Hyperspectral Sensing in Support of Oil Sands Tailings Operation and Management

Iman Entezari, Benoit Rivard, Michael Lipsett, and Ward Wilson

University of Alberta, Edmonton, AB
Spectral Sensing

- Measuring the reflectance of light from a target material as a function of wavelength.

Tailings characterization is required to:
- monitor their state for trafficability and reclamation issues.
- assess the tailings operation performance.
- Sampling campaigns are labour-intensive and limited to a small number of locations.
✓ Use hyperspectral methods for estimating the characteristics of tailings.
  • quick, cost-effective, non-hazardous, large-scale monitoring, little/no sample preparation.
1. Estimation of water content and normalized evaporation.
2. Estimation of MBI.
3. Estimation of clays and quartz content.
Estimation of Moisture Content & Normalized Evaporation

- Real-time & large-scale assessment of dewatering and drying progress without physical sampling.

\[ \text{NSMI} = \frac{R(1.8) - R(2.12)}{R(1.8) + R(2.12)} \]
Estimation of Moisture Content & Normalized Evaporation

Field Monitoring

- Field imagery

- Moisture content maps (using modified NSMI)

- Airborne data
Quick predictions of activity provide insights into geotechnical stability of tailings and can help in tailings operations (e.g. in flocculation process).

Sample Suite

- 6 flocculated and 7 non-flocculated tailings samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBI (meq/100g)</td>
<td>2.3</td>
<td>2.3</td>
<td>3.1</td>
<td>3.4</td>
<td>3.4</td>
<td>0.7</td>
<td>2.7</td>
<td>3.4</td>
<td>5.2</td>
<td>5.2</td>
<td>5.9</td>
<td>10.5</td>
<td></td>
</tr>
</tbody>
</table>

Spectral Measurements
MBI Estimation

- SWIR Spectra & Models

![Graph showing SWIR Spectra & Models with reflectance values for different wavelengths and MBI samples. The graphs indicate the relationship between MBI and reflectance ratio at specific wavelengths.](image-url)
Water Sensitivity Analysis of SWIR Model

- Model based on 1.773 to 1.307 ref. ratio

- SD of the MBI values estimated below 20 wt% moisture content.

<table>
<thead>
<tr>
<th>Sample MBI</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>0.17</td>
</tr>
<tr>
<td>3.5</td>
<td>0.52</td>
</tr>
<tr>
<td>5.2</td>
<td>0.53</td>
</tr>
<tr>
<td>10.5</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Model RMSE = 0.56
MBI Estimation

- LWIR Spectra & Models
Field Monitoring

- Photo
- MBI
- Water content

Low to High water content range
Quick determination of mineralogy of oil sands ore and tailings can enhance bitumen production processes and tailings operation.

**Sample Suite**

- 13 Dean-Stark extracted samples
  - bulk sample (4 samples)
  - <2 µm (3 samples)
  - 0.2-2 µm (2 samples)
  - <0.2 µm (4 samples)
Estimation of Clays and Quartz

- Correlations between Mineralogy & Spectral Features
  - Total 2:1 Clay
  - Kaolinite
Correlations between Mineralogy & Spectral Features

- Quartz

- Total Clay
- Mapping of Kaolinite to Total 2:1 Clays Ratio
  - Using LWIR models
Can spectral observations be related to flocculation process?

<table>
<thead>
<tr>
<th>Dose</th>
<th>500ppm</th>
<th>500ppm</th>
<th>850ppm</th>
<th>850ppm</th>
<th>1000ppm</th>
<th>1000ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing Time</td>
<td>15sec</td>
<td>1min</td>
<td>15sec</td>
<td>1min</td>
<td>15sec</td>
<td>1min</td>
</tr>
</tbody>
</table>
Thank You!