An Overview of External Phosphorus Loading to Lake Erie

Ohio Lake Erie Phosphorus Task Force
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Outline: An Overview of Phosphorus

Phosphorus Sources: external and internal
Phosphorus Sources: point and nonpoint
Phosphorus Forms: dissolved and particulate
Phosphorus Bioavailability: high to low, positional
Phosphorus Inputs: pulsed and steady
Some Trends in the Above: an overview
Lake Erie Phosphorus Sources

**External Loads**
Phosphorus that enters Lake Erie from the atmosphere, the Upper Lakes, or the Lake Erie watershed.

**Internal Loads**
Phosphorus released from bottom sediments, as mediated by chemical, physical and biological processes.

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Total External Phosphorus Loading to Lake Erie

**Annual Loads of Total Phosphorus to Lake Erie, 1967-2002**

- Phosphorus target load 11,000 metric tons/yr.
External Loads

1. Lake Huron output

2. Atmospheric deposition

(From Lake Erie Watershed)

3. Point Sources – associated with municipal and industrial water use

4. Nonpoint Sources – associated with land use activities

Sources of External Phosphorus: The Lake Erie Watershed
How do we measure external phosphorus loading?

- **Lake Huron** – outflow and concentration
- **Atmospheric Deposition** – from deposition network
- **Point sources** – from point source reporting systems (NPDES permits in U.S.)
- **Nonpoint sources** – watershed export/tributary monitoring programs and extrapolations to unmonitored areas
The watershed approach for quantifying nonpoint phosphorus loading

- Point source input
- Stream gaging/monitoring station

**watershed boundary**

Nonpoint source loading = Total watershed output - Point source inputs

The Ohio Tributary Loading Program

Program started by Heidelberg College in 1974 for Lake Erie tributaries

Major support from the Division of Soil and Water Conservation, ODNR
### Phosphorus Forms: Dissolved and Particulate

<table>
<thead>
<tr>
<th>Phosphorus Forms</th>
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</thead>
<tbody>
<tr>
<td><strong>Total Phosphorus (TP)</strong></td>
</tr>
<tr>
<td><strong>Dissolved Phosphorus</strong></td>
</tr>
<tr>
<td></td>
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<tr>
<td><strong>Particulate Phosphorus (PP)</strong></td>
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</table>

### Phosphorus Bioavailability

<table>
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<tr>
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<tr>
<td><strong>Total Phosphorus (TP)</strong> -</td>
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<tr>
<td><strong>Dissolved Phosphorus</strong></td>
</tr>
<tr>
<td>dissolved reactive phos. (DRP) --</td>
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<tr>
<td>dissolved hydrolyzable phos. (DHP) --</td>
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<tr>
<td>total dissolved phosphorus (TDP) --</td>
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<tr>
<td>dissolved organic phosphorus) –</td>
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**Particulate Phos. (PP)** -

- NaOH extractible PP

*Bioavailability varies among phosphorus forms and sources.*
Bioavailability by Phosphorus Source

Point Sources (mostly municipal sources)
- Mostly dissolved reactive phosphorus
- Highly bioavailable

Nonpoint sources (mostly agricultural sources)
- Mostly particulate (attached to inorganic sediments)
- Particulate phosphorus ranges from 10-30% bioavailable
- Dissolved component is mostly dissolved reactive phosphorus and is highly bioavailable.

Timing of Phosphorus Inputs

Point sources
- Steady (approximately equal daily loading from waste treatment plants

Nonpoint sources
- Pulsed inputs associated with rainfall/snowmelt runoff events
- High annual and seasonal variability
Maumee River, Phosphorus loading rate, 2003 water year

Detroit R. + Rouge R.
TP loading rate 2,255 kg/day (2002)
<table>
<thead>
<tr>
<th>Date</th>
<th>Flow (cfs)</th>
<th>TP (mg/L as P)</th>
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</thead>
<tbody>
<tr>
<td>7/1/03</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>7/11/03</td>
<td>0.100</td>
<td>0.200</td>
</tr>
<tr>
<td>7/21/03</td>
<td>0.200</td>
<td>0.400</td>
</tr>
<tr>
<td>7/31/03</td>
<td>0.300</td>
<td>0.600</td>
</tr>
<tr>
<td>8/10/03</td>
<td>0.400</td>
<td>0.800</td>
</tr>
<tr>
<td>8/20/03</td>
<td>0.500</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Detroit River
- 24.3 km³ water
- 287 metric tons TP
- 15x more water

Maumee River
- 1.56 km³ water
- 587 metric tons TP
- 2x more phosphorus

Additional definitions relative to Lake Erie loading calculations

**Point Sources**

A. Indirect –
   - Point sources upstream from tributary loading stations

B. Direct –
   - All other point sources, i.e. point source that discharge into the lake, monitored tributaries downstream from the monitoring station or into any unmonitored stream.

**Nonpoint Sources**

A. Monitored

B. Unmonitored (extrapolated from nearby monitored stations)
The watershed approach for quantifying nonpoint phosphorus loading

Nonpoint source loading = Total watershed output - Point source inputs

The Ohio Tributary Loading Program

Indirect point sources
Direct point sources
Monitored nonpoint loads
Unit area nonpoint loads
Unmonitored nonpoint loads
Trends in Point Source Loading to Lake Erie

Point Source Loading to Lake Erie

- Direct PS
- Indirect PS
- Point Source

Target Load

Trends in Nonpoint Source Loading to Lake Erie

Lake Erie, Nonpoint Phosphorus Loads, 1974-2002

$R^2 = 0.0763$, P-value = 0.15, 28% decrease
**Trends in the ratio of nonpoint to point source loading**

Lake Erie TP Loading: NPS/PS ratio

**Maumee River: Trends in Particulate Phosphorus Loads**
Maumee River: Dissolved Reactive Phosphorus Loading

Maumee River – Trends in Dissolved Reactive Phosphorus as a percent of Total Phosphorus

Maumee River – Dissolved reactive phosphorus loads as a percent of total phosphorus loads
Sandusky River – Trends in Particulate Phosphorus Loading

Sandusky River: Particulate Phosphorus Loading

Particulate phosphorus, m tons


Water Year

Sandusky River – Trends in Dissolved Reactive Phosphorus Loading

Sandusky River: Soluble Reactive Phosphorus Loads

SRP Loads, metric tons


Water Year
Sandusky River – Trends in Dissolved Reactive Phosphorus Loading as Percent of Total Phosphorus Loads

Some Conclusions

1. We probably need to look at more than simply total phosphorus loading to Lake Erie
2. Some of the changes in external loading

a. Point sources had a rapid drop followed by slower declines.

b. Total nonpoint loads have slowly declined since the late 1970s.

C. The ratio of NPS to PS has increased greatly, as has the relative contributions of pulsed inputs.

d. NPS particulate phosphorus has decreased slowly.

e. NPS dissolved reactive phosphorus declined rapidly in the early years but has risen rapidly in recent years.

f. In recent years tributary loads have a higher proportion of bioavailable phosphorus than in earlier years.

Questions

What do these changes in loading characteristics mean for Lake Erie?

Why has dissolved reactive phosphorus loading increased in recent years?

What can be done to reduce the dissolved reactive phosphorus loading… if it needs to be reduced?