Landfill Leachate Treatment Solutions – What Technologies are Working and How to Select the Best Solution

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Outline
- Key Drivers
- Treatment Challenges
- Treatment Technologies
- Approach to Selection
- Case Studies
- Summary
Key Drivers

- High Operating Costs
- Increased Pressure from local POTW's
  - Ammonia/BOD/COD
  - Surcharges
  - Volume control or rejection
  - Variability in Characteristics
  - Impact on UV Systems
  - TDS/Chlorides
- Increasing Condensate/Leachate Extraction
  - Cell Development
  - Stormwater Management
  - On-Site Recirculation
- Disposal is becoming more stringent
- Future? Pharmaceuticals, Tritium, TDS, Nitrogen

Treatment Challenges

- PRETREATMENT FOR POTW
  - NH3-N/TKN, Chloride/TDS, BOD, TSS
- FULL TREATMENT FOR DIRECT DISCHARGE – High degree of treatment needed:
  - ~1 mg/L NH3-N
  - 10 to 15 mg/L BOD
  - 10 to 15 mg/L TSS
  - Metals
  - TDS
  - VOC, SVOC, Pesticides, Herbicides, PCBs and emerging contaminants.
  - Whole effluent toxicity (bioassay)
### Leachate Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical Concentration (mg/L)</th>
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<tbody>
<tr>
<td>BOD</td>
<td>100 – 500</td>
</tr>
<tr>
<td>COD</td>
<td>250 – 1500</td>
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<tr>
<td>TSS</td>
<td>40 – 200</td>
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<tr>
<td>TKN</td>
<td>300 – 1200</td>
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<tr>
<td>Ammonia</td>
<td>200 – 1000</td>
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<tr>
<td>Total P</td>
<td>1 – 3</td>
</tr>
<tr>
<td>TDS</td>
<td>500 – 4000</td>
</tr>
<tr>
<td>Color (TCU)</td>
<td>500 – 1500</td>
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</tbody>
</table>

### Leachate Technology Alternatives

**BIOLOGICAL TREATMENT**
- Activated Sludge
- SBRs – Sequencing Batch Reactor
- PACT
- MBRs – Membrane Bioreactor
- MBBR – Moving Bed Bioreactor
- RBCs & Biofilter
- Wetlands
- Anaerobic Treatment
- Anammox

**PHYSICAL/ CHEMICAL TREATMENT**
- Reverse Osmosis
- Ammonia Stripping
- Vacuum Distillation
- Nutrient Recovery
- Evaporation
- Breakpoint Chlorination
- Chemical Oxidation
Activated Sludge Definition

- Gelatinous mass of microorganisms, zooglaeal bacteria, protozoa & rotifers
- Biosolids floc produced with wastewater by growth of bacteria in presence of dissolved oxygen and recycled floc after settling.

Activated Sludge – Process Flow Diagram
History and Key Milestones

- 1913 – Initial research in MA and UK
- 20s – First plant in US in MA
- 40s – NYC step feed plants
- 50s – 300 AS plants in US, Aerated Lagoons at Pulp and Paper Mills
- 60s – SBRs
- 70s – Pure Oxygen, PACT and Deep Shaft
- 80s – Thermophilic Aerobic and Selectors
- 90s – Membrane Bioreactors and Moving Bed Bioreactors
- 2000 to present – Sharon, Biomag, Nereda, Annamox
- 2014 forward – What’s Next?

Flocculation & Settling Characteristics of Activated Sludge as Related to Organic Loading
Sequencing Batch Reactor
(Freshkills, NY; RI; & Grows, PA)

PACT Wastewater Treatment System
Membrane Bioreactor

Fixed Film Technology

Biofilm/Activated sludge Sedmentation

IFAS System with Pre-DN (Anoxic Zone)
Reverse Osmosis

How does Rochem Treat Leachate?

Leachate

First Stage

Concentrate Stage

Permeate Stage

Permeate

Concentrate
Ammonia Recovery (ARP)

ARP is Physical/Chemical Separation / Recovery

Ammonia Management Alternatives

- Separation
  - ARP: Chemisorption + Vacuum
  - Air/Steam Stripping
  - Struvite Precipitation

- Conversion
  - Biological
    - Sharon®, AT-3
    - Fixed Film
    - Anammox®
    - BABE®, InNitri®, others
    - Breakpoint Chlorination

Physical Chemical

How to Select the Best Solution – Comparison of Treatment Alternatives

- Identify contaminants of concern and treatment objectives
- Prepare evaluation criteria scoring matrix
- List advantages and disadvantages of each alternative
- Develop capital and operating screening costs for each alternative
- Compare non-cost criteria for each alternative based on a ranking system developed with team (performance, reliability, footprint, operator skill, adaptability…)
- Project Team meeting for review and selection of appropriate treatment system for conceptual design
- Discuss need for treatability and pilot study
Importance and Value of Treatability Studies

- Confirm that a design will work in lab first
- Gain more confidence in design and operation
- Troubleshoot performance issues
- Each test program is unique – need test plan
- Laboratory bench scale studies (i.e., biological and physical/chemical technologies)
- On-site pilot studies (i.e., MBR and RO systems)

Treatability Studies

- Treatability and/or pilot studies for technology demonstration and design criteria
  - Bench-scale studies at landfill or at treatability laboratory
  - Pilot studies, if necessary
  - Vendor studies for proprietary or unique technologies
Leachate is similar to some Industrial Wastewaters

- Treatment options
  - Metals – oxidation and precipitation
  - BOD/COD and TKN – Biological (aerobic, anaerobic, nitrification, denitrification and variations)
  - Ammonia – Phys/Chem (steam stripping, vacuum distillation, air stripping, breakpoint chlorination, ion exchange)
  - Particulates – Sedimentation and filtration
  - Trace Organics & Pharmaceutical & Personal Care Products – PACT, GAC and Chemical Oxidation
- Process issues
  - Nitrification inhibition
  - Startup and operation
  - Chemical requirements
  - Sludge production and disposal
  - RO reject disposal
  - Loads can change overtime

What’s Next for Activated Sludge Technologies

- Microbiology – Selecting Organisms
- Solids-Liquid Separation
- Technologies
**Microbiology – Selecting Organisms**
- Heterotrophic and Autotrophic bacteria
- Phosphorus removal bacteria
- Anammox bacteria
- Granules in Nereda
- Others

**Solids – Liquid Separation**
- Membrane Bioreactor
- BioMag
- Nereda
Technologies (New)

- BioMag
- Nereda - Granular Sludge
- Future?

BIOMAG

- Uses magnetite as ballast to enhance settling rates
- Specific gravity 5.6
- Magnetically Retrievable (polish)
- Requires high energy mixing to maintain solids in suspension
**BIOMAG**

**NEREDA**

**Aerobic granules**

- Excellent settling properties
- Pure biomass, no support media required
- High biomass concentration
- Simultaneous extensive biological N- and P-removal
- Simple one-tank concept (no clarifiers)
- Small footprint
- Simple and easy operation
- Sustainable technology
- Low costs
How to Make Granules

Selection mechanism: settling pressure and/or short decant phase

- Heterotrophic growth: \( \text{COD} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \)
- Nitrification: \( \text{NH}_4 + \text{O}_2 \rightarrow \text{NO}_3^- \)
- P-removal/anoxic growth: \( \text{COD} + \text{NO}_3^- + \text{PO}_4^{3-} \rightarrow \text{N}_2 + \text{CO}_2 + \text{H}_2\text{O} + \text{poly-P} \)

Oxygen gradient in granule enables simultaneous COD, P and N-removal

SBR Mode Operation

Nereda™ process

- All processes in one reactor
- Simple cycle
- Short settling phase
- Fill and draw combined
- Continuous feed: multiple reactors or buffer tank
# Case Studies for Landfill Leachate Treatment

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<thead>
<tr>
<th>Location</th>
<th>AS</th>
<th>SBR</th>
<th>MBR</th>
<th>RO</th>
<th>Evaporation</th>
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**Case Study Activated Sludge – MLE Process (Industrial)**
History of Plant

- 2003 – Design of New WWTP – used bench scale treatability and process calculations
- 2008 – Design of Upgrade Capacity using BIOWIN calibration to full scale data
- 2008 – Nitrification upset – bench scale work on inhibition, model on recovery time
- 2009 – Capacity study using BIOWIN and treatability
- 2013 – Evaluating upgrade of capacity and converting to MBR
- 2015 – What’s Next?
Summary

- Leachate is unique, but similar to some industrial wastewaters
- There are a lot of technologies available to choose from
- Use the approach to select best solution and Vendor(s)
- Treatability testing provides value

Thank you

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Questions & Answers