Leachate Pretreatment Options for Landfills

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What is Leachate?

- “Garbage juice” or highly contaminated waste water
- Water percolates through waste materials
- Leaching of organic and inorganic compounds
- Usually contains high concentrations of
  - Organic matter (biochemical oxygen demand or BOD)
  - Nitrogen (ammonia)
  - Phosphorous
  - Inorganics (metals)
What is Leachate?

Infiltration at working face

Dissolution

Biodegradation

Leachate
Why is Managing Leachate Important?

- Direct releases may contaminate:
  - Surface water
  - Groundwater
  - Land

- Potential risks and hazards to public health and ecosystems

- High concentrations may require an efficient, affordable and relevant pretreatment method
How does this affect my facility?

- Treatment, transportation and disposal costs for leachate will increase
- More stringent regulation of surface water (Total Maximum Daily Load or TMDLs) for typical leachate constituents in effect
- Wastewater Treatment Plant (WWTP) capacity will be scarce and at a premium
Competing for WWTP capacity with other users

WWTPs will charge more and be selective of what they accept

May add surcharge fees to both weak and strong leachate

May not accept your leachate at all!
What are TMDLs? Total Maximum Daily Loads (“TMDL”)

- Maximum amount of a pollutant that can be discharged to an impaired water
  - Stream Specific Standard

Section 303(d) of the Clean Water Act
- Requirement to identify impaired waters.
- Requirement to develop Total Maximum Daily Loads (“TMDL”) when technology based effluent limits are insufficient
New Standards - TMDLs

- TMDL for a particular pollutant represents a cap on total daily discharges into that water body.

- States then regulate discharges of that pollutant sufficient to comply with the cap.
  - These are reductions from point sources or non-point sources.
In the interim, what do landfill operators do?

- Landfills that use upgraded WWTPs can continue to use that option
- Pay surcharge fees?
- Facilities that don’t have WWTP to discharge leachate?
Local ordinances will restrict the volume and concentration of leachate to meet County or regional standards for nutrients

Bottom Line:
- Discharging leachate will get more expensive
- Pretreating your leachate may make financial sense
How far reaching are the TMDLs?

- TMDLs will affect other states (besides VA)

- Will affect point sources (existing wastewater treatment plants) and non-point sources

- Other point and non-point sources from agricultural operations
Leachate Phases in the Landfill

Waste Decomposition

- Phase I
  - Aerobic
- Phase II
  - Anaerobic
  - Facultative
- Phase III
  - Methanogenic
Phase I
- Very short time period
- High CO₂
- High H₂

Phase II
- Months to Years
- High BOD
  - >10,000mg/L
- Low pH
  - 5-6
- High Ammonia
  - 500-1000 mg/L

Phase III
- Many Years
- Anaerobic
- High CH₄ and CO₂
- Low BOD
- High Nitrogen/Phosphorus

Treatment Will Depend on Phase of Decomposition
Leachate Composition Factors

- Solid Waste Composition
- Age of Refuse
- Operation of Landfill
- Climate
- Conditions within Landfill
  - Chemical & Biological Activities
  - MC %, Temperature, pH, Degree of Stabilization
These general numbers are VERY deceptive. Leachate is rarely ‘typical’.

Two case studies will illustrate the variability of constituents in landfill leachate.

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Concentration (mg/L)</td>
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<tr>
<td>Constituent</td>
</tr>
<tr>
<td>BOD</td>
</tr>
<tr>
<td>TKN</td>
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<tr>
<td>Ammonia-N</td>
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<tr>
<td>Phosphorous</td>
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Leachate Treatment Challenges

Treatment
- Full On-Site (no discharge)
- Partial On-Site
- Transport Off-Site (pay any applicable fees)

Challenges
- Bioreactor Landfill?
- Sewer nearby?
- Distance to Pump / Haul?
- Pump System Costs
- WWTP Capacity?
- Leachate Strength?
- Local Sewer Use Laws?
- Sewer Surcharges?
- Surface Water Discharge Standards (TMDLs)?
Leachate Minimization

Through design and operations, the objective is to minimize leachate

Reduce generation by:

- Minimizing active working face area
- Cover waste daily
- Grade intermediate slopes to shed water

What can we do with the leachate we do generate?
Leachate Treatment Considerations

- Treatment technologies will depend on the strength (concentration) and volume of the leachate
- High strength leachate? Low strength leachate?
- TMDLs in place to “regulate” nutrients discharged into a stream or under a WWTPs discharge permit?
- Every leachate is different. There is no “one size fits all” model of treatment.
Common Leachate Pretreatment

- Anaerobic or Aerobic Biological Treatment
- Constructed Wetlands
- Physical & Chemical Treatment
- Leachate Recirculation
- Leachate Evaporation Technologies (have a permit pending in Nevada)
- Additional Innovative Technologies
Traditional WWTP Methods

- Traditional biological pretreatment methods:
  - Changes the form of organic constituents
  - Removes BOD$_5$, SS, NH$_3$-N, Organic-N & Metals
  - Generates large quantities of biomass (sludge)

Anaerobic Treatment
- SBR
- MLE
- Two-Stage Reactor
- Fixed Film Filters

Aerobic Treatment
- Lagoons
- Activated Sludge
- RBCs/Trickling Filters
Traditional WWTP Methods

- Organic matter (BOD) is degraded by microorganisms
  
- Use BOD as food in order to degrade other constituents (metals, nutrients)
  
- These “traditional” wastewater methods are extremely expensive, large and O&M intensive
Traditional WWTP Methods
Phases of aeration and non-aeration take turns in same activated sludge basin.

One basin for nitrification (phase of aeration) and denitrification (phase of non-aeration).
Sequencing Batch Reactor (SBR)

One Cycle of a SBR-reactor
SBR System
Modified Ludzack-Ettinger (MLE)

TRADITIONAL

Aeration → Secondary Clarifier → Sand Filter

Return Activated Sludge

Waste Activated Sludge

Anoxic → Aeration → Secondary Clarifier → Sand Filter

Return Activated Sludge

Waste Activated Sludge
Additional Pretreatment Technologies
Bioreactor Landfills

- Leachate is collected and returned to the working face of the landfill
- Accelerates the stabilization of organic materials present in the MSW
- Spray Irrigation or Trench Injection
- Evapotranspiration
Spray nozzle

Aeration in Pond

Aerated Ponds at Landfills
Constructed Wetlands

- Constructed in combination with lagoons and aeration ponds.

- Planted with various plant species
  - Phragmites austalis
  - Typha latifolia

- Organic Removal
  - N, P, Fe & pathogens ~70-95%
Constructed Wetlands
Virginia MSW Landfill

- Leachate was low in COD/BOD but high in nutrients
- Several pre-treatment options were reviewed to pre-treat a high nutrient, low carbon leachate

The goals were to:

- Reduce leachate disposal costs
- Comply with proposed (and to reduce the uncertainty associated with) wastewater effluent standard for nutrients (TMDLs etc.)
Confirmed design criteria and site conditions

Reviewed landfill leachate data (carbon source was needed)

Evaluated two treatment alternatives:
  - Two-stage Modified Ludzack-Ettinger (MLE) biological activated sludge treatment system
  - Sequencing batch reactor (SBR) to remove TKN to below a final effluent standard (County) to below 40 mg/L.

Preliminary design included identifying a carbon source and laying out the system.

Best remedy estimated to cost $1.50 per ton of waste
Virginia CDD Landfill

- Leachate costs were $0.11 / gallon ($0.04 for hauling and $0.07 for treatment)
- County ordinance would decrease the standards for metals and nutrients
- Several pretreatment options reviewed. The goal was to eliminate the discharge of leachate off-site (zero discharge)
- On-site constructed wetland selected
Case Study #2

- Confirmed design criteria and site conditions

- Reviewed landfill leachate data

- Designed two submerged treatment wetlands to remove metals and nutrients
In Conclusion.....

- Review your leachate concentrations
- Meeting effluent limits will drive level of pretreatment
- Treating to the appropriate level is important
- Determining the desired effluent level of BOD, total nitrogen and phosphorous will allow for optimizing costs
- As TMDLs cause costs of transportation and disposal increase, on-site pretreatment becomes cost effective
Thank you very much for your attendance.
Please visit our booth (#40) if you have any questions or would like to learn more.

QUESTIONS?