Announcements

Wednesday lab in lab classroom (230 & 350 TEB)
Activated Sludge Configurations

- List of ten requirements for microorganism growth:

  1. Carbon source
  2. Energy source
  3. Terminal electron acceptor
  4. Macro nutrients
  5. Micro nutrients
  6. Moisture
  7. Temp
  8. pH
  9. Mixing/contact
  10. Absence of inhibition
## Terminal Electron Acceptor (TEA)

### Examples:

<table>
<thead>
<tr>
<th>Process</th>
<th>TEA</th>
<th>Predominant Reactions</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic</td>
<td>O₂</td>
<td>organic matter + O₂ → CO₂ + H₂O</td>
<td>CBOD removal</td>
</tr>
<tr>
<td>Aerobic</td>
<td>O₂</td>
<td>NH₃ + O₂ → NO₃⁻</td>
<td>nitrification</td>
</tr>
<tr>
<td>Anoxic</td>
<td>NO₃⁻</td>
<td>organic matter + NO₃⁻ → N₂ + CO₂ + H₂O</td>
<td>denitrification</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>CO₂</td>
<td>organic matter → CH₄ + CO₂ + H₂O</td>
<td>anaerobic digestion</td>
</tr>
</tbody>
</table>
Nitrification / Denitrification

Activated Sludge System

Anoxic Basin (denitrification)

Aeration Basin (nitrification zone)

Secondary Settling Tank

MLE Modified Ludzak Ettinger

Process TEA C - Source Energy Source End Products

nitrification O₂  CO₂  NH₃  = NH₄⁺ NO₃⁻ H₂ O  CO₂
denitrification NO₃⁻ carbonaceous BOD carbonaceous BOD N₂ H₂ O  CO₂
Enhanced Biological Phosphorus Removal/Activated Sludge

**Anaerobic Selector**
- Release of phosphorus
- Uptake of acetic acid
- ATP → ADP

**Aeration Basin**
- Uptake of phosphorus
- Formation of phosphorus storage granules (up to 7% P)
- ADP → ATP

**Secondary Clarifier**
- Alum, Fe³⁺ (optional)
- waste activated sludge (WAS)

**Phosphate Storage “Battery”**
- ATP → ADP → ATP

Low DO

A/O
Biological Phosphorus & Nitrogen Removal

**A2O**
Biological Phosphorus & Nitrogen Removal

5-Stage Baradenpho
Biological Phosphorus & Nitrogen Removal

Modified UCT
Biological Phosphorus & Nitrogen Removal

**Diagram:**

- **Anaerobic Selector**
- **Anoxic Selector**
- **Aeration Basin**
  - Nitrate rich recirculation
  - Nitrate free recirculation
  - CBOD removal
  - $\text{NH}_4^+ \rightarrow \text{NO}_3^-$
- **Secondary Settling Tank**
  - $\text{NO}_3^- \rightarrow \text{N}_2$
  - Air
  - Return activated sludge (RAS)
  - Waste activated sludge (WAS)

**Text:**

Virginia Initiative Plant (VIP)
Settling Problem in Activated Sludge
Figure 1. Foaming in two Australian activated sludge plants. Plant on right is an oxidation ditch with foam covering the dividing wall.
Activated Sludge Operational Considerations

• An operator of an activated sludge plant is concerned with three things:

1. Effluent quality (BOD5 and SS)

2. Settling characteristics of the biomass (SVI)

3. Sludge wasted or solids inventory ($\Theta_c, F/M$)
Sludge volume index

- Measure of settling characteristics of biomass.
- Measured in a graduated cylinder after 30 minutes of settling.
- Units of mL/g. \[
\text{settle volume} = \frac{\text{mL}}{\text{g}}
\]
- A desirable SVI is in the range of 75 - 150 mL/g.
Sludge Bulking

• Sludge bulking is the condition where the **SVI (> 150)** is high and the suspended solids are not settling in the secondary settling tank.

• It is usually an indication of **filamentous organisms** - long string-like organisms which outcompete the flocculent organisms because of their large surface area.
• Filamentous organisms can be caused by

  \[ \Rightarrow \text{low } \frac{F/m}{\text{ratio}} \]

  - low \( \text{D.O.} \)
  - \text{n.\( \text{utrient} \)} deficiency
  - low \( \text{pH} \)
  - \text{i.\( \text{hibition} \)} or toxicity
F/M Ratio

• The food to microorganism (F/M) ratio is an alternative control parameter to $\theta_c$ for the operation of an activated sludge plant.

\[
\frac{F}{m} = \frac{Q S_o}{V X} = \frac{mg \text{ BOD}_5/d}{mg mLVS}
\]

\[
\frac{f}{m} \propto \Theta_c
\]
F/M Ratio

- Low F/M ratios are typical in completely mixed activated sludge (CMAS) systems.
- CMAS systems, consequently, often have filamentous bulking problems.
• By using a selector, the F/M in the first compartment of an activated sludge system can be increased, giving the flocculent microorganisms a competitive advantage.

• Typically, the selector should be designed to remove 80-90% of the biodegradable COD.