Water Quality Analysis of the Lamprey River Watershed

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Motivation
Good water quality is important to the ecosystem and human health. The Lamprey River was designated as a National Wild and Scenic River in 1984. However, the river has been suffering from pollution, including nutrient enrichment, metal contamination, and invasive species, which can affect water quality. The Lamprey River flows into the Great Bay Estuary, which is suffering from hypoxia and degradation. This study aims to characterize the phosphorus and heavy metal loads of the Lamprey River.

Spatial Analysis
- Locations where highest concentrations were found in 2005 and 2015
- Elevations and water quality
- Metals and pH in 2005 and 2015
- Spatial trends in water quality

Data Summary
- Number of samples from 2005 and 2015
- Total samples from 2005 and 2015
- Number of samples from 2005 and 2015
- Number of samples from 2005 and 2015

Temporal Analysis
- Each parameter and its stage over the years from 2005 to 2015
- Specific stages for each parameter

Conclusions
- The Lamprey River is suffering from high phosphorus and heavy metal concentrations, which affect the water quality, and may be considered for restoration.
- The Lamprey River is considered to be at a high risk of contamination by heavy metals and nutrients.
- The Lamprey River is considered to be at a moderate risk of contamination by organic pollutants.

Acknowledgements
I would like to thank Anne Lightbody and the Lamprey River Advisory Committee for their guidance and support. I would also like to thank the people and organizations that collect water quality data and the NEDSS for making it available.
Motivation

• Good water quality is important for the ecosystem and human health.

• The Lamprey River was designated as a National Wild and Scenic River on the basis of its outstandingly remarkable scenic, recreational, geologic, fish and wildlife, and historical resources, which all depend on its water quality.

• It is also a major water source for residents living in the watershed and the University of New Hampshire.

Figure 1. (A) Photo of the beautiful Lamprey River at Packers Falls in Durham; (B) location of the Lamprey River watershed in New Hampshire.
Data Summary

Figure 2. The Lamprey River watershed in southeast New Hampshire showing the main stem, major tributaries, and sampling locations.
Table 1. Summary of measurements for each solute, including the total number of measurements, average concentration over the period of record, NHDES standard, number of measurements before and after 1/1/2000, and percentage of exceedances before and after 1/1/2000.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total Count</th>
<th>Number of Stations</th>
<th>Average (mg/L)</th>
<th>NHDES Standard (mg/L)</th>
<th>Percentage Exceedance</th>
<th>Number of Measurements Before 2000</th>
<th>Number of Measurements After 2000</th>
<th>Percentage Exceedance Before 2000</th>
<th>Percentage Exceedance After 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>2269</td>
<td>59</td>
<td>0.0236</td>
<td>0.035</td>
<td>13.75%</td>
<td>291</td>
<td>1897</td>
<td>19.93%</td>
<td>12.70%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>165</td>
<td>26</td>
<td>0.1051</td>
<td>0.087</td>
<td>31.52%</td>
<td>133</td>
<td>32</td>
<td>30.83%</td>
<td>34.38%</td>
</tr>
<tr>
<td>Zinc</td>
<td>157</td>
<td>25</td>
<td>0.1827</td>
<td>0.03</td>
<td>25.00%</td>
<td>134</td>
<td>22</td>
<td>29.10%</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>141</td>
<td>25</td>
<td>0.0109</td>
<td>0.0023</td>
<td>51.77%</td>
<td>131</td>
<td>10</td>
<td>54.96%</td>
<td>10.00%</td>
</tr>
<tr>
<td>Lead</td>
<td>133</td>
<td>26</td>
<td>0.0038</td>
<td>0.065</td>
<td></td>
<td>121</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>18</td>
<td>12</td>
<td>0.0042</td>
<td>0.0133</td>
<td>11.11%</td>
<td>13</td>
<td>5</td>
<td>11.11%</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>13</td>
<td>11</td>
<td>0.0003</td>
<td>0.0002</td>
<td>15.38%</td>
<td>13</td>
<td></td>
<td>15.38%</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>13</td>
<td>11</td>
<td>0.0100</td>
<td>0.011</td>
<td></td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>13</td>
<td>10</td>
<td>0.6145</td>
<td>1</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>5</td>
<td>4</td>
<td>&lt;0.0001</td>
<td>0.0008</td>
<td></td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Summary of measurements for each solute, including the total number of measurements, average concentration over the period of record, NHDES standard, number of measurements before and after 1/1/2000, and percentage of exceedances before and after 1/1/2000.
Figure 3. All data for phosphorus shown by day of year with monthly average concentration and daily average discharge
Figure 4. All data for aluminum, chromium, iron, and zinc shown by day of year
Figure 5. All data for cadmium, copper, lead, mercury, and nickel shown by day of year
Temporal Analysis

Figure 6. Time series of annual average total phosphorus concentration and its recommended standard
Figure 7. Time series of aluminum, chromium, iron and zinc concentrations for all sites with their standards (dashed lines) and trends (solid lines) if the concentration changes over time (p<0.05)
Figure 8. Time series of cadmium, copper, lead, mercury, and nickel concentrations for all sites with their standards (dashed lines) and trends (solid lines) if the concentration changes over time (p<0.05)
Spatial Analysis

Figure 9. Spatial patterns of phosphorus averaged measurements (a) before and (b) after 1/1/2000
Figure 10. Spatial patterns of aluminum averaged measurements (a) before and (b) after 1/1/2000
Figure 11. Spatial patterns of (a, b) copper and (c, d) zinc averaged measurements (a, c) before and (b, d) after 1/1/2000.
Conclusions

• Overall the surface water quality of the Lamprey River watershed is high, and it is suitable for recreational purposes. However, the Lamprey River occasionally exhibits high phosphorus and heavy metal concentrations. Heavy metals exceedances occurred in portions of the watershed that are more developed or have a legacy of industrial activity.

• Conclusions about heavy metal levels are limited by a lack of regular monitoring data for the water column and deposited sediment. In addition, isolated grab samples cannot capture fluxes during storms, even though those short-duration events may drive annual loads.

• Frequent phosphorus monitoring is recommended in spring and summer to recognize conditions that could promote algal blooms in embayments and impoundments.
Thank You!