BIOLOGICAL TREATMENT FOR LEACHATE?

Pete A. Shack, P.E.

Nashville, Tennessee

(615)292-0401 • pshack@phoenixengineers.com
What are we talking about?

BIOLOGICAL DEGRADATION - the decomposition of putrescible matter by bacteria.
It is a naturally occurring process that can be harnessed to remove organic materials and nitrogen compounds in leachate.

When Biological Degradation is **Anaerobic** (with no oxygen present):
- organic components are reduced to organic acids, carbon dioxide, methane and hydrogen sulfide.

When Biological Degradation is **Aerobic** (with oxygen present):
- organic components are oxidized (broken down) into carbon dioxide and water.
- Ammonia Nitrogen is oxidized to Nitrate Nitrogen.
BIOLOGICAL DEGRADATION

So if it is a naturally occurring, why not let it do its thing?
• As it occurs in nature it is too slow.
• But bacteria are everywhere.
• In soil they decompose organic matter such as dead vegetation, animals, etc.

How do we speed it up?
• We accelerate it by concentrating the bacteria and providing them everything they need to be efficient
• Most commonly we call this process activated sludge treatment
ACTIVATED SLUDGE TREATMENT

• Discovered over 100 years ago on domestic sewage
• We use soil bacteria in a water suspension
• The bacteria absorb the organic matter, oxygen, and nutrients through their cell walls to generate energy and make new cells
• Most used method to treat municipal sewage throughout the world
How does it work?

Key ingredients are:

- Bacteria – naturally occurring, may seed from the city
- Air – blow air in with compressor
- Nutrients – Nitrogen and Phosphorus
- Mixing – usually provided by air, but mechanical mixer sometimes used
- Food – feed the leachate in at controlled rate

Put everything in tanks for good control over the process

- Aeration Basin to dissolve oxygen into water and mix for good contact
- Clarifier to clarify water via settling and concentrate bacteria

Control the process by regulating the feed rate and the average retention time of the bacteria (sludge age)
Activated Sludge Components

• AERATION BASIN
  • Aerate and mix the bacteria, food and nutrients
    • Bacteria are concentrated – **MLSS = 2,000 to 6,000 mg/L**
    • Keeps bacteria in suspension
  • Allow sufficient detention time for the bacteria to degrade the **BOD** or **COD**

• CLARIFIER
  • Allow for the bacteria to settle from the water
  • Allow bacteria to concentrate in bottom
  • Return the bacteria to the Aeration Basin
Activated Sludge Diagram

- **Raw Water** flows into the **Aeration Tank**.
- **Air** is introduced into the Aeration Tank.
- The treated water exits the **Clarifier-Settler**.
- **Recycle Sludge** flows back into the Aeration Tank.
- **Waste Sludge** is directed to sludge treatment.
- **Treated Water** is the final output.
AERATION BASIN
CLARIFIER
SEQUENCING BATCH REACTOR
SBR OPERATION
Monitoring

Measure bacteria population (biomass) as suspended solids - MLSS

Measure air as Dissolved Oxygen - DO

Measure nutrients as Ammonia Nitrogen - NH\textsubscript{3}-N and Ortho Phosphate - PO\textsubscript{4}-P

Measure food as Biochemical Oxygen Demand - BOD or Chemical Oxygen Demand - COD – in terms of the amount of oxygen consumed

Example: calories

Put everything in a tank for good control over the process

Control the process by regulating the feed rate and the average retention time of the bacteria (sludge age)
Activated Sludge Parameters

LOADING RATE

• Food/Biomass Ratio (F/M) – can be expressed in terms of BOD or COD
  • The amount of food per bacteria - lbs BOD/lb MLSS/day
    • For river discharge – 0.1 to 0.25
    • For sewer discharge – 0.2 to 0.3
    • For ammonia removal – 0.05 to 0.15
Activated Sludge Parameters

SLUDGE AGE

• The average retention time of bacteria in the system
  • Total Biomass in Aeration Basin / Biomass lost per day

• Typical Sludge Ages - Days
  • For river discharge – 10 to 30
  • For sewer discharge – 5 to 20
  • For ammonia removal – 30 to 60
Process Control

• Keep the conditions in the process acceptable for good performance
• Dissolved Oxygen $\text{DO} = >2.0 \text{ mg/L}$
• Mixing = complete mix
• Temperature $T = 10^\circ - 35^\circ \text{C} (50^\circ - 95^\circ \text{F})$
• $\text{pH} = 7.0 - 8.5$
• Dissolved Solids (salts) $\text{TDS} = 1\%$ or less
Ammonia Removal using Activated Sludge

• Called NITRIFICATION
  • Ammonia $\text{NH}_3$ is oxidized to Nitrate $\text{NO}_3$ – oxygens are traded for hydrogens
  • Requires 4.33 lbs of oxygen for every 1 lb of ammonia

$\text{NH}_3 + \text{O}_2 + \text{NaHCO}_3 + \text{NITRIFIERS} \rightarrow \text{NO}_3 + \text{H}_2\text{O} + \text{More NITRIFIERS}$

• Nitrifiers are slower growing and more sensitive bacteria
  • Requires longer detention times and sludge ages

• Some leachates may require an organic removal step prior to the ammonia removal step to make the process more efficient
Why use it?

• Cost
  • Most cost effective approach to remove organics from water
  • Also cost effective for ammonia

• Effectiveness
  • Produces a high quality effluent

• Relative simplicity
  • Main equipment is tankage, blowers and pumps
  • Easy to operate, but requires specialized training
# Biological Treatment Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>CAPITAL ($/GPD)</th>
<th>OPERATING (¢/GAL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAULING</td>
<td>0.5-1.5</td>
<td>10-25</td>
</tr>
<tr>
<td>COAGULATION</td>
<td>3-10</td>
<td>0.3-1.5</td>
</tr>
<tr>
<td>EVAPORATION</td>
<td>10-100</td>
<td>0.5-3</td>
</tr>
<tr>
<td>CARBON ADSORPTION</td>
<td>2-10</td>
<td>2-10</td>
</tr>
<tr>
<td><strong>CONV. ACTIVATED SLUDGE</strong></td>
<td><strong>9-18</strong></td>
<td><strong>0.3-1</strong></td>
</tr>
<tr>
<td>AMMONIA STRIPPING</td>
<td>5-12</td>
<td>1.5-7</td>
</tr>
<tr>
<td>NITRIFICATION</td>
<td>10-25</td>
<td>0.7-2</td>
</tr>
</tbody>
</table>
Keys to Success with Activated Sludge

• Don’t underestimate flow or load
• Equalize the flow and strength
• Don’t overload system
• Keep feed as consistent as possible, lbs not gallons are what is important
• Make certain you can obtain removal at winter temperatures
Questions?

Pete Shack, PE
Phoenix Environmental Engineers, Inc.
(615)292-0401
pshack@phoenixengineers.com