REAL-TIME PREDICTION OF OIL SANDS TAILINGS PROPERTIES USING HYPERSPECTRAL OBSERVATIONS

Iman Entezari, Benoit Rivard, James Sharp, Sean Wells, Mark Styler, and Dallas McGowan
Background

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

IOSTC 2014: Real-time & large-scale assessment of dewatering and drying progress.

\[ \text{NSMI} = \frac{R(1.8)-R(2.12)}{R(1.8)+R(2.12)} \]
Background

IOSTC 2014

Tailings Water Content Map

dry  wet
Background

IOSTC 2016: MBI Estimation (unsaturated tailings)

<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>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>
</tr>
</tbody>
</table>

RMSE = 0.56 meq/100g
R² = 0.96

Model performs well when water content is <20 wt%
Objective:
Calibrating and validating spectral models for the estimation of tailings characteristics using a large suite of saturated/wet tailings.

- MBI
- Water content
- Bitumen content
Samples

• More than 1000 samples from various Suncor tailings ponds were made available.
• 290 samples were selected based on the pond, the site location, and the laboratory data to ensure they represented the entire sample population.
• Samples from froth treatment tailings were included.
Samples

• Split samples to calibration and validation sets
• 232 samples for calibration
• 58 samples for validation
Spectral Measurements

Saturated/Wet Tailings Spectral Measurements
Spectral Measurements

Dry Tailings Spectral Measurements
ShortWave IR Spectra

Saturated Tailings Spectra
Pre-Processing

- Mean Vector Normalization
- $1^{st}$ Derivative Transformation
- Absorbance
Modelling

Partial Least Square Regression

PLS finds a linear regression model by projecting the predicted variables (tailings properties) and the observable variables (hyperspectral data) to a new space.

An iterative stepwise elimination process was employed to select the optimum bands (most informative bands) for PLS regression.

• Calibrate a PLS model using all bands (wavelengths)
• Eliminate the band with the lowest importance
• Examine 5 to 30 PLS components in each iteration
• Determine the optimum number of bands and PLS components (i.e. best model) by assessing R-squared and root mean square error (RMSE) values on the validation set.

- Any errors in the laboratory data will inherently introduce errors in the spectral models.
- The laboratory data is incorrectly assumed to be perfect in order to determine models errors.
MBI Estimation

R-squared = 0.94
RMSE = 1.12 (meq/100g)
Water Content Estimation

R-squared = 0.96
RMSE = 4.3 (wt%)

- Calibration Set
- Validation Set
Bitumen Content Estimation

- R-squared = 0.91
- RMSE = 0.57 wt%
Key Advantages

- Real-time assessment of MBI, water content, and bitumen content of oil sands tailings with sufficient accuracy.
- Repeatable and objective predictions of tailings characteristics that are less prone to human errors.
- Minimal sample preparation for measuring the tailings spectra.
- A single measurement (i.e. spectrum) can be used to estimate multiple tailings characteristics.
- Significantly lower cost than laboratory analysis procedures.
- Eliminates chain of custody and sample handling / disposal issues.
Future Work

• Implement the technology for on-site characterization of tailings properties in 2019.
• Measure more samples and improve the models, extending the range of tailings types.
• Estimation of other tailings characteristics.
• Combine hyperspectral data and measurements from other sources (e.g. Gamma CPT, Ball CPT, Spectral Gamma) to improve models.
BETTER INFORMATION BETTER DECISIONS

conetec.com