Chapter 11: Water

Section 1: Water Resources

Objectives

1. Describe the distribution of Earth's water resources.
2. Explain why fresh water is one of Earth's limited resources.
3. Describe the distribution of Earth's surface water.
4. Describe the relationship between groundwater and surface water in a watershed.

A. The Water Cycle

- Water is a _____ resource because it is circulated in the water cycle.

B. Global Water Distribution (Fig. 2, p. 270)

Earth is about 71% water:

- 68.87% (or 97% total water) is *saltwater* (oceans)
- 2.13% (or 3% total water) is *freshwater*, which is found in
  - _____ (1.64% or 77% total freshwater)
  - _____ (0.47% or 22.1% total freshwater)
  - Lakes, streams, soil, atmosphere, etc. (0.02% or 0.9% total freshwater)

C. Surface Water

- Includes all fresh water that is above ground: lakes, streams, wetlands, etc.
- Provides drinking water, food, power, and transportation

1. River Systems

- Streams form as runoff, either from precipitation or snowmelt, drains from higher elevations.
- Streams combine to form rivers, and rivers combine to form river systems.
- Largest river system in North America: _____
- Largest river system in the world: _____

2. Watersheds (Fig. 3, p. 270-271)

- _____
- Drain variable amounts of water from season to season and year to year
- Largest watershed in North America: _____
  _____
- Largest watershed in the world: _____

D. Groundwater (Fig. 4, p. 274-275)

- Is water stored in the ground
- Makes up the majority of _____ fresh water
- *Water table*
  - Is the level underground at which rocks and soil are saturated with water
  - Varies with climate: close to surface in wet/humid areas and far below surface in arid/dry areas

- ○ _____

1. **Aquifers**
   - Are underground rock formations that store groundwater
   - Consist of materials, such as rock, sand, and gravel, that have open spaces, or pores
   - Are an important water source for cities and agriculture
2. **Porosity and Permeability**
   - Porosity: the percentage of the total volume of a rock or sediment that consists of open spaces
     - ○ _____
   - Permeability: the ability of a rock or sediment to let fluids pass through it open spaces or pores
     - ○ *Permeable* – _____; examples: sandstone, limestone, or layers of sand or gravel
       vs.
     - ○ *Impermeable* – _____; examples: clay, granite, metamorphic rocks, concrete, asphalt
3. **The Recharge Zone**
   - _____
   - Size is dependent on the permeability of the surface above the aquifer
   - Is highly susceptible to pollution
   - Recharge can take a few years to 1000s of years
4. **Wells**
   - Are holes that are dug or drilled to reach groundwater
   - Dry up when water table falls below the bottom… generally due to a drought or _____ (pumping out water faster than it is recharged)

Section 2: Water Use and Management

Objectives

1. Identify patterns of global water use.
2. Explain how water is treated so that it can be used for drinking.
3. Identify how water is used in homes, in industry, and in agriculture.
4. Describe how dams and water diversion projects are used to manage freshwater resources.
5. Identify five ways water can be conserved.

A. Global Water Use (Fig. 5, p. 277)

- Most used for _____
- Usage affected by availability of freshwater, population size, and economics

★ _____ *lack access to clean water (World Health Organization).*

B. Residential Water Use (~8%)

- Water must be _____, or safe to drink.
- Water Treatment
  - Used to remove toxic elements, such as mercury (Hg), arsenic (As), and lead (Pb); and pathogens such as bacteria, viruses, protozoa, and parasitic worms
  - Steps (Fig. 6, p. 277)

    (1) _____

    (2) _____

    _____

    (3) _____

    (4) _____

    (5) _____

    (6) _____

    _____

C. Industrial Water Use (~19%)

- Used to manufacture goods, dispose of waste, and generate power
- _____

D. Agricultural Water Use (~67%)

- Up to 80% of the water used evaporates before reaching plant roots
- Irrigation methods: water-filled ditches, high pressure sprinklers (most common in US but inefficient)

E. Water Management Projects

1. Water Diversion Projects

- All or part of a river can be diverted to supply dry regions with water
- _____

2. Dams and Reservoirs

- _____: built to control water flow, but also useful for generating electricity (20% of world's energy)
- _____: form behind dams; water can be used for flood control, drinking, irrigation, recreation, and industry
- Consequences: species may be displaced, ecosystems may be destroyed (behind and below the dam), failure may cause deaths

F. Water Conservation

1. In Agriculture

- Water loss due to evaporation, seepage, and run-off
- Conservation strategies: drip irrigation systems, watering early or late

2. In Industry
- Strategies: recycle cooling water and wastewater; financial incentives to conserve

3. At Home (Table 2, p. 282)
- Strategies: water-saving technology, xeriscaping

G. Solutions for the Future

1. Desalination

(1) Water is heated, which forces the water to evaporate.
(2) The water vapor (steam) is collected.

★ *EXPENSIVE*

2. Transporting Water
- Ship water from one area to another… ~50% of US freshwater is found in Alaska
- ~77% of Earth's water is frozen in icecaps and glaciers… why not tow an iceberg? *EXPENSIVE and inefficient*

3. Other
- _____: water is pushed through a semipermeable membrane that prevents the salt from passing through

Section 3: Water Pollution

Objectives

1. Compare point-source pollution and nonpoint-source pollution.
2. Classify water pollution by five types.
3. Explain why groundwater pollution is difficult to clean.
4. Describe the major sources of ocean pollution, and explain the effects of pollution on ecosystems.
5. Describe six major laws designed to improve water quality in the United States.

A. Point-source Pollution
- Is discharged from a single source, such as a factory, a waste water treatment plant, or leaking oil tanker
- Can generally be identified and traced but clean-up is difficult to enforce
- Sources (Table 3, p. 284): _____

_____

B. Nonpoint-source Pollution
- Comes from many sources, such as streets and storm sewers
- _____
- Sources (Table 4, p. 285): _____

C. Principal Water Pollutants (Table 5, p. 286)

Type of Pollutant	Agent	Major Sources
1.	Disease-causing organisms, such as bacteria, viruses, protozoa, and parasitic worms	Mostly nonpoint sources; sewage or animal feces, livestock feedlots, and poultry farms; sewage from overburdened wastewater treatment plants
2.	Animal and plant matter remains, feces, food waste, and debris from food-processing plants	Mostly nonpoint sources
3.	Pesticides, fertilizers, plastics, detergents, gasoline and oil, and other materials made from petroleum	Mostly nonpoint sources; farms, lawns, golf courses, roads, wastewater, unlined landfills, and leaking underground storage tanks
4. Inorganic chemicals		
5.		Point sources and nonpoint sources; industrial discharge, unlined landfills, some household chemicals, and mining processes; heavy metals also occur naturally in some groundwater
6. Physical agents		Point sources and nonpoint sources; heat from industrial processes and suspended solids from soil erosion

A. Wastewater

1. Treating Wastewater (Fig. 17, p. 287)

- **Primary Treatment**

  (1) _____

  (2) _____

- **Secondary Treatment**

  (3) _____

  (4) _____

  (5) _____

2. Sewage Sludge

- *Sewage sludge*: the solid material that remains after wastewater has been treated
- Disposal: difficult and expensive if it contains toxic or hazardous materials (hazardous waste)

B. Artificial Eutrophication

- Eutrophication: natural process of nutrient enrichment

- Artificial eutrophication: human-induced eutrophication; excess _____ can lead to algal blooms
- Sources of excess P and nitrogen (N): detergents, animal waste, and fertilizer

C. Thermal Pollution

- Is a human-induced increase in the temperature of a body of water, which has a harmful effect on water quality and on the ability of that water to support life
- Can occur when industrial cooling water is discharged into a body of water
- _____

D. Groundwater Pollution (Fig. 20, p. 290)

- _____
- Sources: pesticides, herbicides, chemical fertilizers, petroleum products, etc. from surface water pollution, underground storage tanks, unlined landfills, etc.
- The Environmental Protection Agency (EPA) has detected _____ hazardous chemicals that can seep through the soil and into the groundwater.
- Cleaning up is difficult and may take 1000s of years

E. Ocean Pollution

- _____ comes from *land* activities:
  - Some due to rivers, which carry runoff to the ocean
  - Most from near-shore activities, primarily threatening sensitive near-shore ecosystems like estuaries and coral reefs
  - 200-300 million gallons of oil/year
- _____ comes from other sources:
  - Ships *legally* dump wastewater and garbage
  - Accidental oil spills (Fig. 21, p. 291): ~37 million gallons/year spilled by tankers (=5% of all oil pollution in the oceans)
- The discharge of oil and the disposal or abandonment of plastics in the ocean or coastal water regulated by laws
- _____ (UN 1982)
  - Nation's laws extend 22 km from shore = _____
  - Nations have control over economic activity, environmental preservation and research out to 370 km from shore = _____
  - The rest of the ocean is communal property controlled by the _____

F. Water Pollution and Ecosystems

- _____: accumulation of pollutants at successive levels of a food chain
- Example: DDT biomagnification (Fig. 22, p. 292)

G. Cleaning Up Water Pollution

- _____: "restore and maintain the chemical, physical, and biological integrity of the nation's waters"
  - Not much progress: ~30% increase
  - Led many states to adopt stricter water-quality standards
  - Led to other federal laws (Table 6, p. 293)
    (1) **Marine Protection, Research, and Sanctuaries Act of 1972**, amended 1988:

    _____

    _____

    _____

    (2) **Safe Water Drinking Act of 1975**, amended 1996: This act introduced programs to protect groundwater and surface water from pollution. The act emphasized sound science and risk-based standards for water quality. The act also empowered communities in the protection of source water, strengthened public right-to-know laws, and provided water system infrastructure assistance.

    (3) **Comprehensive Environmental Response Compensation and Liability Act of 1980** (CERCLA): AKA Superfund Act. The act makes owners, operators, and customers of hazardous waste sites responsible for the cleanup of the sites. The act has reduced the pollution of groundwater by toxic substances leached from hazardous waste dumps.

    (4) **Water Quality Act of 1987**: _____

    _____

    _____

    (5) **Oil Pollution Act of 1990**: _____

    _____

    _____