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**Water Pollution**

***“Today everybody is downwind or downstream from somebody else” – William Ruckelshaus***

**I. Intro to Water Pollution**

A. Water pollution is any chemical, biological, or physical change in water quality that harms living organisms and makes water unsuitable for desired uses.

B. Water pollution can come from a single (point) sources, or from larger, dispersed sources (nonpoint).

C. Point sources discharge pollutants at specific locations through drain pipes, ditches, or sewer lines into standing bodies of water.

1) Examples include \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

D. Because point sources are located at specific places, they are fairly easy to identify, monitor, and regulate.

E. Most developed countries have laws that help control point source pollution and discharge of toxic chemicals. In most developing countries, there is little control of such discharges.

F. The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_led to numerous improvements in U.S. water quality, by addressing point source pollution and targeting industrial discharge.

G. Nonpoint pollution sources are broad, diffuse areas, rather than points, from which pollutants enter bodies of water.

1. Examples include runoff of chemicals and sediments from cropland, livestock feedlots, clear-cut forests, urban streets, parking lots, lawns, and golf courses.
2. We have made little progress in controlling water pollution from nonpoint sources because of the difficulty and expense of identifying and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

H. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_are by far the leading cause of water pollution. Sediment eroded from agricultural lands is the largest source, but other major agricultural pollutants include fertilizer and pesticides, bacteria from livestock and food processing, and excess salt from soils of irrigated cropland.

I. Industrial facilities, which emit a variety of harmful inorganic and organic chemicals, are a second major source of water pollution.

J. Mining is the third biggest source of water pollution. Surface mining disturbs the land, creating major erosion of sediments and runoff of toxic chemicals.

K. Newer sources of pollution:

1) Parking lots – grease, toxic metals, and sediments that collect on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_are a major source of nonpoint pollution. Additionally parking lots disrupt the hydrologic cycle by preventing rain from soaking into the ground and worsening local flooding and erosion.

2) Another wide-spread problem is the use of plastics, and the polymers that make them up. Plastics are everywhere in aquatic environments, and cause damage to animals in their whole form (plastic bags) or to smaller organisms (zooplankton) when the plastics have started to break down into small particles.

3) Climate change from global warming will also contribute to water pollution in some areas. In a warmer world, some areas will get more precipitation, some will get less. Flooding will\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and prolonged drought will reduce the river flows that dilute wastes.

L. The classic water pollution story: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_It was so polluted with flammable chemicals that it caught fire several times in the 1950s and 60s as it flowed through the city of Cleveland. A highly publicized photo of this river burning in 1969 led to point-source legislation (evidence and validation for legislators working on the Clean Water Act. )

**II. Types of Water Pollution**

A. Nutrient pollution – Primarily nitrate (NO3 -1) and phosphate (PO4 -3) pollution from fertilizers, farms, sewage, lawns, and golf courses.

B. Solutions to nutrient pollution include:

* + - Phosphate-free detergents (laundry is mandated, dishwashing is here but not mandated yet)
    - Planting vegetation to increase nutrient uptake
    - Treat wastewater
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**C. Nutrient pollution leads to Eutrophication**

* 1. Eutrophication – the natural nutrient enrichment of a shallow lake, estuary, or slow-moving stream, mostly from runoff of plant nutrients from surrounding land.
  2. Eutrophication is a natural process, but is frequently accelerated (a lot) from human activities. This acceleration is called cultural eutrophication.
  3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**D. Pathogens and waterborne diseases**

1) Enters water supply via inadequately treated human waste and animal waste via feedlots

2)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3) E. coli, giardia are two major disease causing pathogens, but cholera, typhoid, and hepatitis A cause huge problems as well.

4) Fecal coliform bacteria indicate fecal contamination of water – fecal coliform itself is very rarely pathogenic, but it is much easier to monitor than some of the other pathogens. Fecal coliform gives quantitative data on fecal contamination of a water source.

**E. Pathogens cause massive human health problems**

1) Currently, 1.1 billion people are without safe drinking water

2) 2.4 billion have no sewer or sanitary facilities

* + Mostly rural Asians and Africans

3) An estimated 5 million people die per year from water-borne illnesses.

* Solutions:
  + Treat sewage
  + Disinfect drinking water
  + Public education to encourage personal hygiene
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**F. Toxic chemicals**

1) From natural and synthetic sources

* + Pesticides, petroleum products, synthetic chemicals
  + Arsenic, lead, mercury, acid rain, acid drainage from mines

2) Effects include: poisoning animals and plants, altering aquatic ecosystems, and affecting human health

3) Solutions:

* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Modify industrial processes
  + Modify our purchasing decisions

**G. Sediment pollution**

1) Sediment can impair aquatic ecosystems

* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Dramatically changes aquatic habitats, and fish may not survive

2) Solutions: better management of farms and forests; avoid large-scale disturbance of vegetation

**H. Thermal pollution**

1) Warmer water holds less oxygen

* + Dissolved oxygen decreases as temperature increases
  + Industrial cooling heats water
  + Removing streamside cover also raises water temperature

2) Water that is too cold causes problems

* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + When water is released, downstream water temperatures drop suddenly and may kill aquatic organisms

**III. Indicators of water quality**

A. Scientists measure properties of water to characterize its quality

1) Biological indicators: presence of fecal coliform bacteria and other disease-causing organisms

2) Chemical indicators: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3) Physical indicators: turbidity, color, temperature

B. Biological Oxygen Demand (BOD) - The amount of oxygen used for biological decomposition. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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C. BOD and dissolved oxygen (DO) are inversely related – the lower the BOD of a body of water, the higher the DO available for aquatic life. As BOD increases, the amount of DO available for aquatic organisms decreases. If DO is below 5 mg/L, the EPA designates a body of water as polluted.

**IV. Groundwater Pollution**

**A. Groundwater is increasingly contaminated, but is hidden from view**

1) Difficult to monitor

2) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3) Takes longer for contaminants to breakdown in groundwater because of the lower dissolved oxygen levels

**B. Sources of groundwater pollution**

1) Some toxic chemicals occur naturally - Aluminum, fluoride, sulfates

2) Pollution from human causes

* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Pathogens enter through improperly designed wells
  + Hazardous wastes are pumped into the ground
  + Underground storage septic tanks may leak

**C. Agriculture and industries pollute groundwater**

1) Agricultural pollution

* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Pesticides were detected in more than half of the shallow aquifers tested

2) Manufacturing industries and military sites have been heavy polluters

**V. Legislation and Cleaning Polluted Water**

A. Federal Water Pollution Control Act (1972)

1) Renamed the Clean Water Act in 1977

2) Illegal to discharge pollution without a permit

3) Standards for industrial wastewater

4) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B. The EPA sets standards for more than \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1) Local governments and private water suppliers must meet standards

2) Before water reaches the user it is chemically treated, filtered, and disinfected.

**C. Treating wastewater**

**1) Wastewater** = water that has been used by people in some way; includes sewage, showers, sinks, manufacturing, storm water runoff

**2) Septic systems** = the most popular method of wastewater disposal in rural areas

* + Underground septic tanks separate solids from wastewater
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**D. Municipal sewer systems**

1) In populated areas, sewer systems carry wastewater

* + Physical, chemical, and biological water treatment

**D. Primary treatment** = the physical removal of contaminants in settling tanks (clarifiers)

1. A PHYSICAL process – uses screens and a grit tank to remove large floating objects and allow solids to settle out.
2. Then, the waste stream flows into a primary settling tank where suspended solids settle out as sludge. By itself, primary treatment removes about 60% of suspended solids and 30-40% of oxygen-demanding organic wastes from sewage.
3. Primary treatment removes no \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**E. Secondary treatment** = water is stirred and aerated so aerobic bacteria degrade organic pollutants. A biological process.

1. Aerobic bacteria remove as much as 90% of dissolved and biodegradable, oxygen-demanding organic wastes.
2. Removes about 70% of most toxic metal compounds, 70% of phosphorus, and 50% of nitrogen.
3. Secondary treatment removes only a tiny fraction of long-lived radioactive materials and persistent organic substances such as pesticides, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. At the end of the secondary sewage treatment, water is usually bleached to remove water coloration and disinfected to kill disease-carrying bacteria and some viruses. The usual method of doing this is chlorination. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

F. In some areas, tertiary sewage treatment is used. A series of specialized chemical and physical processes are used to remove specific pollutants left in the water after primary and secondary treatments – usually phosphates and nitrates are removed from wastewater.

**E. Artificial wetlands**

1) Natural and artificial wetlands can cleanse wastewater

* + After primary treatment at a conventional facility, water is pumped into the wetland
  + Microbes decompose the remaining pollutants
  + Cleansed water is released into waterways or percolated underground

2) Constructed wetlands serve as havens for wildlife and areas for human recreation

- \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Group 1: Exxon Valdez oil spill**

**Group 2: BP gulf oil spill**

**Group 3: India’s Ganges River**

**Group 4: Great *Pacific* Garbage *Patch*, also described as the *Pacific Trash* Vortex**

**Group 5: Minamata Disaster/Disease**

**Group 6: Major waterborne illnesses around the world, including the Cholera outbreak in Haiti**

**Group 7: Gulf of Mexico “Dead Zone”**

**Group 8: 1993 *Cryptosporidium* outbreak in Milwaukee, WI**