4.4 Water Pollution
Significant Ideas

• Water pollution, both groundwater and surface water, is a major global problem the effects of which influence human and other biological systems.
Knowledge and Understandings:

• There are a variety of freshwater and marine pollution sources.

• **Types of aquatic pollutants** include floating debris, organic material, inorganic plant nutrients (nitrates and phosphates), toxic metals, synthetic compounds, suspended solids, hot water, oil, radioactive pollution, pathogens, light, noise and biological pollutants (invasive species).

• A wide range of parameters can be used to directly test the quality of aquatic systems, including pH, temperature, suspended solids (turbidity), metals, nitrates and phosphates.

• Biodegradation of organic material utilizes oxygen, which can lead to anoxic conditions and subsequent anaerobic decomposition, which in turn leads to formation of methane, hydrogen sulfide and ammonia (toxic gases).

• **Biochemical oxygen demand (BOD)** is a measure of the amount of dissolved oxygen required to break down the organic material in a given volume of water through aerobic biological activity. BOD is used to indirectly measure the amount of organic matter within a sample.

• Some species can be indicative of polluted waters and can be used as indicator species.
Knowledge and Understandings:

- A **biotic index** indirectly measures pollution by assaying the impact on species within the community according to their tolerance, diversity and relative abundance.

- **Eutrophication** can occur when lakes, estuaries and coastal waters receive inputs of nutrients (nitrates and phosphates), which results in an excess growth of plants and phytoplankton.

- **Dead zones** in both oceans and fresh water can occur when there is not enough oxygen to support marine life.

- Application of figure 3 to water pollution management strategies includes:
  - reducing human activities that produce pollutants (for example, alternatives to current fertilizers and detergents)
  - reducing release of pollution into the environment (for example, treatment of waste water to remove nitrates and phosphates)
  - removing pollutants from the environment and restoring ecosystems (for example, removal of mud from eutrophic lakes and reintroduction of plant and fish species).
Application & Skills:

• **Analyze** water pollution data.
• **Explain** the process and impacts of eutrophication.
• **Evaluate** the uses of indicator species and biotic indices in measuring aquatic pollution.
• **Evaluate** pollution management strategies with respect to water pollution.
Types of Water Pollution

• Anthropogenic (created by humans) or natural

Anthropogenic water pollution (solid domestic waste)  

Red Tide caused by algae bloom. Usually toxic to shellfish and other marine organisms.
Types of Water Pollution

• Point Source or Non-point Source
Types of Water Pollution

- Organic or Inorganic

Human and animal waste are examples of organic waste entering waterways.

Oil spill clean up in Sundarbans 2015. This is an example of inorganic waste.
Types of Water Pollution

- Direct or Indirect

- Dumping dye and other toxins into waterway as disposal method from textile industries in Bangladesh.

- Excess nitrates enter waterways from agricultural fertilizers causing algal blooms (eutrophication).
Possible Sources of Water Pollution

• Sewage (human & animal)
• Pesticides
• Chemicals from industry
• Pathogens
• Nitrates (fertilizers)
• Phosphates (detergents)
• Heavy metals (industry)
• Oil spills
• Heat (thermal pollution from electrical stations/desalination)
• Radioactive waste
• Solid domestic waste (trash & debris)
• Suspended particles (from runoff/erosion or construction)
• Invasive species (ex: cane toad)
Possible Effects of Water Pollution

- Eutrophication
- Loss of biodiversity (species & habitat)
- Increase in disease from pathogens and exposure to toxins or radiation
- Bioaccumulation and biomagnification in food webs
- Disruption to breeding grounds, nesting sites
- Damage to coral reefs
- Damage to organisms (ingesting plastics, caught in debris, etc)
Measuring Water Pollution

There are Many Direct Methods to Measure Water Quality Including:

• pH
• Nitrates or Ammonia
• Dissolved Oxygen (DO)
• Conductivity (may indicate dissolved pollutants in water or presence of heavy metals)
• Turbidity
• Fecal Coliform Test
Measuring Water Pollution

Indirect Measures

Biochemical Oxygen Demand (BOD)

• The amount of dissolved oxygen required for decomposers to aerobically break down organic matter in a given volume of water.

• If enough oxygen is present, aerobic decomposition by microorganisms will continue until all waste is consumed.

• Dissolved oxygen (DO probe) should measured initial amount of oxygen in sample.

• Sample of water should be kept sealed and in the dark.

• After 5 days a second DO reading should be recorded.

• Calculate the change in oxygen levels (this is the amount of oxygen that has been used/demanded by microbes for decomposition).

• Unpolluted, natural waters have a BOD of 5 mg/L or less.
Measuring Water Pollution

Indicator Species

• Organisms that show something about their environment by their abundance or scarcity.

• These species are sensitive to changes in an environmental factor so are often an early indicator of the health of the ecosystem.

• In Freshwater Ecosystems the following are often indicators of the water quality
  • **Frogs and Toads** have permeable skin so are affected by water pollutants and only present in clean water
  • **Mayfly Larva** indicate clean water
  • **Water Louse** indicated polluted water
  • **Sludgeworms** indicate very polluted water
Measuring Water Pollution

Indicator Species

<table>
<thead>
<tr>
<th>Indicator Species</th>
<th>Pollution Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayfly nymph</td>
<td>Low (Stream)</td>
</tr>
<tr>
<td>Dragonfly nymph</td>
<td>Low (Pond)</td>
</tr>
<tr>
<td>Freshwater shrimp</td>
<td>Slight</td>
</tr>
<tr>
<td>Hoglouse</td>
<td>Medium</td>
</tr>
<tr>
<td>Worm (Tubifex)</td>
<td>High</td>
</tr>
<tr>
<td>NO LIFE</td>
<td>Extreme</td>
</tr>
</tbody>
</table>
Measuring Water Pollution

Biotic Indices (ex: Trent Biotic Index)

• An indirect measure of pollution by determining the relative abundance of organisms present and classifying them by tolerance levels (look at both the diversity and the abundance by tolerance.)

• A scale of 1-10 is used to give a measure of the quality of the ecosystem

• Often used in conjunction with BOD as invertebrates are sensitive to decreases in oxygen concentration.

• Often used to compare 2 ecosystems or point source pollutants as a comparison using Simpson’s diversity index can be used to support.

• Measures the effect of pollutants on biodiversity, not the pollutant itself.
# Measuring Water Pollution

**Biotic Indices (ex: Trent Biotic Index)**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>ANIMALS</th>
<th>POLLUTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mayfly nymph, Stonefly nymph</td>
<td>If you find these animals in your stream, then there is <strong>LITTLE OR NO POLLUTION</strong></td>
</tr>
<tr>
<td>A</td>
<td>Dragonfly nymph, Damselfly nymph</td>
<td>If you find these animals in your pond, then there is <strong>LITTLE OR NO POLLUTION</strong></td>
</tr>
<tr>
<td>B</td>
<td>Dragonfly larva, Freshwater shrimp</td>
<td>If you find these animals, but none from Group A, then there may be <strong>SLIGHT POLLUTION</strong></td>
</tr>
<tr>
<td>B</td>
<td>Hoglouse, Bloodworm</td>
<td>If you find these animals, but none from Group A or B, then there is <strong>MEDIUM POLLUTION</strong></td>
</tr>
<tr>
<td>C</td>
<td>Worm (Tubifex), Rat-tailed maggot</td>
<td>If you find these animals, but none from Groups A, B or C, then there is <strong>A LOT OF POLLUTION</strong></td>
</tr>
<tr>
<td>D</td>
<td>No live animals found</td>
<td>If you find no animals at all, then the water is <strong>VERY POLLUTED</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HBI Value</th>
<th>Water Quality</th>
<th>Degree of Organic Pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00-3.50</td>
<td><strong>Excellent</strong></td>
<td>No apparent organic pollution</td>
</tr>
<tr>
<td>3.51-4.50</td>
<td><strong>Very Good</strong></td>
<td>Slight organic pollution</td>
</tr>
<tr>
<td>4.51-5.50</td>
<td><strong>Good</strong></td>
<td>Some organic pollution</td>
</tr>
<tr>
<td>5.51-6.50</td>
<td><strong>Fair</strong></td>
<td>Fairly significant organic pollution</td>
</tr>
<tr>
<td>6.51-7.50</td>
<td><strong>Fairly Poor</strong></td>
<td>Significant organic pollution</td>
</tr>
<tr>
<td>7.51-8.50</td>
<td><strong>Poor</strong></td>
<td>Very significant organic pollution</td>
</tr>
<tr>
<td>8.51-10.00</td>
<td><strong>Very Poor</strong></td>
<td>Severe organic pollution</td>
</tr>
</tbody>
</table>
Eutrophication

• Occurs when excess nutrients enter an aquatic ecosystem resulting in a drastic increase in algae growth.
• May happen in freshwater or oceans (red tides)
• May be natural or anthropogenic
• Humans influence eutrophication mostly through using fertilizers containing nitrates and detergents containing phosphates and sewage
Process of Eutrophication

• Fertilizers (or detergents) wash into river or lake
• High levels of nitrates and/or phosphates lead to increased algal and plant growth
• Algal blooms block sunlight from penetrating deeper into the lake
• More producers result in increase in consumer population
• Plants not on surface die due to lack of sunlight
• Decomposer population grows significantly
• Increased decomposition and consumer population leads to decreased dissolved oxygen
• Due to low levels of oxygen everything begins to die
• May result in dead zones (in oceans or freshwater)
Impacts of Eutrophication

- Anaerobic (anoxic) water
- Loss of biodiversity
- Death of aerobic organisms
- Death of plants
- Increased turbidity
- Produce toxic (and smelly) gases such as methane, hydrogen sulfide, and ammonia (due to anaerobic decomposition)
Red Tides

• When algal bloom occurs due to an increase in dinoflagellates (a type of phytoplankton)
• Causes water to look red
• Danger due to toxics produced by dinoflagellates that kill fish and accumulate in shellfish
• If humans eat the shellfish during a red tide it will make them very sick.
Management Strategies for Eutrophication

• Altering Human Activity
  • Ban/limit detergents containing phosphates
  • Plant buffer zones between agricultural lands and water sources
  • Prevent leaching of sewage into waterways
  • Educate farms about effective timing of fertilizer application

• Regulating and Reducing Pollutant at Point of Emission
  • Treat wastewater to remove phosphates and nitrates
  • Divert and treat sewage
  • Minimize fertilizer dosage or use organic matter

• Clean Up & Restoration
Management Strategies for Eutrophication

• Clean Up & Restoration
  • Pump oxygen into lakes (re-oxygenate)
  • Dredge sediment from river and lake beds
  • Remove excess weeds
  • Restock pond with appropriate organisms
HOMEWORK

• To Do Boxes pp. 229 & 233