ESM 202

Eutrophication

Maps showing geographic regions and water bodies.

Images of landscapes and water bodies.
US East Coast

Effects of Eutrophication

Adverse Effects of Eutrophication

- Increased biomass of phytoplankton
- Shifts in phytoplankton to blooming species which may be toxic or indelible
- Increases in blooms of gelatinous zooplankton (marine environments)
- Increased biomass of benthic and epiphytic algae
- Changes in macrophyte species composition and biomass
- Death of coral reefs and loss of coral reef communities
- Decreases in water transparency
- Taste, odor, and water treatment problems
- Oxygen depletion
- Increased incidence of fish kills
- Loss of desirable fish species
- Reductions in harvestable fish and shellfish
- Decreases in perceived aesthetic value of the water body
Effects of Eutrophication

Figure 4 - Nitrogen over-enrichment can lead to nuisance blooms of eutrophic seaweeds (macroalgae, left photo), which can have severe impacts on euryhaline bivalves and coral reefs. On the right, sponges and corals overgrown by the seaweed Codium tomentosum in Southeast Florida.


Effects of Eutrophication

Figure 5 - The severe short-term detrimental impacts of nitrogen and phosphorus in Lake Erie are the cause of concern from 1970 to 1975. Note that P inputs decreased after 1970 due to controls of waste inputs of N and P. Eutrophication first appeared in the late 1960s and became much worse in the following two decades, clearly indicating that N caused the eutrophication involved from Root et al. 1990, as printed in NIE, 2003.


Sources of Cultural Eutrophication

Discharge of untreated municipal sewage and stormwater runoff
- Nutrient inputs and release of nitrogen
- Release of phosphates

Discharge of treated municipal sewage
- Primary and secondary treatment
- Release of nitrogen and phosphates

Discharge of industrial and agricultural runoff
- Nutrient inputs and release of nitrogen
- Release of phosphates

Discharge of municipal sewage
- Nutrient inputs and release of nitrogen
- Release of phosphates

Lake eutrophication
- Nutrient overload and biodegradation chemical cycling

Sources of Point and Nonpoint Pollution

POINT SOURCES
- Wastewater effluents from municipal and industrial
- Runoff and leaching from waste disposal sites
- Runoff and infiltration from animal feedlots
- Runoff from mines, oil fields, and unsealed industrial sites
- Storm water outfalls from cities with a population greater than 100,000
- Runoff from construction sites larger than two hectares
- Overflows of combined storm and sanitary sewer systems

NONPOINT SOURCES
- Runoff from agriculture (including return flow from irrigated agriculture)
- Runoff from pastures and range
- Urban runoff from unsewered areas and sewer systems with a population of less than 100,000
- Septic systems and runoff from ditches and ditches
- Runoff from construction sites smaller than two hectares
- Runoff from abandoned mines
- Atmospheric deposition over water surfaces
- Activities on land that generate contaminants, such as logging, mining, and construction and development of land or waterways

Source: Principles Env. Sci. & Eng. (Stein & Weisburg)

Lake Ageing

Figure A-33

Source: Principles Env. Sci. & Eng. (Stein & Weisburg)
Classification of Lakes

Table 4-2: Lake Classification Based on Productivity

<table>
<thead>
<tr>
<th>Lake Classification</th>
<th>Chlorophyll a Concentration (μg • L⁻¹)</th>
<th>Secchi Depth (m)</th>
<th>Total Phosphorus Concentration (μg • L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligotrophic</td>
<td>Average: 1.7</td>
<td>4.6</td>
<td>0.3 – 2.0</td>
</tr>
<tr>
<td></td>
<td>Range: 0.9 – 8.6</td>
<td>2.0</td>
<td>1.0 – 10.6</td>
</tr>
<tr>
<td>Mesotrophic</td>
<td>Average: 4.7</td>
<td>4.2</td>
<td>5.0 – 10.0</td>
</tr>
<tr>
<td></td>
<td>Range: 3.1 – 10.6</td>
<td>1.5 – 5.0</td>
<td>10.0 – 45.6</td>
</tr>
<tr>
<td>Eutrophic</td>
<td>Average: 14.3</td>
<td>2.5</td>
<td>84.4</td>
</tr>
<tr>
<td></td>
<td>Range: 7.1 – 100</td>
<td>0.8 – 7.0</td>
<td>15.0 – 366</td>
</tr>
<tr>
<td>Hypertrophic</td>
<td>Average: &gt; 80</td>
<td>&lt; 0.5</td>
<td></td>
</tr>
</tbody>
</table>


Probable, not certain...

![Graph](image)

Figure 4-21: Relationship between annual levels of chlorophyll a and measured total phosphorus concentration for 142 lakes. (Source: Jones, J. K., Bachmann, E. W., & Bingham, W. C. "Predictions of phosphorus and chlorophyll levels in lakes," *Journal of the Water Pollution Control Federation*, vol. 49, p. 2176, 1977.)

Lake Stratification

Figure 4-19: Overview of stratified lakes. (Source: The Great Lakes: An Environmental Atlas and Resource Book. Natural Resources Institute, Great Lakes National Program Office, Kenora, ON, 1995.)
Lake Stratification

Source: Principles Env. Sci. & Eng. (Davis & Masten)

Diagnostics...

Table 7.5 Sources of Nitrogen and Phosphorus as Percentages of the Total Annual Input to Lake Ecosystems*

<table>
<thead>
<tr>
<th></th>
<th>Precipitation</th>
<th>Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Oligotrophic lakes</td>
<td>56</td>
<td>50</td>
</tr>
<tr>
<td>Eutrophic lakes</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

*From Likens (1975a).

Diagnostics...

Table 8.2 Yearly Fluxes of Organic Carbon, Nitrogen, and Phosphorus in Bear Brook, New Hampshire*

<table>
<thead>
<tr>
<th>Flux in g/m² yr</th>
<th>Organic carbon (g/m²)</th>
<th>Nitrogen (g/m²)</th>
<th>Phosphorus (g/m²)</th>
<th>Atomic ratio C:N:P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>260</td>
<td>56</td>
<td>0.39</td>
<td>1700:390:1</td>
</tr>
<tr>
<td>Total fine particulate</td>
<td>12</td>
<td>0.27</td>
<td>0.55</td>
<td>54:1:1</td>
</tr>
<tr>
<td>Total coarse particulate</td>
<td>340</td>
<td>8.2</td>
<td>0.70</td>
<td>1500:26:1</td>
</tr>
<tr>
<td>Total gaseous</td>
<td>1</td>
<td>&lt;0.1</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Total inputs</td>
<td>620</td>
<td>64</td>
<td>1.6</td>
<td>990:80:1</td>
</tr>
<tr>
<td>Output</td>
<td>260</td>
<td>57</td>
<td>0.29</td>
<td>2300:440:1</td>
</tr>
<tr>
<td>Total fine particulate</td>
<td>35</td>
<td>0.43</td>
<td>1.1</td>
<td>59:0:1</td>
</tr>
<tr>
<td>Total coarse particulate</td>
<td>100</td>
<td>1.8</td>
<td>0.58</td>
<td>720:5:1</td>
</tr>
<tr>
<td>Total gaseous</td>
<td>250</td>
<td>7</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Total outputs</td>
<td>620</td>
<td>59</td>
<td>1.8</td>
<td>890:72:1</td>
</tr>
</tbody>
</table>

*From Meyer et al. (1981).