Background and Introduction

Mercury Atmospheric Deposition to and Runoff from Catchments in Michigan’s Upper Peninsula

Hang Wang¹, Noel R. Urban¹, Huaxin Zhang²
¹ Dept. of Civil and Environmental Engineering, ² Dept. of Geological and Mining Engineering and Sciences, hangw@mtu.edu

Mercury Atmospheric Deposition to and Runoff from Catchments in Michigan’s Upper Peninsula

Background and Introduction

• To understand lake sediment profiles of mercury or to use mass balance models to predict mercury methylation and bioaccumulation in lakes, mercury inputs from the catchment must be known.
• Several previous mercury mass balance models for lakes include an assumption that 25% of mercury entering the catchment from atmospheric deposition will run off the catchments into the lake Szlachta et al. (2008).
• Other studies have assumed identical rates for wet and dry atmospheric deposition, or identical rates of atmospheric deposition to the lake and the catchment, or other similar assumptions that impact the model results.
• The goal of this study is to re-examine the fraction of atmospheric deposition that enters a catchment and is mobilized into lakes.
• This study focuses on the Upper Peninsula of Michigan because land cover and environmental conditions are relatively uniform across the region.

Assumptions

• To calculate the conversion rate in GIS, a few assumptions were made:
  o There is no catchment area readily available for individual inland lakes. So 12-digit hydrologic units (USGS) were used instead of lake catchments. All lakes within a hydrologic unit were regarded as one lake for which the hydrologic unit is the catchment.
  o The average runoff rate in the Upper Peninsula is 3 cm/m^3/year (Szalma 2010). This runoff rate is applied to all modeled catchments and lakes.

Results and Discussion

Mercury Inlet to Catchments

• Mercury inputs to catchments include both Dry & Wet Atmospheric Deposition
• Previous studies have assumed dry deposition and wet deposition are equal, and deposition over lakes equals deposition to catchments. We focus on runoff, and gathered information from MICHIGAN’S WATER CHEMISTRY MONITORING PROGRAM (10) about mercury concentrations in runoff at 70 monitoring sites in the U.P. (Figure 5.)
• Mercury entering a catchment may follow one of three pathways: (1) Accumulate in soil,
• We focus on runoff, and gathered information from MICHIGAN’S WATER CHEMISTRY MONITORING PROGRAM (10) about mercury concentrations in runoff at 70 monitoring sites in the U.P. (Figure 5.)
• Future Work

Reference


Figure 1. Mercury mass model for a lake and its catchment

Dry & Wet Dep. C = Deposition on the Catchment
Dry & Wet Dep. L = Deposition on the Lake

Conversion Rate = Runoff
Dry Dep. + Wet Dep.

Figure 2. Taking Hydrologic units in Schoolcraft County as an example, we treat all the watersheds within a hydrologic unit as one lake, and the hydrologic unit as the catchment for this lake.

Figure 3. Total mercury dry deposition flux for 2008 (points) with Kriging interpolation applied to each county.

• Interpolated deposition along the shoreline of the Great Lakes is underestimated in some areas due to the Kriging: nearshore deposition over the Great Lakes is also inaccurately estimated by this method.

Figure 4. Total mercury wet deposition flux for 2008 (points) with Kriging interpolation applied to each county.

• Interpolated deposition along the shoreline of the Great Lakes is underestimated in some areas due to the Kriging: nearshore deposition over the Great Lakes is also inaccurately estimated by this method.

Figure 5. Monitoring Sites located in the Upper Peninsula, Michigan from MICHIGAN’S WATER CHEMISTRY MONITORING PROGRAM (10)
• All sites are the mouths of rivers entering a Great Lake.

Table 1. Median and average mercury concentration in 7 rivers in the Upper Peninsula.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Median Hg Conc. (ng/L)</th>
<th>Average Hg Conc. (ng/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontonagon River</td>
<td>1.94</td>
<td>9.54</td>
</tr>
<tr>
<td>Menominee River</td>
<td>2.44</td>
<td>2.57</td>
</tr>
<tr>
<td>Escanaba River</td>
<td>2.74</td>
<td>4.28</td>
</tr>
<tr>
<td>Sturgeon River</td>
<td>2.69</td>
<td>4.62</td>
</tr>
<tr>
<td>Manistique River</td>
<td>2.3875</td>
<td>3.47</td>
</tr>
<tr>
<td>Tahquamenon River</td>
<td>3.09</td>
<td>5.95</td>
</tr>
<tr>
<td>Pine River</td>
<td>2.34</td>
<td>1.96</td>
</tr>
</tbody>
</table>

Table 2. Conversion Rate of 7 Hydrologic Units in Upper Peninsula

<table>
<thead>
<tr>
<th>Site name</th>
<th>Using Median Conc.</th>
<th>Using Average Conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontonagon River</td>
<td>3.8%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Menominee River</td>
<td>2.9%</td>
<td>20.0%</td>
</tr>
<tr>
<td>Escanaba River</td>
<td>3.8%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Sturgeon River</td>
<td>8.6%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Manistique River</td>
<td>4.4%</td>
<td>6.4%</td>
</tr>
<tr>
<td>Tahquamenon River</td>
<td>6.9%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Pine River</td>
<td>3.3%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

The conversion rates range from 2.0% to 18.5% with a mean value of 6.4%.

More mercury concentration data are needed for the Upper Peninsula area.

The assumptions made in this study will be evaluated; one option is to test all hydrologic units linked by a single river as a catchment.

We gratefully acknowledge the help of Tanvir Khan in this study.

Future Work

The average mercury concentration is calculated by mean annual mercury load and mean annual flow rate. Since the time scale of our study is 1 year, we will choose average concentration as our input data. We use median concentrations as indicative of summer conditions.

Mercury runoff output = Hg Concentration × 3 cm/m^3/year × Hydrologic Unit Area

Future Work

The assumptions made in this study will be evaluated; one option is to test all hydrologic units linked by a single river as a catchment.

We gratefully acknowledge the help of Tanvir Khan in this study.

Acknowledgement:

Future Work

The average mercury concentration is calculated by mean annual mercury load and mean annual flow rate. Since the time scale of our study is 1 year, we will choose average concentration as our input data. We use median concentrations as indicative of summer conditions.

Mercury runoff output = Hg Concentration × 3 cm/m^3/year × Hydrologic Unit Area

Future Work

The average mercury concentration is calculated by mean annual mercury load and mean annual flow rate. Since the time scale of our study is 1 year, we will choose average concentration as our input data. We use median concentrations as indicative of summer conditions.

Mercury runoff output = Hg Concentration × 3 cm/m^3/year × Hydrologic Unit Area

Future Work

The average mercury concentration is calculated by mean annual mercury load and mean annual flow rate. Since the time scale of our study is 1 year, we will choose average concentration as our input data. We use median concentrations as indicative of summer conditions.

Mercury runoff output = Hg Concentration × 3 cm/m^3/year × Hydrologic Unit Area

Future Work

The average mercury concentration is calculated by mean annual mercury load and mean annual flow rate. Since the time scale of our study is 1 year, we will choose average concentration as our input data. We use median concentrations as indicative of summer conditions.

Mercury runoff output = Hg Concentration × 3 cm/m^3/year × Hydrologic Unit Area

Future Work

The average mercury concentration is calculated by mean annual mercury load and mean annual flow rate. Since the time scale of our study is 1 year, we will choose average concentration as our input data. We use median concentrations as indicative of summer conditions.

Mercury runoff output = Hg Concentration × 3 cm/m^3/year × Hydrologic Unit Area