Exploring the Potential of Remote Sensing Techniques for Quantitative Estimation of Mercury Concentration in Inland Surface Water Bodies

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Key Points of Presentation

• Mercury Pollution Issue
• Mercury Estimation in Enid Lake, MS using Remote Sensing
• Mercury Pollution Issue in TN
• Future Research Potentials
Mercury Pollution Issue

- Mercury is one of the widely distributed pollutants in the environment.
- Coal-burning power plants – largest mercury air emissions in the U.S. (50% of all domestic human-caused mercury emissions).
Mercury Pollution Issue

- Thousands of waterbodies are listed on state Clean Water Act Section 303(d) lists as impaired due to mercury, often due to high mercury levels in fish.

- Mercury accumulates in fish tissue as methylmercury, the form that presents the greatest risk to human health through consumption of contaminated fish.

<table>
<thead>
<tr>
<th>Cause of Impairment</th>
<th>Rivers and Streams (Miles)</th>
<th>Lakes, Reservoirs, and Ponds (Acres)</th>
<th>Bays and Estuaries (Square Miles)</th>
<th>Coastal Shoreline (Miles)</th>
<th>Ocean and Near Coastal (Square Miles)</th>
<th>Wetlands (Acres)</th>
<th>Great Lakes Shoreline (Miles)</th>
<th>Great Lakes Open Water (Square Miles)</th>
<th>Great Lakes Connecting Channel (Miles)</th>
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<tbody>
<tr>
<td>Mercury</td>
<td>29,810</td>
<td>1,710,439</td>
<td>6,760</td>
<td>12</td>
<td>213</td>
<td>69,385</td>
<td>322</td>
<td>29,816</td>
<td>151</td>
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<tr>
<td>Mercury in Fish Tissue</td>
<td>69,172</td>
<td>6,247,713</td>
<td>14,416</td>
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<td>5,264</td>
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<td>2,131</td>
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<td>Mercury in Water</td>
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<td>Mercury in Water Column</td>
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<td>Methylmercury</td>
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Source: https://www.epa.gov/tmdl/impaired-waters-and-mercury
Mississippi currently has 11 water bodies under fish consumption advisories for mercury, including Enid Lake.

The potential of remote sensing techniques were explored to estimate mercury concentration associated with suspended sediments in Enid Lake.
MODIS visible and near-infra red (VNIR) imagery (Band 1 and Band 2).

- **Orbit**: 705 km, 10:30 a.m. descending node (*Terra*) or 1:30 p.m. ascending node (*Aqua*), sun-synchronous, near-polar, circular

- **Swath Dimensions**: 2330 km (cross track) by 10 km (along track at nadir)

- **Repeat coverage**: Twice Daily

- **Spatial and Spectral Resolution**: 250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36)

- **Data Available**: Since early 2000
Ground Measurements of Mercury

Sampling Locations for Field Trip in March 12, 2013 in Enid Lake, MS

Field campaign on March 12, 2013

Sampling Locations for Field Trip in Nov 19, 2013 in Enid Lake, MS

Field campaign on Nov 19, 2013
## Water Quality and Reflectance Data

### March 12, 2013 Field Campaign

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>TDS (mg/L)</th>
<th>DO (mg/L)</th>
<th>Cond. (μs/cm)</th>
<th>TSS (mg/L)</th>
<th>Total-Hg (ng/L)</th>
<th>Reflectance (%)</th>
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<td></td>
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<td>Unfiltered</td>
<td>Filtered</td>
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<td>48.3</td>
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<td>6.6</td>
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<td>37.7</td>
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<td>3.8</td>
</tr>
</tbody>
</table>
Mercury Associated TSS

Correlation Between Unfiltered Hg and TSS
March 12, 2013

$y = 0.1452x + 4.1783$
$R^2 = 0.5652$
Correlation Between Unfiltered Hg and TSS
November 20, 2013

\[ y = 0.371x - 3.6792 \]

\[ R^2 = 0.5258 \]
Correlation Between MODIS Red Band and TSS
March 12, 2013

\[ y = 14.643x - 148.52 \]
\[ R^2 = 0.8273 \]
Mercury Estimation Using Remote Sensing

Correlation Between MODIS Red Band and Unfiltered Hg
March 12, 2013

$y = 2.5624x - 22.879$

$R^2 = 0.6788$
Mercury Estimation Using Remote Sensing

Correlation Between MODIS Near-infra Red (NIR) Band and TSS
March 12, 2013

\[ y = 11.882x - 27.983 \]
\[ R^2 = 0.5728 \]
Mercury Estimation Using Remote Sensing

Correlation Between MODIS Near-infra Red Band and Unfiltered Hg
March 12, 2013

\[ y = 2.3597x - 3.2944 \]
\[ R^2 = 0.6053 \]
Mercury Estimation in Enid Lake, MS

Estimated Mercury concentration associated with TSC (March 12, 2013)
Mercury Pollution in TN Waterbodies

There are currently 263 stream miles and 67,562 reservoir acres assessed as impaired by mercury in Tennessee (TDEC, 2010).

This is due to a variety of sources including current and legacy industrial discharges, contaminated bridges and air deposition.

Source: TDEC, 2010
A fish tissue and water chemistry monitoring study was conducted on 33 waterbodies across the state by the Division of Water Pollution Control, TDEC in summer and fall 2009.

The study was designed to field test the REMSAD model’s ability to accurately predict waterbody and fish tissue contamination from air deposition of mercury in Tennessee.

Source: TDEC, 2010
Mercury Pollution in TN Waterbodies

- Results were variable. In general, the model did not appear to be a good predictor of fish tissue contamination.

- Several fish taken from areas with predicted high levels of air deposition contained relatively little mercury.

- Fish with higher concentrations of mercury came from areas with low predicted air deposition.

- Six fish fillet composites had elevated mercury. None of these were in areas where the REMSAD mercury air deposition prediction was highest.

Source: TDEC, 2010
Mercury Pollution in TN Waterbodies

- Mercury was undetected in the water samples at most sites.
- Five sites had mercury above Tennessee’s water quality criterion for the classified use of recreation.
- None of the elevated water samples were collected where air deposition predictions were highest.

Source: TDEC, 2010
Potential Future Research

- Develop remote sensing based techniques to estimate different water quality parameters including mercury in TN rivers, lakes, and reservoirs.

- Estimate mercury concentration in rivers, lakes, and reservoirs after storm events using historical data.

- Evaluate the impacts of upland watershed landuse and landcover changes on the water quality of rivers, lakes, and reservoirs.