Algae & Water Hyacinth

Bioresmediation potential for landfill leachate
Landfills

- Handle municipal solid waste (MSW), construction & demolition (C&D), and hazardous wastes.
- 1,754 reported US MSW landfills in 2007 received 137 million tons of waste.
- Material & nutrient sinks
- Air & water pollution
  - CH$_4$, H$_2$S
  - Leachate
Landfill Leachate

• Every landfill has leachate
• Leachate from MSW
  – High NH3-N, BOD, Dissolved Solids, Suspended solids, heavy metals
• Unconfined landfills ➔ groundwater pollution
• Many US landfills are now lined and fitted with pump systems
# Leachate Contents

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>60.2μg/L</td>
</tr>
<tr>
<td>Chromium</td>
<td>77.4μg/L</td>
</tr>
<tr>
<td>Iron</td>
<td>6410μg/L</td>
</tr>
<tr>
<td>Potassium</td>
<td>574mg/L</td>
</tr>
<tr>
<td>Sodium</td>
<td>2290mg/L</td>
</tr>
<tr>
<td>Ammonia as N</td>
<td>1300mg/L</td>
</tr>
<tr>
<td>Ammonium as N</td>
<td>1200mg/L</td>
</tr>
<tr>
<td>COD</td>
<td>2100mg/L</td>
</tr>
<tr>
<td>Electroconductivity</td>
<td>1800μS/cm</td>
</tr>
<tr>
<td>pH</td>
<td>7.6</td>
</tr>
<tr>
<td>Orthopohsophorus</td>
<td>19mg/L</td>
</tr>
</tbody>
</table>
Leachate Treatment Paths

Adapted from (Mulamoottil et al)
What to do with leachate?

• Conventional leachate treatment
  – Trucked to wastewater treatment facilities
    • High ammonia levels creates problems for facilities
    • Cost is High

• Treatment ranges from ponds to electrochemical oxidation

• Treatment Cost is often prohibitive and highly energy consumptive causing difficulties

• Efficient treatments transfer energy cost to environment and sacrifice time
The Ecological Approach

- Increasing interest in environmentally driven systems
  - Lower energy costs
  - On site treatment
- Algae
  - Associated with polluted water
  - Vast biodiversity
- Water Hyacinth
  - Hardiness to nutrients and electroconductivity
  - Easy to harvest
  - Potential for anaerobic digestion
Research

• Water Hyacinth batches removed 24%-80% of heavy metals from serial concentrations in leachate (El-Gendy, 2008)
  – Fast initial adsorption at roots
  – Slower long-term uptake driven by vascular system
• Water Hyacinth batches removed >90% of total nitrogen and phosphorous in diary farm effluent (Sooknah and Wilkie)
• Significant uptake of heavy metals from solution, survival in solutions ~3mg/L total metals (Soltan and Rashed, 2001)
• Potential for biofuel production and nutrient recycle with anaerobic digestion of Water Hyacinth (Wilkie and Evans, 2010)
• Water Hyacinth utilized in stormwater/leachate pond at Escambia County landfill (Mulamoottil et al, 1999)
Experiments

• Water Hyacinths placed in 20 gallon batches of 5, 10, 20, & 50% leachate dilutions to test survival
• 250 gallon batches of 10% leachate; one containing Water Hyacinth the other left alone
  – Conductivity, pH, orthophosphorus, NH$_3$-N, and cell counts monitored
• 2 liter batches of 25, 50, & 75% dilutions of leachate
  – 3 replicates of each dilution; one dilution allowed to grow algae before use the other using fresh leachate
Survival of Hyacinths in Leachate Dilutions

- 5% Leachate
- 10% Leachate
- 20% Leachate
- 50% Leachate
250 Gallon Batch Conductivity

Conductivity (mS/cm)

Date

Ahyacinth

Hyacinth
250 Gallon Batch NH₃-N Nitrogen

Concentration (mg/L) vs. Date

Ahyacinth
Hyacinth
# 2-L Batch Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Initial Conductivity (mS/cm)</th>
<th>Final Conductivity (mS/cm)</th>
<th>Survival (# of Specimens)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% Leachate w/ Algae</td>
<td>2.45</td>
<td>1.88</td>
<td>6 of 6</td>
</tr>
<tr>
<td>25% Fresh Leachate</td>
<td>4.44</td>
<td>2.86</td>
<td>0 of 6</td>
</tr>
<tr>
<td>50% Leachate w/ Algae</td>
<td>3.84</td>
<td>2.88</td>
<td>6 of 6</td>
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<tr>
<td>50% Fresh Leachate</td>
<td>7.88</td>
<td>5.23</td>
<td>0 of 6</td>
</tr>
<tr>
<td>75% Leachate w/ Algae</td>
<td>5.46</td>
<td>4.12</td>
<td>6 of 6</td>
</tr>
<tr>
<td>75% Fresh Leachate</td>
<td>11.31</td>
<td>7.81</td>
<td>0 of 6</td>
</tr>
</tbody>
</table>
2 Liter Batch Experiment
Day 1
2 Liter Batch Experiment
Day 4
Conclusions

• Change in conductivity similar between Hyacinths and native Algae
• Major removal of NH$_3$-N appears non-biological despite uptake by Hyacinth and Algae
• Phosphorus appears to cycle within decreasing trend
  – Possibly influenced by outside sources (animal waste, grass clippings)
• Water Hyacinth grown in leachate dilutions containing algae has greater survivability than in fresh diluted leachate
  – Possibility for two stage treatment utilizing lower volume of clean/treated water
• Investigate utilization of water hyacinth biomass after cultivation in leachate
References

- Soltan ME., Rashed MN. *Laboratory study on the survival of water hyacinth under several conditions of heavy metal concentrations*. Advances in Environmental Research. Vol 7, Pp 321-334. Elsevier.