Preliminary Biodegradation Correlation for Bioventing

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INTRODUCTION

- Soil contamination with total petroleum hydrocarbons (TPH) is a problem
SOURCES of CONTAMINATION

http://www.brinkenv.com/gsa/asmills.jpg
http://www.epa.gov/reg5rcra/wptdiv/r5lust/Leaking%20Tank.jpg
BIOREMEDIATION

- Effective technique for cleaning petroleum contaminated soil
  - Natural attenuation
  - Phytoremediation
  - Landfarming
  - Biopiles
  - Bioaugmentation
  - Bioventing
BIODEGRADATION KINETICS

\[- \frac{dC}{dt} = k \cdot C\]

\[\ln \left( \frac{C}{C_0} \right) = -k \cdot t\]

C: TPH concentration

C_0: initial concentration of TPH

t: time

k: degradation rate constant
FACTORS AFFECTING BIOVENTING

- Controllable
  - Environmental condition
  - Soil properties
  - Contaminant characteristics

- Non-controllable
BENEFITS OF A MODEL

- Biodegradation kinetics are required for prediction purposes
- Field experiments are time consuming and expensive
- Biodegradation rate kinetics are not transferable from one site to another
OBJECTIVES

- Identifying the factors affecting biodegradation rate, including
  - soil properties
  - Contaminant concentration

- Correlating these factors with biodegradation rate constant
METHODOLOGY OVERVIEW

- Simulate field conditions
- Use a respirometer
- Test variety of soils
- Synthetic gasoline
- Optimal environmental conditions
- Develop a model
RESPIROMETER
## SOIL PROPERTIES

<table>
<thead>
<tr>
<th>Soil Characteristics</th>
<th>Delhi</th>
<th>Elora</th>
<th>Brookston</th>
<th>Simcoe</th>
<th>Soil B</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Sand</td>
<td>86.5</td>
<td>34</td>
<td>21</td>
<td>61.9</td>
<td>25.9</td>
</tr>
<tr>
<td>% Silt</td>
<td>9</td>
<td>50</td>
<td>35.1</td>
<td>30.2</td>
<td>14.1</td>
</tr>
<tr>
<td>% Clay</td>
<td>4.5</td>
<td>15.9</td>
<td>43.9</td>
<td>7.9</td>
<td>60</td>
</tr>
<tr>
<td>% Organic Matter</td>
<td>1.2</td>
<td>3.1</td>
<td>1.5</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>CEC (cmol/kg)</td>
<td>8.27</td>
<td>18.9</td>
<td>28.5</td>
<td>5.5</td>
<td>16.2</td>
</tr>
<tr>
<td>EXPERIMENTAL CONDITIONS</td>
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<td>-------------------------</td>
<td></td>
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</tr>
<tr>
<td><strong>Contaminant type</strong></td>
<td>Synthetic gasoline</td>
<td></td>
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<tr>
<td><strong>Initial concentration</strong></td>
<td>200-8000 (mg/kg dry soil)</td>
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<tr>
<td><strong>Nitrogen source</strong></td>
<td>NH₄Cl</td>
<td></td>
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<tr>
<td><strong>C:N ratio</strong></td>
<td>10:1</td>
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<tr>
<td><strong>Water content</strong></td>
<td>18% (wt)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Temperature</strong></td>
<td>25°C</td>
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</tbody>
</table>
DEGRADATION OF TPH

- Measured in three ways:
  
  ✓ TPH consumption (TPH extraction followed by gas chromatography (GC-FID))
  
  ✓ Oxygen consumption (measuring the pressure reduction in the system)
  
  ✓ CO₂ production (trapped in KOH solution followed by titration by 0.1N HCl)
RESULTS

- $k$ vs. TPH initial concentration

![Graph showing the relationship between $k$ (1/day) and Gasoline initial concentration (mg/kg).]
RESULTS – cont.

- $k$ vs. soil type
  (clay, sand, and silt)
RESULTS – cont.

- $k$ vs soil organic matter
RESULTS – cont.

- $k$ vs soil CEC
RESULTS – cont.

- Preliminary correlation using SYSTAT

\[ \ln(k) = 0.794 \cdot OM + 0.040 \cdot Sand + 0.017 \cdot Clay - 0.263 \cdot \ln(CEC) - 5.891 \]

\[ r^2 = 0.87 \]

\( k \): biodegradation rate constant (1/day)
\( OM \): organic matter content of soil (%)
\( Sand \): soil sand content (%)
\( Clay \): soil clay content (%)
\( CEC \): cation exchange capacity of soil (cmol/kg)
RESULTS – cont.

- Predictions vs. measurements

![Graph showing predictions vs. measurements](image)
FURHER WORK

- Evaluate effect of other parameters affecting the k value, including:
  - soil microorganism population
  - spill age

- More experiments to improve the reliability of the model
ACKNOWLEDGMENT

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