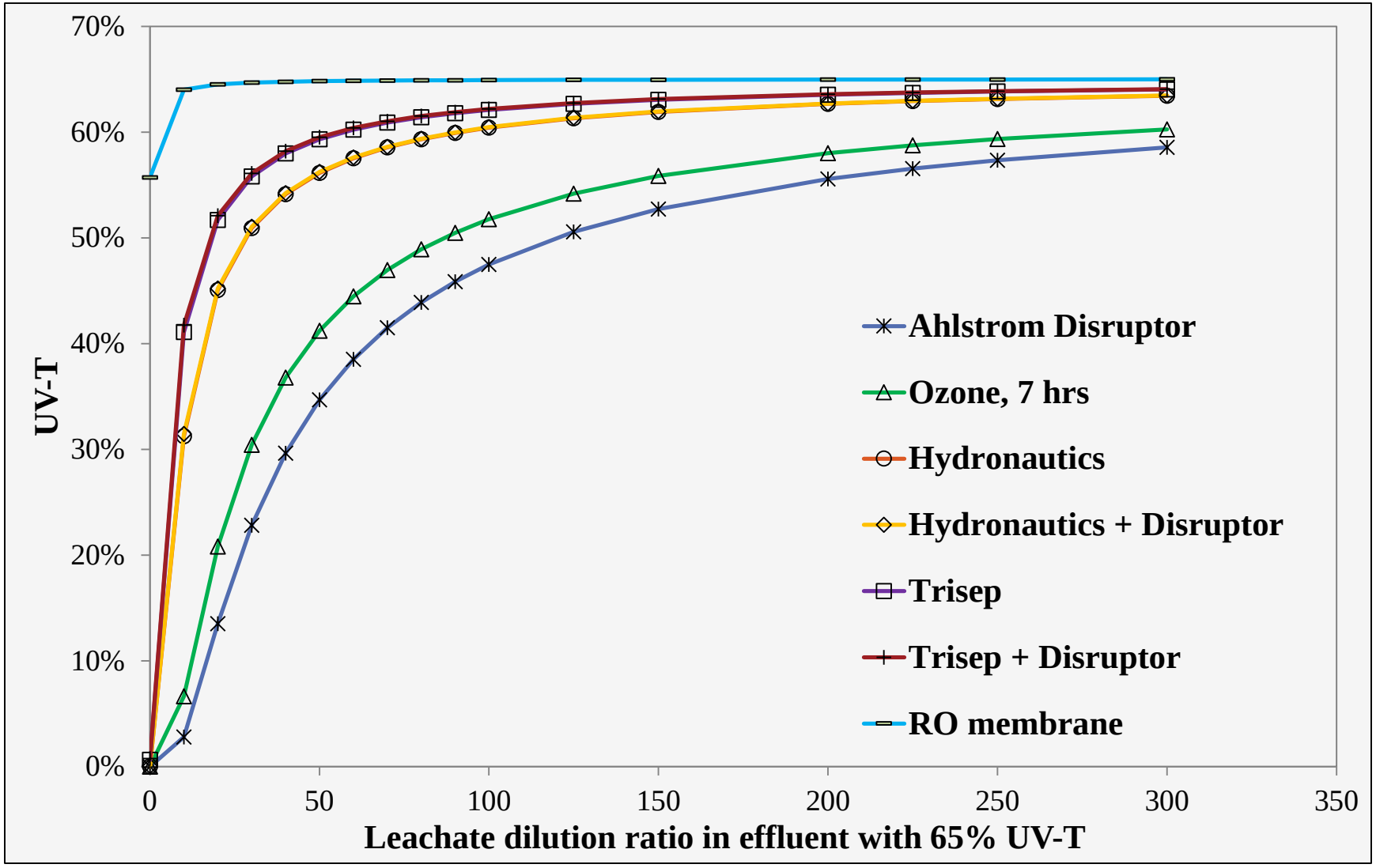
Nanofiltration

Comparison of leachate color before and after nanofiltration

Leachate color before and after several nanofiltration and resin steps

Membrane Alternatives



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Site Design Considerations

- **Variability – Flow/Strength**
- **Temperature – Cooling Towers / Heat Exchangers**
  - Mesophilic vs. Thermophilic
- **Odor Control – Scrubber/RTO – Collect Tank Air**
- **Aeration Control**
- **Foam Control**
- **Sludge Generation – Rolloffs > Trailers**
- **Corrosion**
- **Scaling – High calcium/magnesium**
- **MBR – UF - strainers, cleaning frequency, plugging**
- **Stormwater / Spill Collection**
- **UV Transmittance**

Design Components

- **Equalization**
- **Treatment Building**
  - Straining
  - Chemical addition
  - pH adjust
  - Precipitation – metals
  - Screening/Ultrafiltration
  - Chemical sludge/Biological sludge thickening, Dewatering
- **Aeration**
  - Jet Aeration System – 4 tanks @ 1 MG each
- **Discharge**
  - Calcium nitrate to limit H_2S odors in discharge sewer

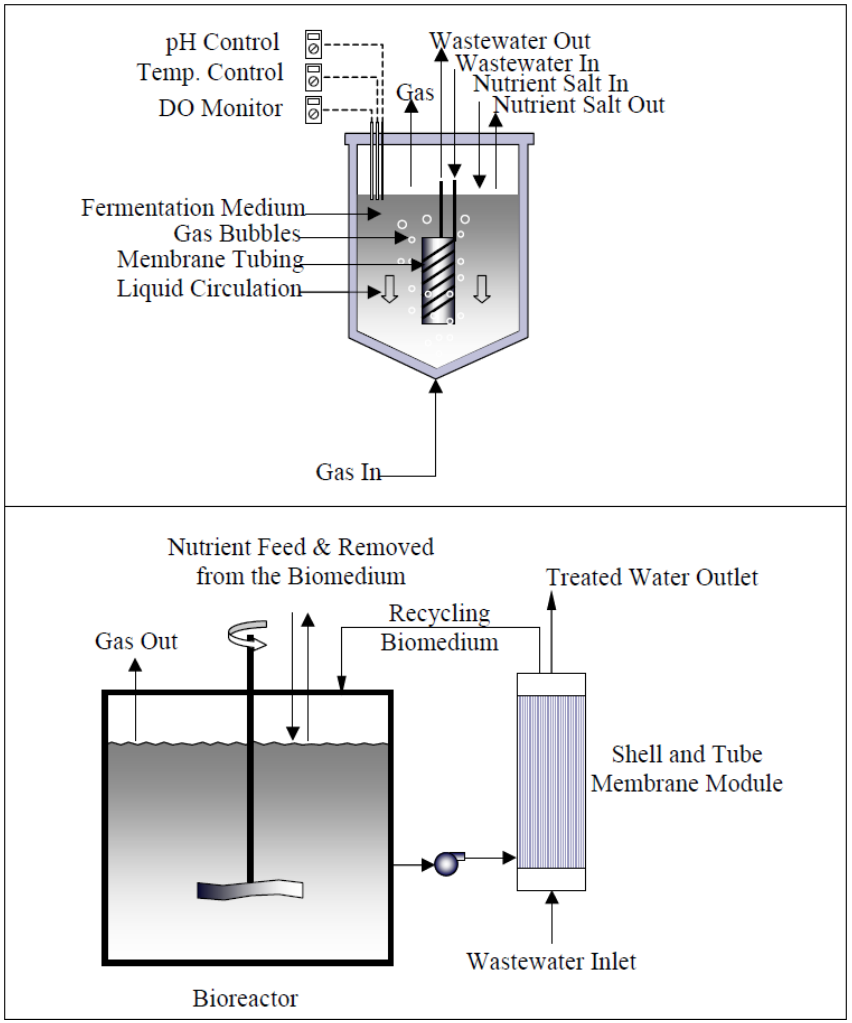
Activated Sludge Alternative Processes - Numerous Types

- **Oxidation Ditch**
- **Conventional Activated Sludge (complete mix)**
- **Contact Stabilization**
- **Step aeration**
- **Extended aeration**
- **Nutrient removal types**

- **AERATION TYPES**
  - Diffused aeration – coarse bubble/fine bubble
  - Spray Aeration
  - Jet aeration
  - Turbine aeration
  - Surface aeration

MBR Process

- **Used at many landfills**
- **Requires aeration and membrane separation**
- **Aeration Required**
- **Sludge Production/Solids Management**
- **System Control by wasting, aeration**
- **Maintenance needed on membranes**
- **High quality effluent**



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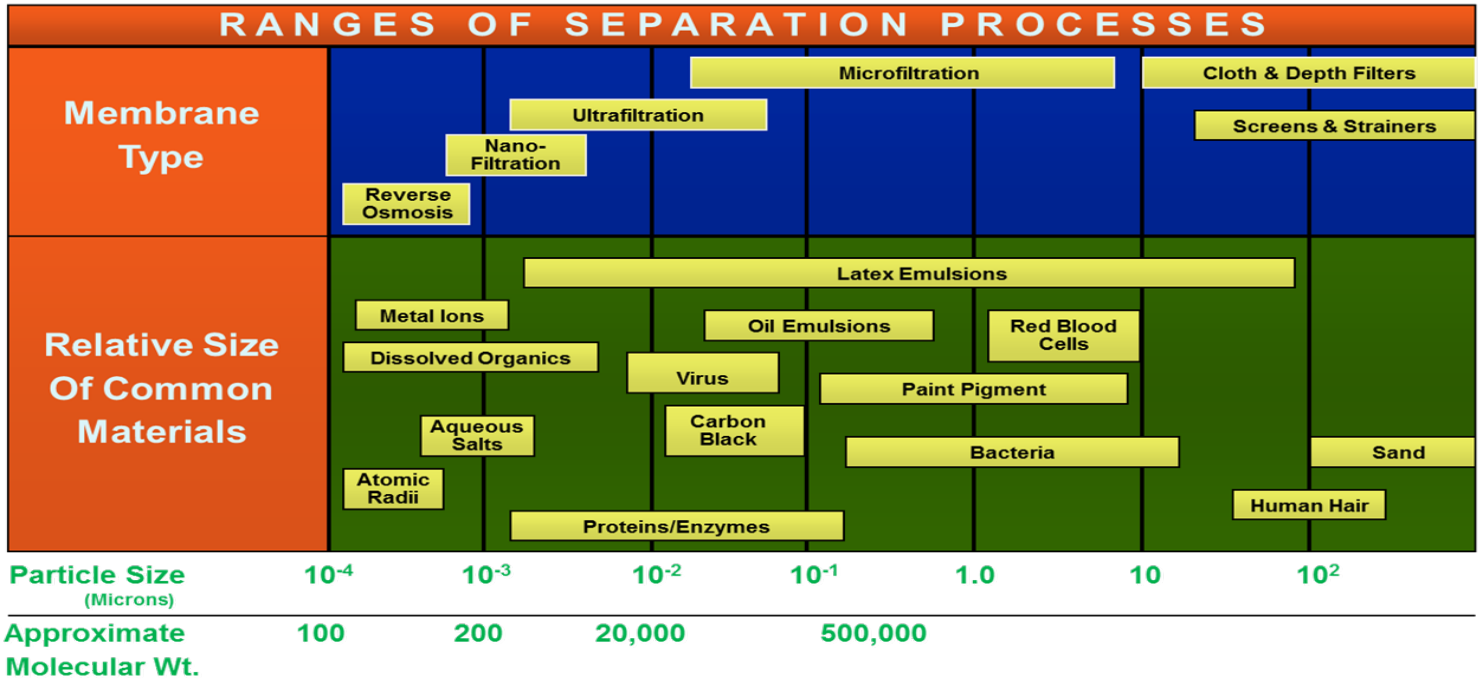
Jet Aeration

- **Jet Aeration Systems Often Used for Leachate Treatment**
- **Needs Blowers (VFD)/External Pumps @ Fixed Speed**

MBR Technology



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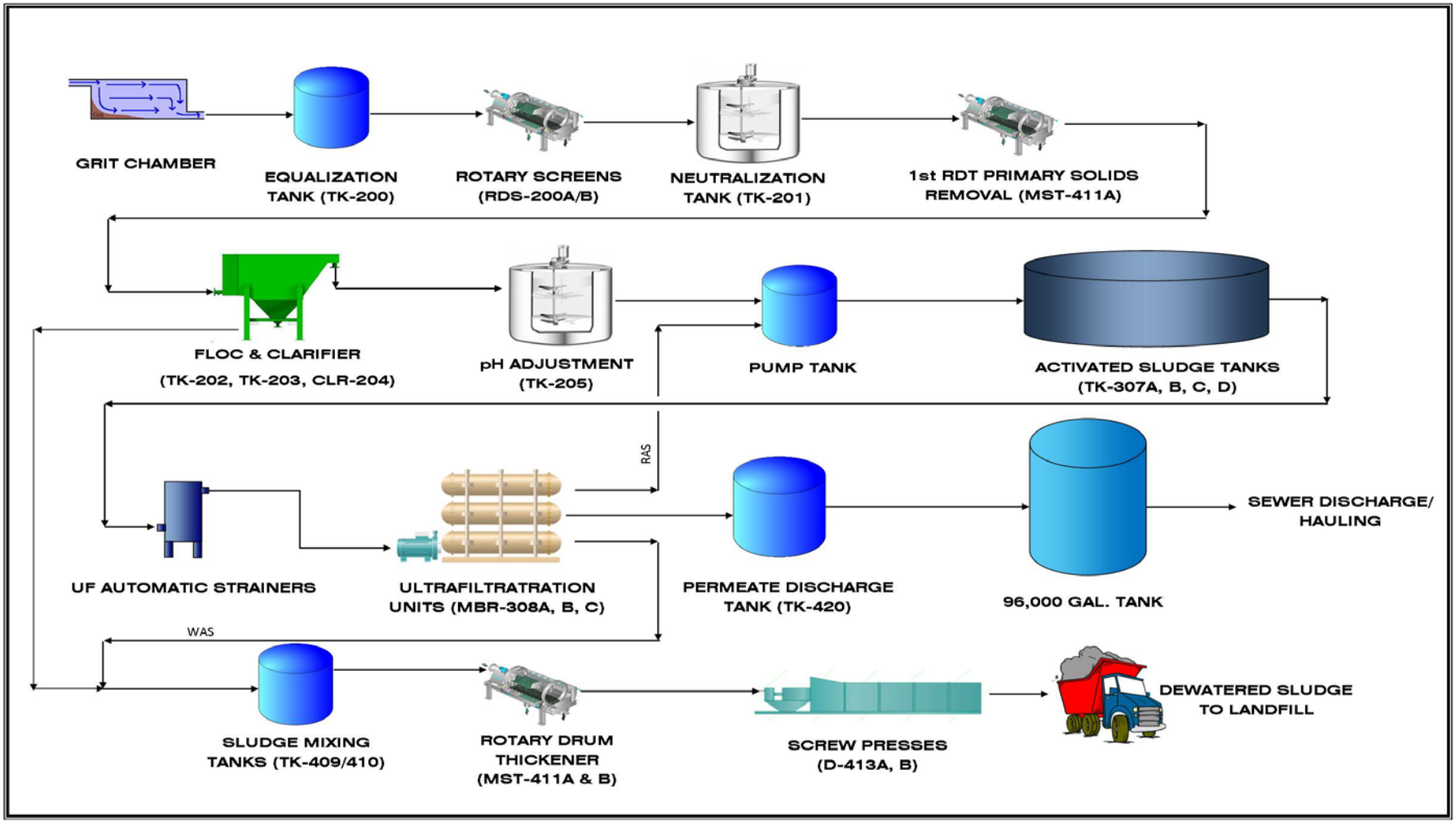
Advantages / Disadvantages

ADVANTAGES

- **BOD removal – high 90%**
- **Oxidation/Nitrification**
- **Biological phosphorous removal possible**
- **Temperature Dependent**
- **Very common process**
- **Recommend Screening first**

DISADVANTAGES

- **No color removal – possibly increase by forming colored intermediates**
- **Nutrient removal may require several stages/ May be Land Intensive – based on design**
  - Heterotrophic versus autotrophic populations
- **Energy intensive**
- **Close operation attention needed – Cleaning/scale control/avoid plugging**
- **High WAS flows**



Pretreatment Process Flow

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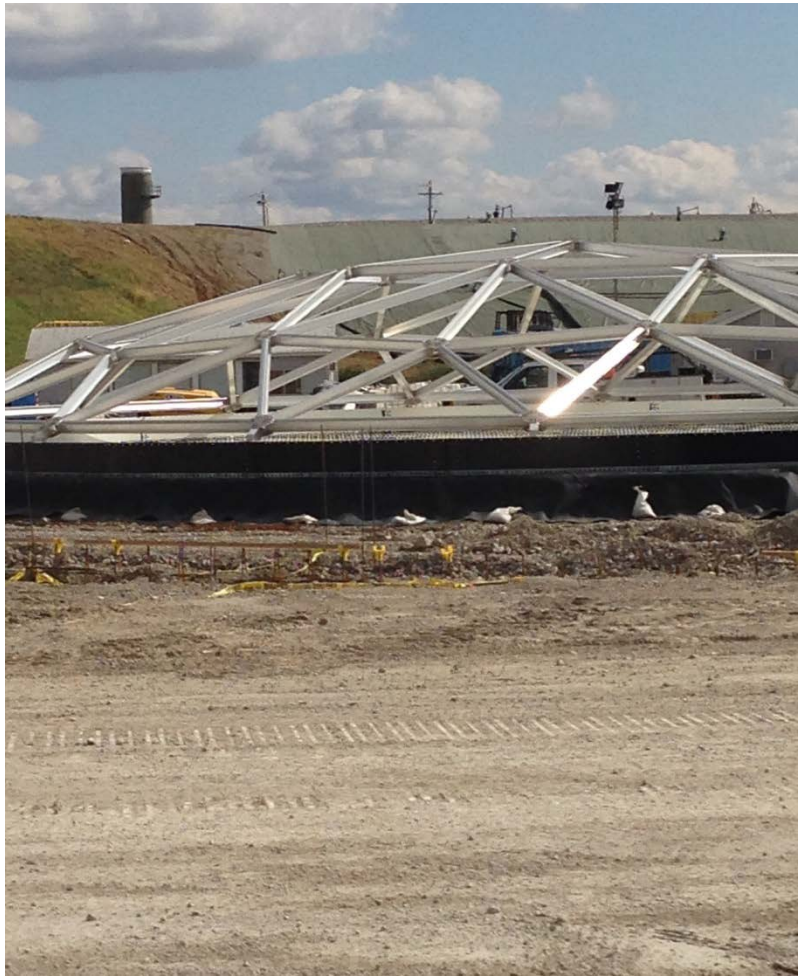
Rapid Construction Schedule

- **Start April 2013 Investigation**
- **Design/Construct or Construct/Design??**
- **CEC ID Equipment; Order; Initial CM Services, Schedule**
- **CEC forms team**
  - Site Contractor
  - Building Contractor
  - Electrical Engineer/Contractor
  - Instrumentation Engineer/Contractor
  - Architect
  - Mechanical Engineer
- **CM joins team October 2013**
- **Plant Startup June 2014**
- **CEC takes over full O&M**
  - Hire 11 full time operations staff



Construction Progress – May 2013

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Construction Progress – June 2013

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Construction Progress – Fall 2013

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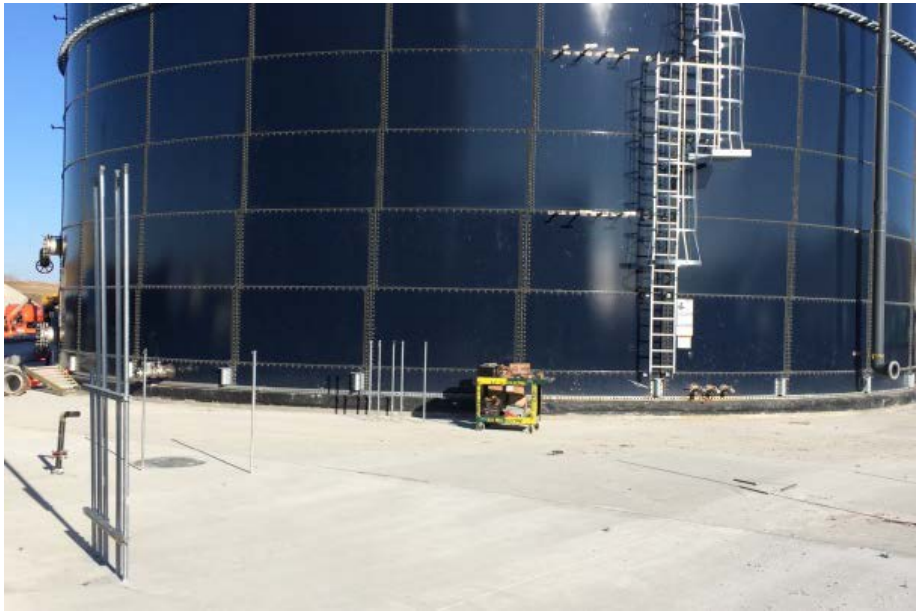

Construction Progress – December 2013

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Construction Progress – January 2014

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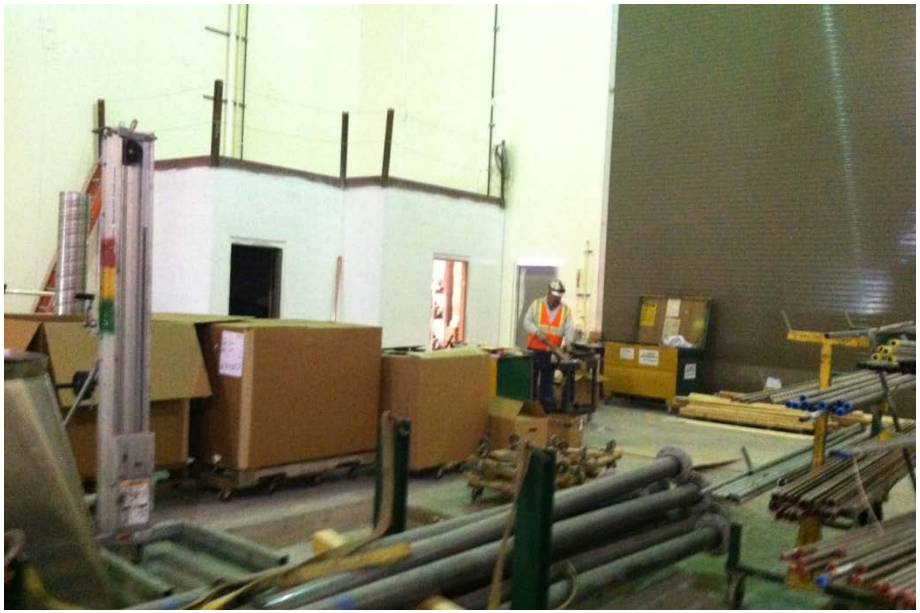

Construction Progress – March 2014 – Treatment Building

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Construction Progress – March 2014 – Aeration Tanks

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Construction Progress – April 2014

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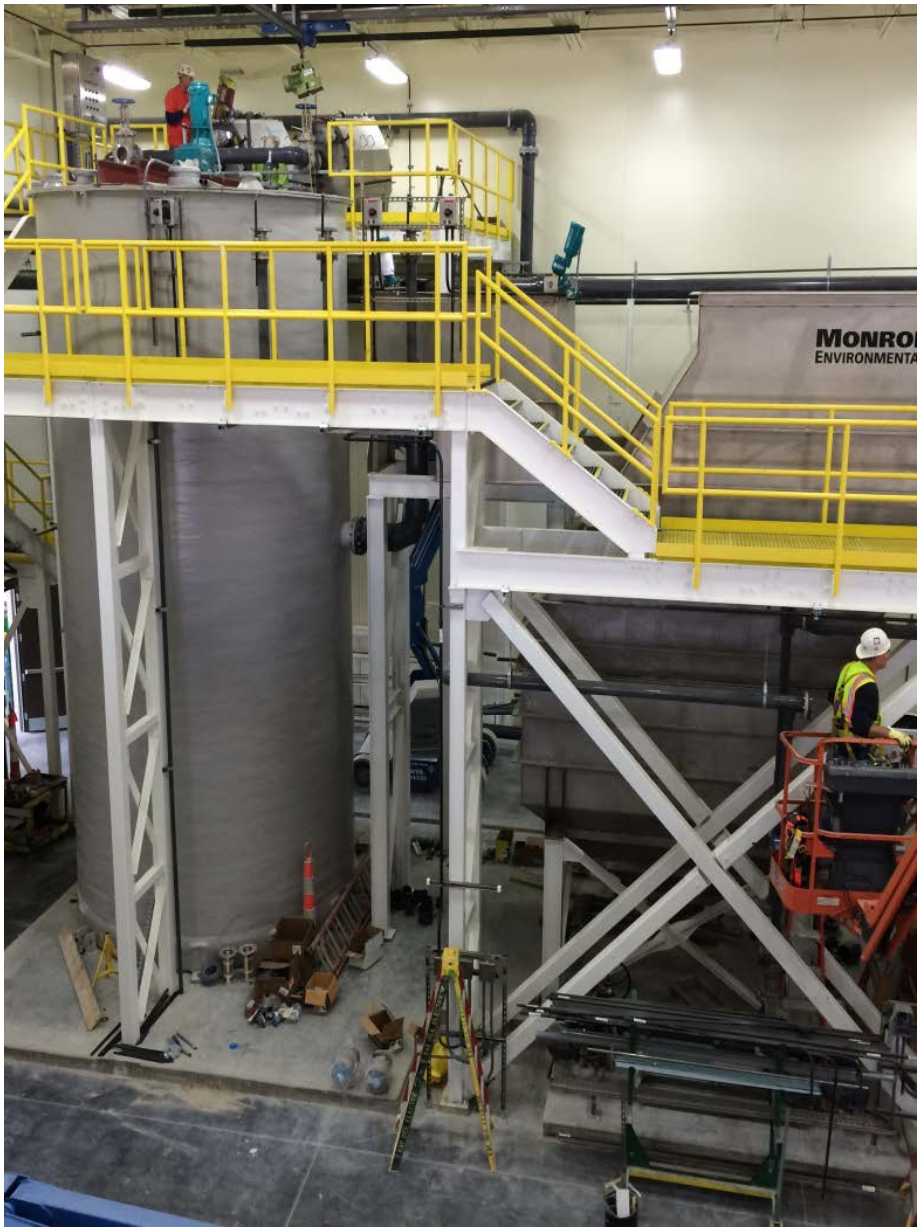

Construction Progress – May 2014

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Construction Progress – May 2014

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Startup – May 2014

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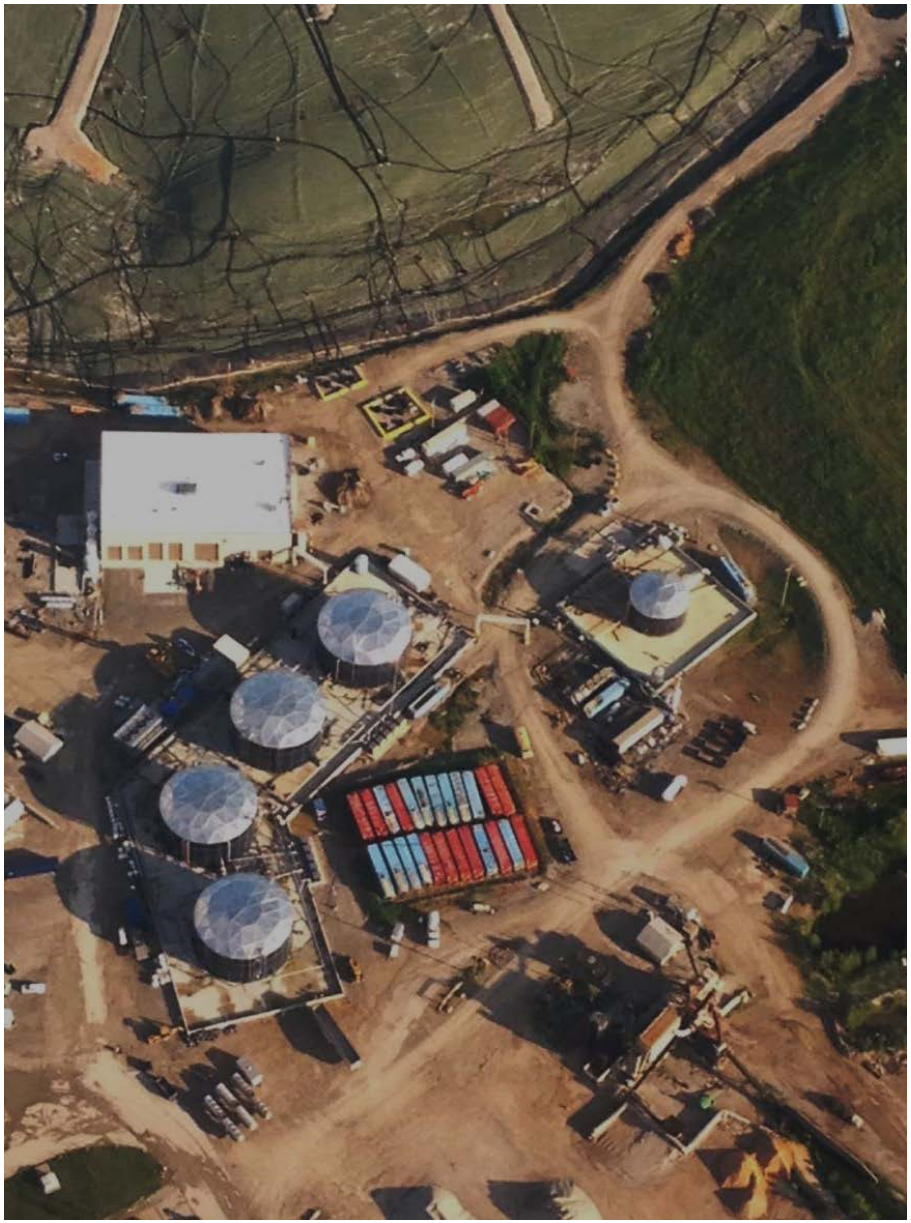

Construction Status – June 2014

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Startup – July 2014 – Process Flow

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Progress – July 2014 – Solids Processing

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Startup – August 2014 – We Make Sludge!

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Weather & Power Outage Protection – September 2014

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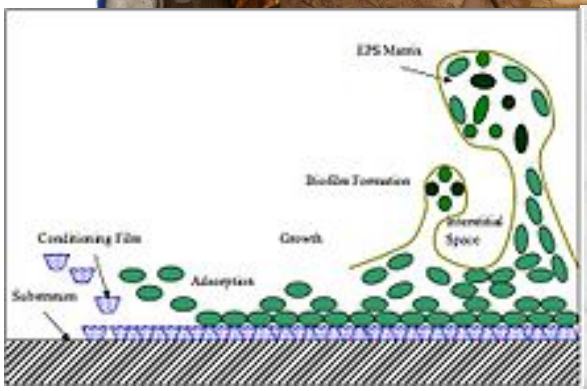

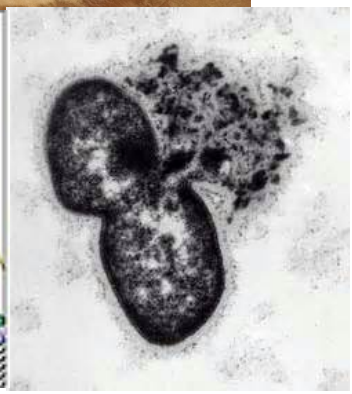

- **Operator Training**
- **Foam**
- **Temperature**
- **Pump Issues**
- **Scaling – Piping and UF**
- **UF - EPS and SMP**
  - Extracellular Polymeric Substances – Polysaccharides
  - Soluble Microbial Products- Cell Lysis – release internal contents

Startup Challenges – September 2014

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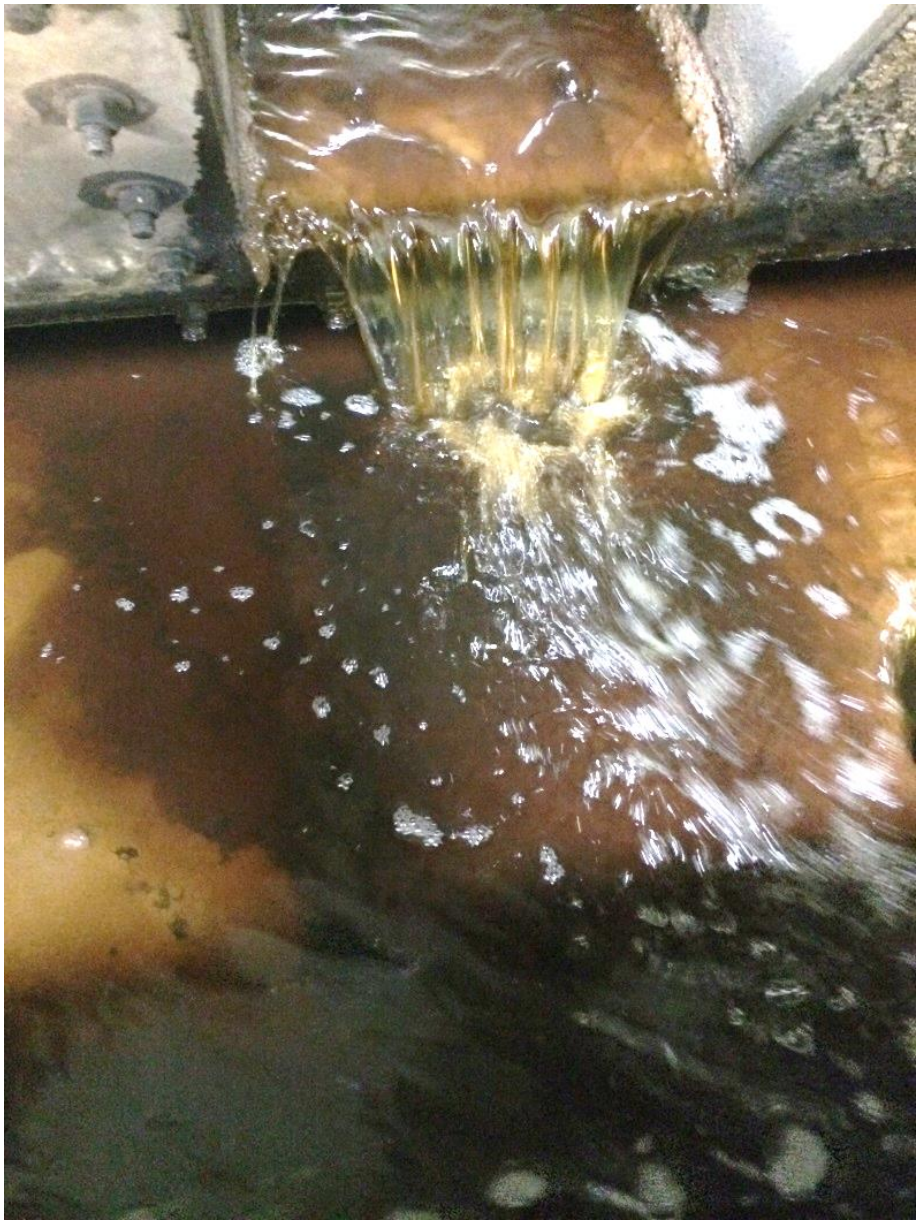
Foaming Challenges

- **Foaming**
  - High MLSS = older sludge (SRT)
  - Foaming varies with f/m
  - Controls:
    - Spray water = more to UF
    - Harnessing a portion of the jet mix recycle as a continuous knockdown spray;
    - Incorporating a knockdown defoamer (antifoam) injection into the continuous spray feed pipe;
    - functional foam level sensor incorporating to control the defoamer feed.



Clarifier Removes 75% solids

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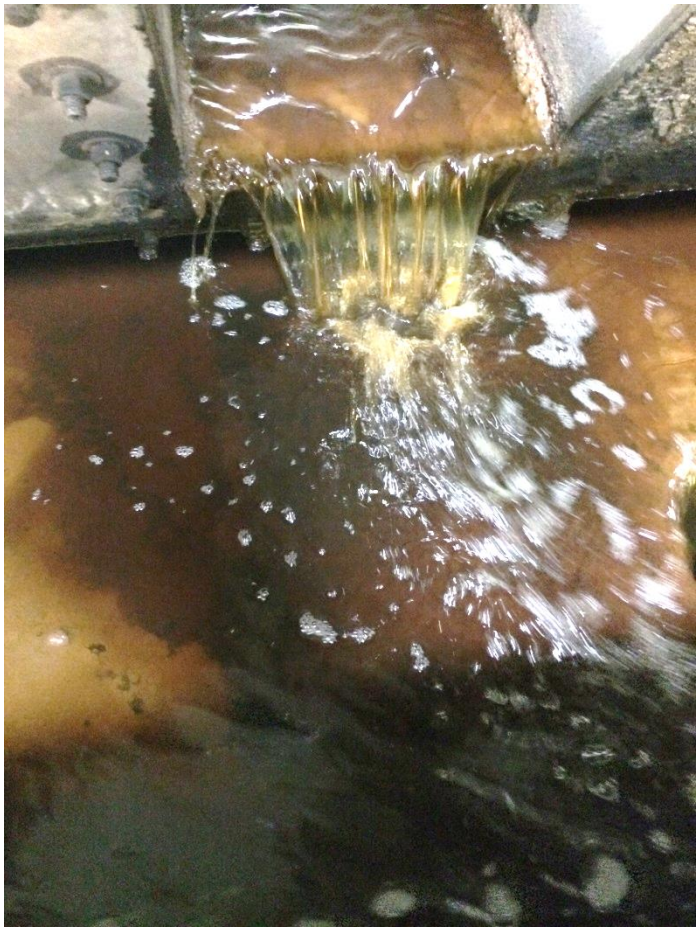
Clarifier Operational Issues

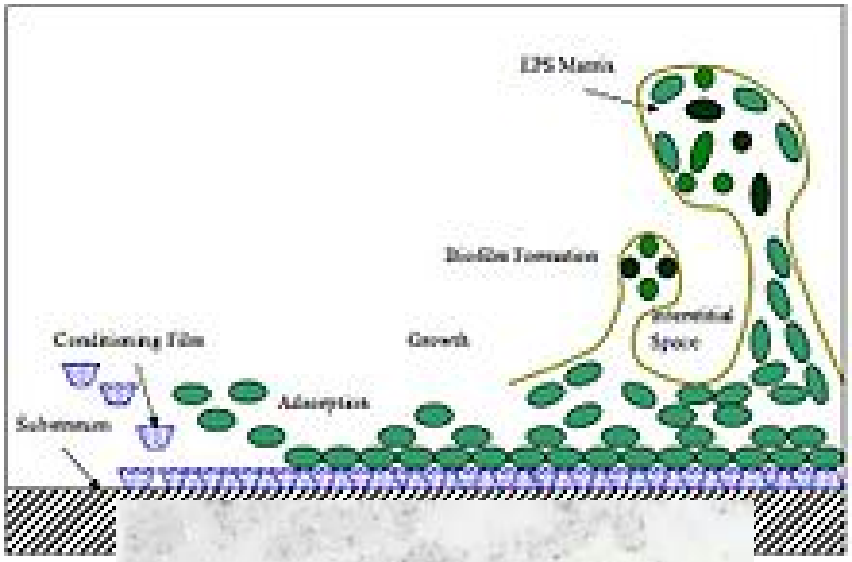


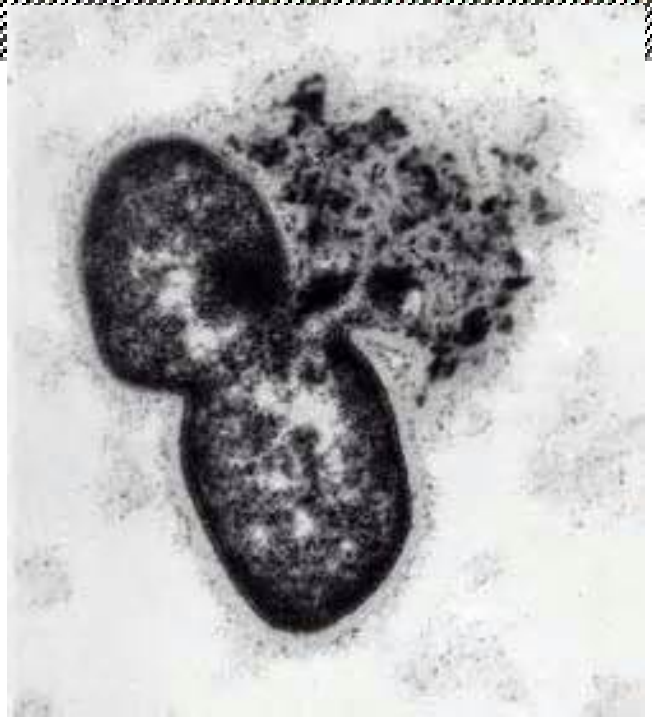
- **Inclined Plate Clarifier**
  - Watch effluent and sludge levels for cleaning
  - Progressive cavity pumps failed and clarifier became sludge locked
  - Solids carried over to aeration system
  - Replaced stators - EPDM with Buna –N (Coupon Tests)
  - Drained clarifier and hauled off solids/washdown water

Ultrafilter Operation

- **External MBR Ultrafilters**
  - Excellent quality effluent
  - Requires monitoring pressure drop and cleaning
  - Initially plant staff ran below recommended pressure drop; elements clogged.
  - Additional system training helped operations
  - Scale formation – added soda ash addition to primary step to remove Ca hardness
  - Membrane autopsy – Calcium carbonate scale controlled by acid cleaning. Calcium sulfate more difficult to remove.
  - Operations changed from sulfuric acid to CO_2 for pH control

Biological Fouling of UF





- **Currently being investigated**
  - Caustic clean helps remove
  - UF - Two biological fouling mechanisms
  - Soluble Microbial Product (SMP)/Extracellular Polymeric Substance (EPS)
    - Soluble Microbial Products - Cells Lysis – release internal contents
    - Extracellular Polymeric Substances – Polysaccharides
  - Control by proper nutrients – P/N/micronutrients
  - SRT optimized by testing
  - Calcium carbonate scale

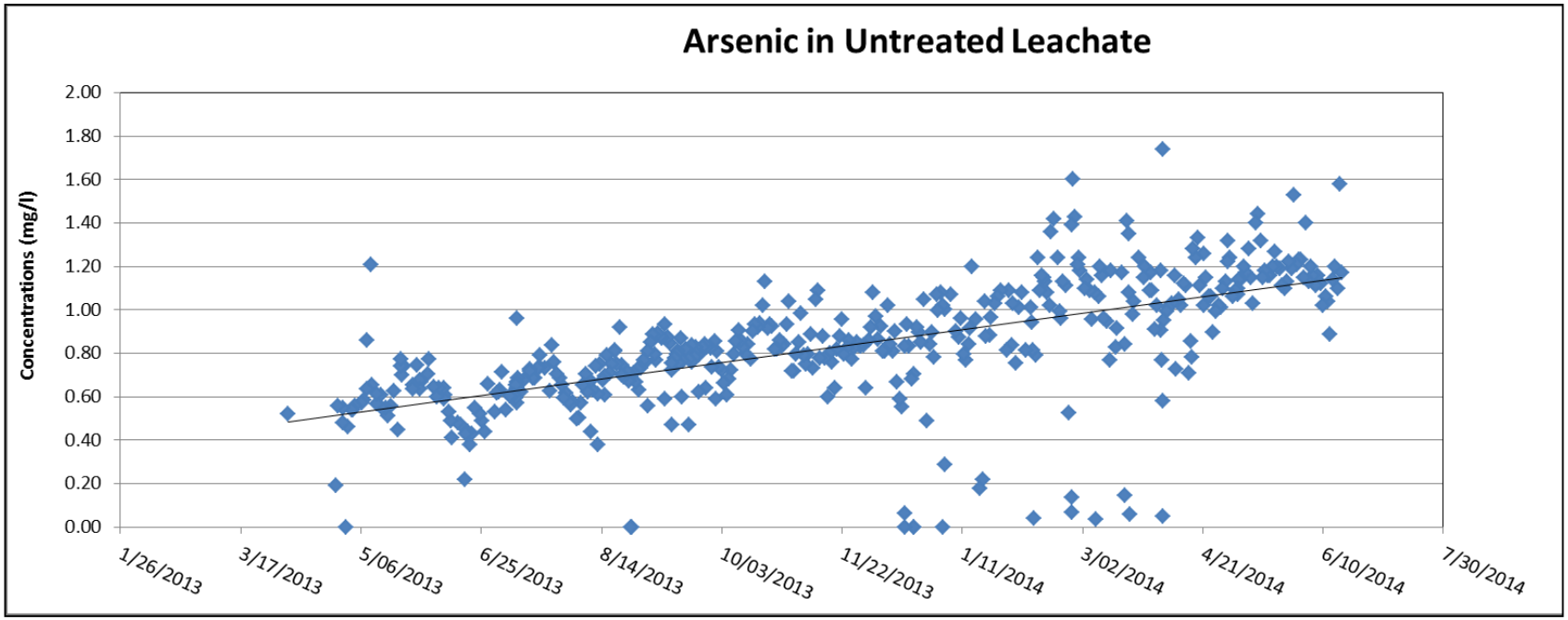
Operations Startup – How fast can you dance??

- **Design Staff started plant May-July 2014**
- **Hired 11 staff Summer 2014**
- **On-boarding process**
  - Background Evaluation
  - CEC Introduction
  - Process training
    - Solids & Clarification-Chemical Feed- Hardness Scaling – CT Water Treatment- MBR – Odor Control – Water Use – Effluent odor- calcium nitrate & flushing
  - Lab evaluation
    - Ex: Orthophosphate testing problems lead to nutrient deficiency
    - Bench tests for phosphorus/nitrogen (urea) /nutrient addition
    - Testing load – COD, MLSS/MLVSS, P, N, others
  - Reporting – city and state
    - Operations tracking – flows, pressures, temperature, odors
    - Software implementation
      - Spare Parts Inventory
      - Periodic and breakdown maintenance task reports- JobCal+
  - Site Safety training

Operations Challenges –

Constant Improvements

- **Equipment Reliability**
- **Increasing Leachate Concentrations**
- **Arsenic (Variance)**
- **TSS increased**
- **Hardness increases >Scaling**
  - Soda Ash softening
- **CO_2 replace H_2SO_4**
- **Controls (KPI)**
- **Odor Control**



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Effluent Acceptance by POTW

- **BOD:**
  - 30,000 mg/l ⇨ 34 mg/l = 99.932% removal
- **COD**
  - 55,000 mg/l ⇨ 2,200 mg/l = 96% removal

- **Metals – All under limits**

Metals	Permit, mg/l	Acceptance Test, mg/l
Arsenic	0.4	0.0529
Chromium	5.0	0.0298
Copper	2.7	0.247
Iron	150	2.7
Lead	0.4	0.0082
Nickel	2.3	0.0359
Zinc	3.0	0.0595

Questions & Discussion

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