APES - Water Pollution

I. Water Pollution – the contamination of water that lessens its value to living organisms.

A. Point Pollution - water pollution that has a well defined source.

B. Non-Point Pollution - water pollution which source is spread over a wide area.
C. **Input Control** - method used to prevent water pollutants from entering environment.

(Aeration Pond)

D. **Output Control** - removing pollutant after it enters into the environment.

(oil spill response)
II. Types of Water Pollutants

A. Sediment Pollution - the clouding of water with soil sediments. Is the most widespread form of water pollution.

(sediment plumes)
1. Sediment pollution blocks photosynthesis, clogs fish gills, damages water intake machinery, washes.
toxic metal into water, clogs boating channels, covers fish eggs.

2. Causes of Sediment Pollution -

- Runoff - caused by accelerated erosion as a result of construction, agriculture, poor logging practices, and mining.

3. Control of Sedimentation
- **Input Controls** - Proper soil management (cover crops, contour farming), gully reclamation, hydroseeding, diversion ditches on roads, vegetative buffers.

- **Output Controls** - redirect water flow into wetlands (constructed wetland), sediment control ponds, silt fence, dredging, dams.
B. Nutrient Pollution (Cultural Eutrophication) - the enrichment of plant fertilizers in an aquatic ecosystem. Mainly in the form of Nitrates ($\text{NO}_3^-$) and Phosphates ($\text{PO}_4^{3-}$).

1. Cultural Eutrophication and Algal Blooms - Increased nutrient input (Mainly in the form of Nitrates and Phosphates) into water resources causes rapid growth of algae. The high populations of algae die and settle to the bottom of the water where they are decomposed by aerobic bacteria which greatly depletes the dissolved oxygen levels of the lake.
- Biological Oxygen Demand (BOD) - the amount of oxygen required by decomposing bacteria to break down organic waste in water. High BOD = Low DO

- Cultural Eutrophication can also kill off aquatic plants by blocking sunlight.
3. Sources of Nutrients

- Agricultural Fertilizers - Runoff from farms, home lawns and gardens, recreational facilities.

- Domestic Sewage - Detergents, and waste.

4. **Nutrient Pollution Input Controls**

- Controlled Animal Feeding Operation (CAFO)
- Legislation that regulates animal feed lots, manure runoff, manure spreading.

- Phosphate free detergents

- Vegetative buffer strips - 50 feet or more buffer to absorb nutrients.

- Collection ponds/artificial wetlands

- Applying fertilizers at the right time!

- Wastewater Treatment Plants
5. **Nutrient Pollution Output Controls**

- Tertiary Treatment for Wastewater to remove nitrates and phosphates.

- Herbicides

- Aquatic Plant Harvest

-Dredging
C. **Thermal Pollution** - the increase or decrease of water temperature as a result of human activity. Mainly affects the dissolved oxygen level of the water, but can also adversely affect aquatic organisms (Thermal Shock).

1. **Causes of Thermal Pollution** - Industrial use, and power generation utilize water for cooling. Runoff from hot pavement can also increase water temperature. Dams can cause a drastic decrease in water temperature as cool water from the bottom of a reservoir is released downstream.
2. **Input controls**

- **Cooling towers** - transfer heat from the water into the atmosphere.

- **Co-generation** - waste heat can be used to heat buildings or greenhouses, and used for aquaculture.
V. Disease Causing Organisms - water that is contaminated by microorganisms that cause water borne illness. This was a major threat to human health for thousands of years.
1. **Bacteria** - single celled bacteria that live in water cause deadly diseases. The source of these organisms is usually wastewater and sewage.

   - **Cholera** - Cholera is caused by the bacterium *Vibrio cholerae* and can cause nausea, diarrhea, and vomiting. If untreated 50% of people exposed to it will die.

   - **Typhoid** - Typhoid fever cause by the *Salmonella* bacteria.
- **E-Coli** - *E. Coli* is a bacterium that is present in the intestines in animals.

2. Microorganisms - single celled protozoans and amoebae can cause water borne illness.

- Amoebic dysentery (amoebiasis) - is an infection of the intestine (gut) caused by an amoeba called *Entamoeba histolytica*, which, among other things, can cause severe diarrhea.

- Giardia - Giardia is a one-celled parasite that can cause a gastrointestinal illness called giardiasis.
- **Cryptosporidiosis** - is a diarrheal disease caused by microscopic parasites of the genus *Cryptosporidium* can survive for days in swimming pools with adequate chlorine levels.

3. **Viruses** - Deadly viruses can also be found in wastewater and sewage that can spread disease.

- **Hepatitis** - this virus is often associated with consuming seafood that lives in polluted water. The consumption of raw oysters, clams, and other shellfish can spread the virus.
4. **Blue-Green Algae** – *Anabaena* secretes a neurotoxin.
5. **Input and Output Controls - Disinfection of water by chlorination, ozonation, ultra-violet radiation, or boiling.**
V. **Toxic Organic Compounds** - (Organic = Carbon containing)

Synthetic compounds used in industry, medicine, and agriculture that have contaminated water.


2. **DDT** - Pesticide once widely used throughout the country which became linked to decline in bird populations. Although harmless in small doses, DDT can remain active in the environment for many years and bioaccumulate in the food chain. It was banned for use in the U.S in 1972, but was still manufactured for export until 1985.

- **Bioaccumulation** - the increase in the concentration of a chemical as it moves up through the food chain. Upper levels of consumers can accumulate toxic concentrations of chemicals.
3. **Organochlorides** - many chlorinated compounds are used in industry that can cause adverse health effects. Trichloroethylene (TCE) used for cleaning metal parts and carbon tetrachloride used in many manufacturing.

4. **Petroleum** - crude oil can have many adverse health effects when spilled into the environment (oil spills).
Worst Oil Spills

Gulf War, Kuwait 1990 ~ 336 million gallons
Deepwater Horizon, 2010 (5,000 feet deep) ~ 205.8 million gallons

Mexico’s Ixtoc, 1979 ~ 147 million gallons
Prince William Sound, Alaska 1989 ~ 10 million gallons
5. **Input and Output controls for Toxic Organic Compounds**

**Input Controls** - Water treatment (carbon filtration) and safe disposal of waste water containing toxins (Incineration or sanitary landfill disposal). Safe
transportation of crude oil (double hull tankers), or lessening dependence on crude oil!!!

**Output Controls** - Dredging, extraction wells, water purification, oil spill clean-up.

- **Bioremediation** - the use of living organisms to clean-up toxins. Microorganisms that can degrade toxins, or plants that can remove toxins from the soil (hyperaccumulators)

VI. **Heavy Metal and Toxic Inorganic Water Pollutants**

1. **Heavy Metals** - Arsenic, Zinc, Mercury, Copper, and Lead.

   - **Lead** - lead poisoning from old pipes, lead based solder, old paints, and batteries.

   - **Mine waste and leakage**

2. **Nitrates** - This plant available form of nitrogen not only contributes to nutrient pollution but can adversely affect
human health if ingested in drinking water in amounts greater than 10 ppm (blue baby disease).

3. **Input/Output Controls - Water filtration/purification**

### Sources of Mercury

<table>
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<tr>
<th>Source</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Residential boilers</td>
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<tr>
<td>Hazardous waste</td>
<td>4%</td>
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<tr>
<td>Medical waste</td>
<td>10%</td>
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<tr>
<td>Coal, industrial</td>
<td>16%</td>
</tr>
<tr>
<td>Coal, utility</td>
<td>34%</td>
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<tr>
<td>Manufacturing</td>
<td>10%</td>
</tr>
<tr>
<td>Area sources</td>
<td>3%</td>
</tr>
<tr>
<td>Municipal waste</td>
<td>5%</td>
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</tbody>
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**If you weigh:**

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<th>White Albacore</th>
<th>Chunk Light</th>
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<td>6 weeks</td>
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<td>40 lbs</td>
<td>5 weeks</td>
<td>11 days</td>
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<tr>
<td>50 lbs</td>
<td>4 weeks</td>
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<td>60 lbs</td>
<td>3 weeks</td>
<td>7 days</td>
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<tr>
<td>70 lbs</td>
<td>3 weeks</td>
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<td>140 lbs</td>
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<tr>
<td>150+ lbs</td>
<td>9 days</td>
<td>3 days</td>
</tr>
</tbody>
</table>
Source: Food and Drug Administration test results for mercury and fish, and the Environmental Protection Agency’s determination of safe levels of mercury.

Total Mercury Concentration, 2005

Sites not pictured:
Hidalgo, Mexico 01  8.7 ng/L

National Atmospheric Deposition Program/Mercury Deposition Network
VII. Common Water Quality Tests

**Nitrate (NO$_2^-$)** – fertilizers and waste contribute nitrate to water.

- Typical natural levels for freshwater - less than 1.0 ppm
• Recommended level for Trout - less than 0.06 ppm
• Human health risks, and drinking water standards ~ 10.0 ppm
• Sewage treatment plant effluent ~ 30.0 ppm

**pH** - a measure of the acidity or alkalinity of a solution, and can effect the biological and chemical properties of water.

- Optimal range for most life - 6.5 - 8.2
- Federal drinking water standards - 6.5 - 8.5

**Dissolved Oxygen (DO)** - required for aquatic respiration

Greater than 7 ppm

**Temperature** - important for the amount of oxygen dissolved in the water.

**Alkalinity/Hardness (CaCO₃)** - Hardness is a measure of the amount of calcium carbonate dissolved in water (limestone).

• Federal drinking water standards set limits at 200 ppm
0-60 ppm soft, 60-120 medium hard, 120—180 hard, 180+ very hard

**Phosphate (PO$_4^-$)** - Phosphate is a plant nutrient found in phosphate containing rocks, oil, and animal waste. Phosphate can also be found in detergents.

- **Natural levels** - less than 0.03 ppm
- **Above 0.1 ppm** - impact likely
- **Above 0.5 ppm** - impact certain
- **Federal drinking water standards** - less than 0.5 ppm
- **Wastewater effluent** - 5.0 – 30.0 ppm

**Turbidity** – Clarity of the water.

**Total Dissolved Solids (TDS)** — Is a measure of the amount of solids dissolved in water measured in parts per million.
**E-Coli Bacteria**—Coliform bacteria present in the intestinal tract of animals—Is an indicator of waste getting into water.

- **Federal drinking water standards**—Recreational Waters less than 100 colonies/100 ml
- **Shell fishing Waters** less than 70 colonies/100 ml
- **Drinking Water Supply** less than 4 colonies/100 ml

**VIII. Groundwater Pollution**—Groundwater contamination is probably the worst form of water pollution due to the fact that groundwater is not visible, and can easily be
contaminated by a number of sources, and can travel long distances.

1. **Leaching** - the process of water moving into something, dissolving it, and carrying it away as a result of groundwater flow.

2. **Lechate** - contaminated groundwater exposed at the surface.

3. **Plume** - a well defined area of polluted groundwater.
4. Sources of Groundwater Pollution
Contaminants:
- bacteria
- viruses
- nitrates
- cleaning chemicals
- paint thinners, other wastes

Contaminants:
- used oil
- other chemicals

Contaminants:
- paint thinners
- pesticides
- chemical cleaners
- floor care products
- poisons
- polishers & degreasers
- automotive products
- acids
- other toxic substances
Contaminants:
- Diverse; some quite toxic

Contaminants:
- Gasoline
- Heating oil
- Diesel fuel
- Solvents
Contaminants: *diverse - includes chemical cleaning compounds, metals, petroleum, fertilizers, paint products, etc.

Transport Spill

- wind transport & fallout
- road
- water table

Contaminants: *gasoline, oil, acids, corrosives, & many others.

Transfer Spill

- spilling during coupling
- hose break
- water table

Contaminants: groundwater flow
5. **Groundwater Pollution Remediation**
- Identify source of groundwater pollutant, and stop it.

- Stop recharge and infiltration at the site (cap with impermeable barrier)
- Identify location of plume, and its direction of movement (monitoring wells, local topography and geology of region)
- Stop movement of plume by constructing containment walls (only possible for shallow plumes)

- Use of Permeable Reactive barriers (PRB’s) – a wall built below ground, made of a reactive material
to neutralize polluted groundwater. Common substance include charcoal, limestone, or iron.
- Drill extraction wells to remove polluted water and treat at the surface.

- Construct interceptor or collection trenches to collect polluted groundwater and treat at the surface.
IX. Clean Water Act

A. The United States Congress passed the Federal Water Pollution Control Act Amendments of 1972, and
it became known as the Clean Water Act after Congress passed amendments to it in 1977. The law was further amended in 1987 (Safe Drinking Water Act).

- **Main Objective:** To restore and maintain the chemical, biological, and physical integrity of the Nation's water (surface waters only until 1987).
- achieve a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife.
- to improve water quality for recreation in and on the water.
- eliminate or control the discharge of pollutants into surface waters
- prohibit discharge of pollutants without a permit.
- the act also prohibits potentially harmful spills of oil and certain hazardous substances, and requires clean up.

2. **Other important Acts of Congress used to protect water:**
- Rivers and Harbors Act (1899) - protects nation's waters to promote commerce.
- Water Pollution Control Act (1948) - provides federal funding to States to promote efforts to protect water quality.
- Marine Protection, Research, and Sanctuaries Act (1972) - prevents unacceptable dumping in the ocean.