Ted Talk Video Water

Chapter 15 & 16

Water Pollution

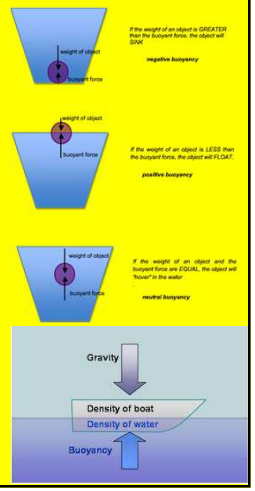
Properties of Water Supporting Life

High Specific Heat - fluctuations in heat are not as great as on land, reduce risk of temperature related problems

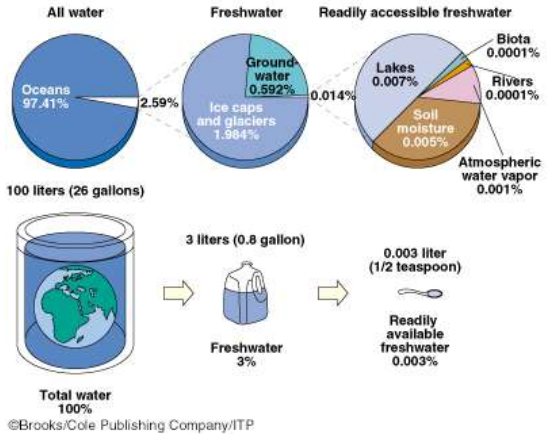
Buoyancy- physical support allows for larger sized creatures with less rigid support

Nutrient availability- nutrients are dissolved and "on tap" in surrounding waters

Waste elimination- wastes are quickly dissolved, dispensed, and diluted

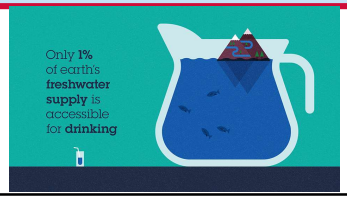


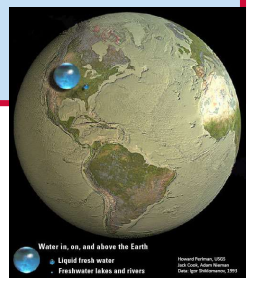
Global Water Distribution



Global Water Distribution

- 71% of the Earth's surface is covered in water
- 97% of that water is salt water: Unusable
- 3% is freshwater: Usable by humans
  - 77% of the fresh water is frozen in icecaps and glaciers
- Fresh water is a limited resource
- **Potable Water: Drinkable**

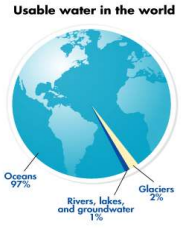




Marine Biomes

- **Consist of coastal ocean, open ocean, coral reefs, estuaries, coastal marshes, and mangrove swamps.**

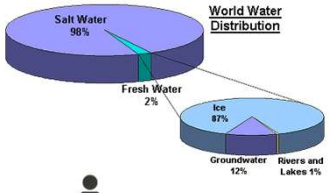
- 71% of earth's surface
- Currents distribute solar heat and regulate the earth's climate
- participate in nutrient cycles
- reservoir for carbon dioxide - thus help regulate temperature of the troposphere



- 2/3rds of population live within 100 miles of the ocean

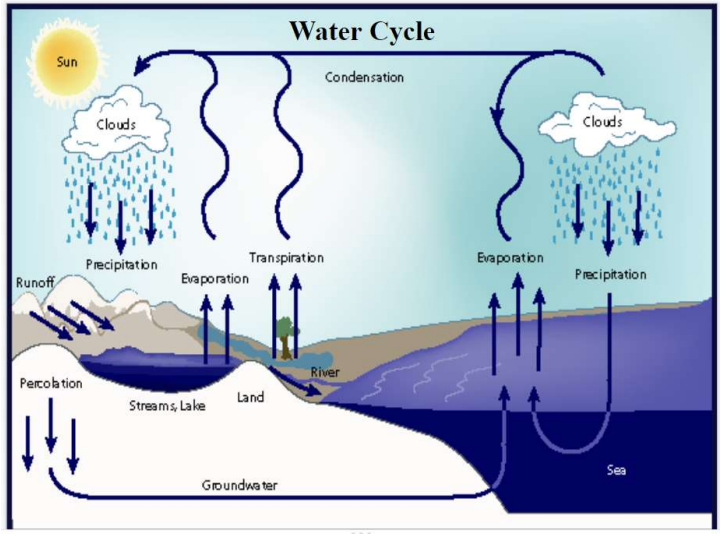
Fresh Water Biomes

Earth's surface water
Streams, rivers, ponds, lakes and wetlands



- **Total of fish species**
- **Lentic Waters: Still**
  - **Lakes & Ponds**
- **Lotic Waters: Moving/flowing**
  - **Streams, rivers**

Water Cycle

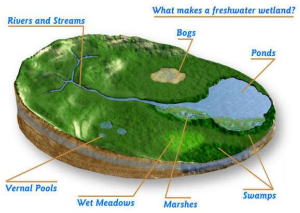


The Water Cycle

- Powered by solar energy and gravity
- Evaporation and precipitation
- Continuous recycling of water
  - Runoff
  - Infiltration
  - Evaporation
  - Temporary storage as snow and ice
  - Temporary storage in lakes
  - Temporary storage in plants (transpiration) and animals
  - Chemical reactions with rocks and minerals
  - Volcanism also causes melting of snow caps and mudflows as melted water mixes with ash
  - Source of additional water? volcanism (steam)

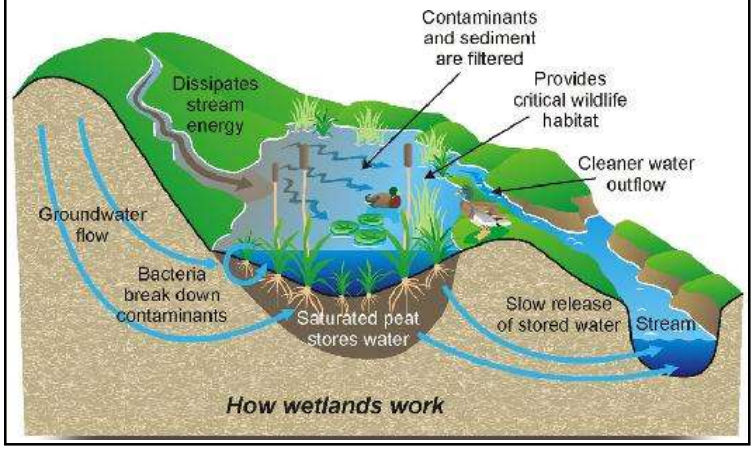
Wetlands

- Surface runoff flows into streams, lakes, wetlands and reservoirs
- A watershed or drainage basin
  - Region that drains into a streams, lakes, wetlands or reservoirs. Marshes, swamps, bogs
- Very productive ecosystems



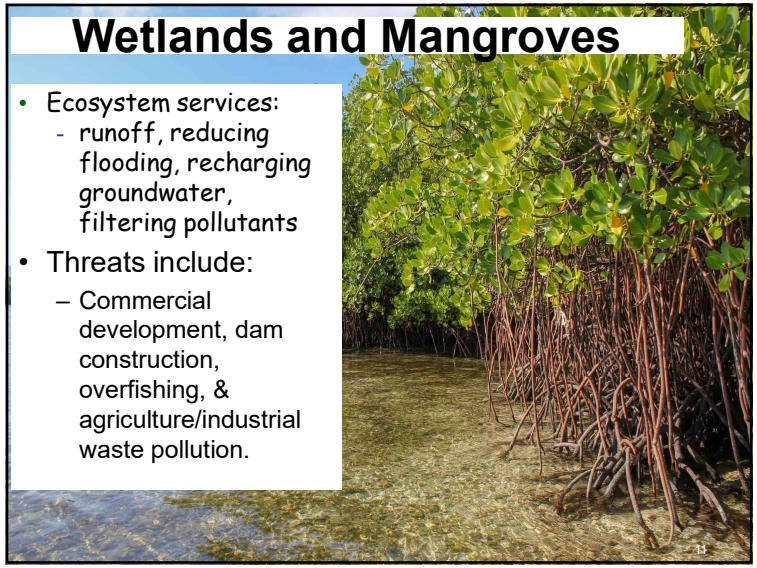
Over half have been drained and filled; many are now protected

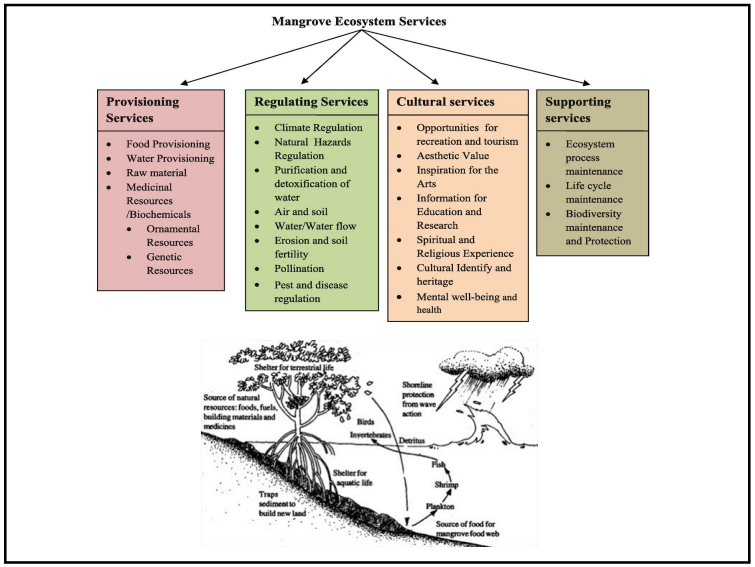
How Wetlands Work



Wetlands and Mangroves

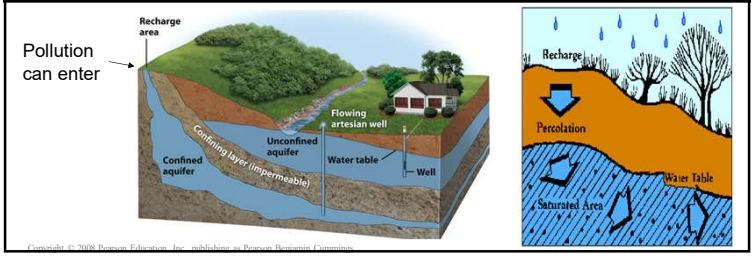
- Ecosystem services:
  - runoff, reducing flooding, recharging groundwater, filtering pollutants
- Threats include:
  - Commercial development, dam construction, overfishing, & agriculture/industrial waste pollution.





Groundwater

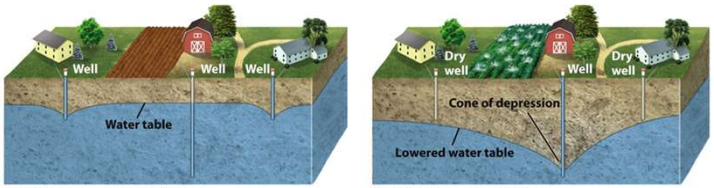
- **Aquifers**: porous sediment that holds water
- (2 types)
  - **Unconfined**: porous rock covered by soil
  - **Confined**: surrounded by layer of impermeable rock or clay
- Recharge zone: An area in which water travels downward to become part of an aquifer.
  - **Percolation** is the process of a liquid slowly passing through a filter.



Groundwater

- **Water table**: uppermost layer at which water in an area fully saturates the rock or soil
  - Falls in dry weather
  - Rises in wet weather

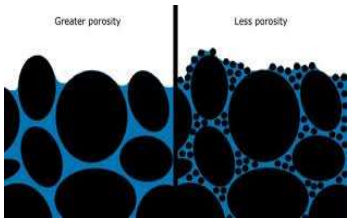
- Cone of depression- an area where there is no longer any groundwater; may cause sinkholes
- Zone of saturation is at a depth were ground is filled with water



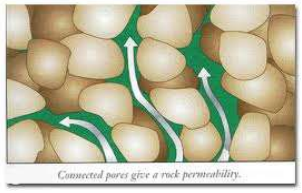
(a) Before heavy pumping (b) After heavy pumping

Porosity vs. Permeability

- Is the percentage of the total volume of a rock that has spaces or pores.
- The more porous a rock, the more water it can hold



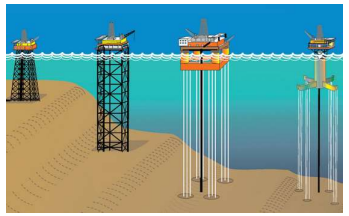
- The ability of rock or soil to allow water to flow through it.
- Example: granite, sandstone, and limestone are permeable but <u>clay is impermeable.</u>



Energy from the Ocean

- We extract energy from oceans
  - Crude oil and Natural gas
  - Oil spills damage fisheries

- Renewable energy sources, such as waves, tides, heat



Impacts of Overfishing

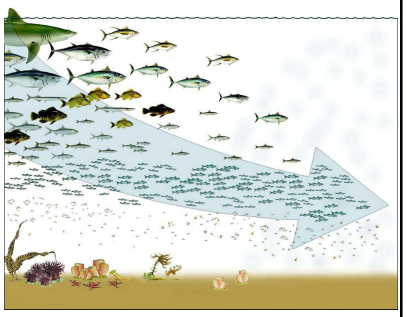
- We are placing unprecedented pressure on marine resources
  - Half the world's marine fish populations are fully exploited from overharvesting.
  - Decrease in biodiversity of fish species
- Total fisheries catch leveled off after 1998, despite increased fishing effort
- Fishing practices cause severe damage to aquatic habitat like coral reefs.

Seafood Watch Video

Impacts of Overfishing

We are "fishing down the food chain"

- As fishing increases, the size and age of fish caught decline
  - 10-year-old cod, once common, are now rare
- Decrease in biodiversity.
  - As species become too rare to fish, fleets target other species.



Open ocean systems

Causes of decline of Coral reefs around the world

1. Coral bleaching = occurs when *zooxanthellae* leave the coral
  - Coral lose their color and die, leaving white patches
  - From climate change, pollution, or unknown natural causes

2. Nutrient pollution causes algal growth, which covers coral
3. Divers damage reefs by using cyanide to capture fish
4. Acidification of oceans deprives corals of necessary carbonate ions for their structural parts

Artificial Coral Reefs

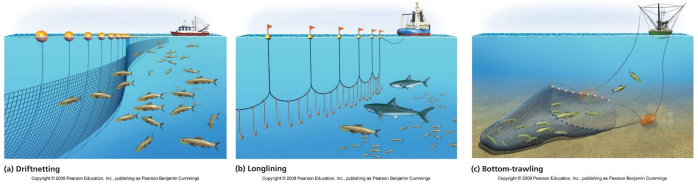
Fishing Techniques

- **Factory fishing** = highly industrialized, huge vessels use powerful technologies to capture fish in huge volumes

1.Driftnets for schools of herring, sardines, mackerel, sharks

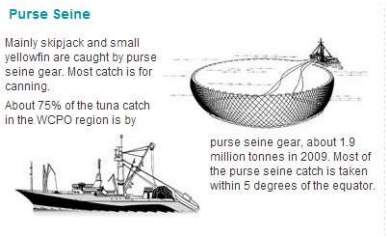
2.Longline fishing for tuna and swordfish

3.Trawling for pelagic fish and groundfish



Fishing Techniques

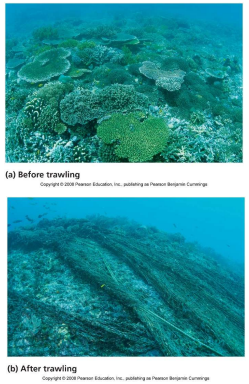
4. Purse Seine- fishing net called a seine, that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats.



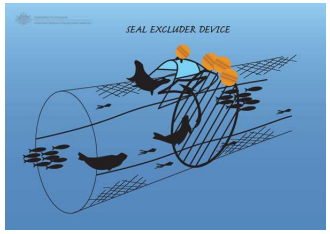
Fishing has industrialized

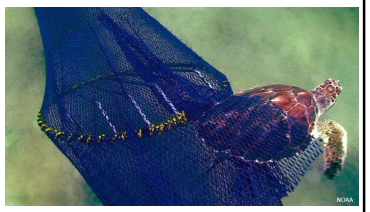
- **Fishing practices kill non-target animals**

- **By-catch** = the accidental capture of animals
  - Driftnetting drowns dolphins, turtles, and seals
  - Longline fishing kills turtles, sharks, and albatrosses
  - Bottom-trawling destroys communities
    - Same level of destruction as clear-cutting and strip mining



By-Catch Solution

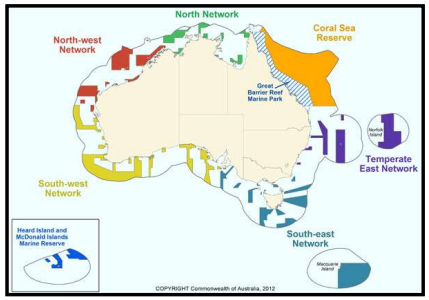




We can protect areas in the ocean

- **Marine protected areas (MPAs)** = established along the coastlines of developed countries
  - Protect habitat and habitat
  - Support fisheries (young fish are allowed to grow and replenish)

- Many commercial, recreation fishers, and businesses do not support marine reserves



Altering the Availability of Water

Dams

- Interruption of natural flow of water to which organisms are adapted.
- Fish ladders- a set of stairs with water flowing over them that have been added to some dams to help migrating fish such as salmon get upstream.

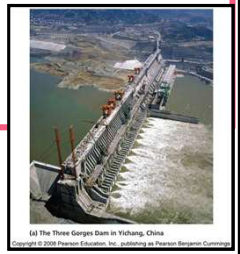
- Reservoir- the area where water is stored behind the dam.

Dams

Advantages	Disadvantages
• No CO_2 emissions or other ghgs	• Displaces people living behind dams
• Provides irrigation & drinking water	• Decreases sediment/nutrient flow downstream
• Provides flood control	• Fish harvest downstream decrease
• Cheap electricity	• Disrupts fish migration patterns
• Reservoir can be used for recreation such as boating	• Loss of water by evaporation
	• Loss of some recreation such as fly-fishing, rafting

Altering the Availability of Water

- Dams- a barrier that runs across a river or stream to control the flow of water.
  - World's Largest= **Three Gorges.**
  - World's largest hydroelectric dam, **Three Gorges, Yangtze River**
  - 1.2 - 1.9 million people displaced


(a) The Three Gorges Dam in Yichang, China

Altering the Availability of Water

- Aqueducts- canals or ditches used to carry water from one location to another.
  - Lose 55% of the water they carry through evaporation or leakage.
  - Some of the largest US cities depend on aqueducts for their daily water supplies (New York and Los Angeles

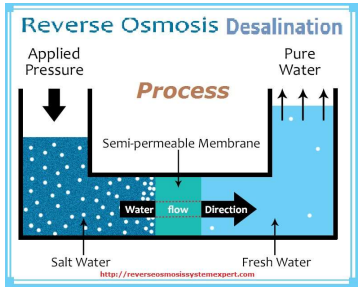

Figure 9.12
Environmental Science

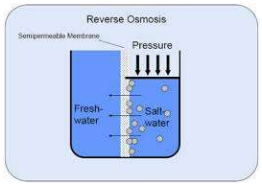
Altering the Availability of Water

- Desalination- removing the salt from salt water to obtain fresh water.

saline water

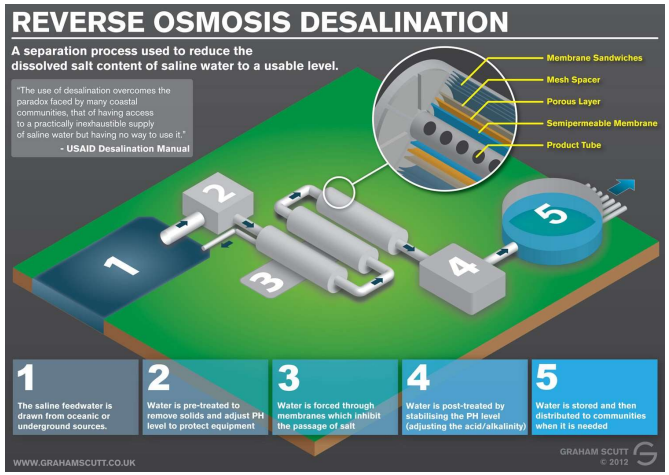
- **Distilling** = hastens evaporation and condenses the vapor
- **Reverse osmosis** = forces water through membranes to filter out salts





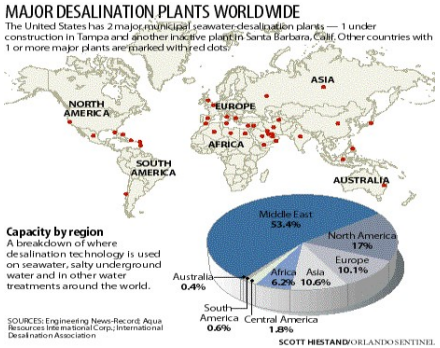
In the US, due to a 2011 court ruling under the Clean Water Act, ocean water intakes are no longer viable without reducing mortality of the life in the ocean, the plankton, fish eggs and fish larvae, by 90%. The alternatives include beach wells to eliminate this concern, but require more energy and higher costs, while limiting output.

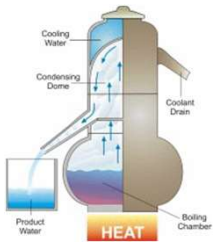
Video



Desalination

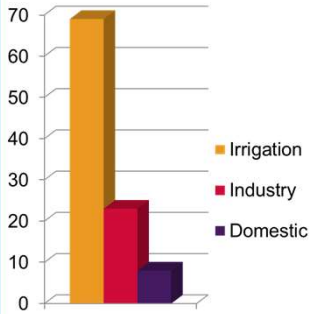
Jebel Ali Desalination Staion, Dubai
Lahmeyer International





Water Use

- A human can survive 3 weeks (plus) without food, but only a few days without water.
- World fresh water use:
  - **70% of used in agriculture (irrigation)**
  - **23% is used in industry**
  - **7% used domestically (household, drinking water, sanitation)**



Great Water Video

Agriculture, Industry & Household Needs

- Agriculture- Largest user of water around the world.


Flood irrigation


Spray irrigation


Drip irrigation


Furrow irrigation

- Industry- the 2nd largest user of water worldwide.

Generating electricity, cooling machinery, refining metals and paper

Agriculture, Industry and Household Needs

- Households- 3rd largest user of water worldwide .
  - 157 gallons per day (U.S.)

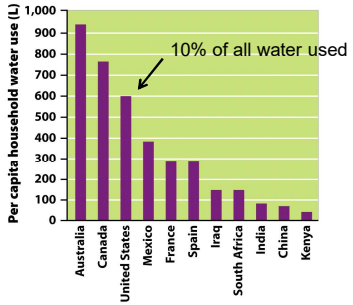


Figure 9.20

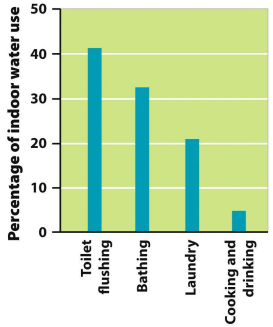


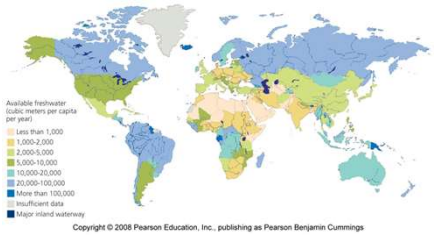
Figure 9.21

Poor Distribution

- Earth's water is not distributed evenly.
  - 1 billion people (15%) lack access to clean drinking water .
    - 1.8 million people die from diarrheal diseases related to contaminated water.

The future of water availability will depend on many things:

How we resolve issues of ownership.
How we improve water conservation.
Development of water-saving technologies.



Can the Aral Sea be saved?

Once the fourth-largest lake on Earth
It has lost more than 80% of its volume in just 45 years

People may have begun saving the northern part of the Aral Sea

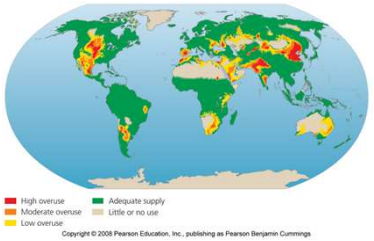

(a) Ships stranded by the Aral Sea's fast-receding waters

Water Use

Will we see a future of water wars?

- Freshwater depletion leads to shortages, which can lead to conflict
  - 261 major rivers cross national borders
  - Water is a key element in hostilities among Israel, Palestinians, and neighboring countries
- Many nations have cooperated with neighbors to resolve disputes

Areas where water use exceeds supply



Water Pollution

- **Water pollution**: the introduction of chemical, physical, or biological agents into water.
- Two causes are **industrialization** and **rapid human population growth**
- **Agriculture** is the largest sources of water pollution.

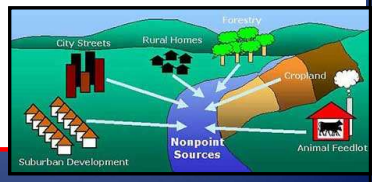
Two Sources of Water Pollution

Point-Source Pollution

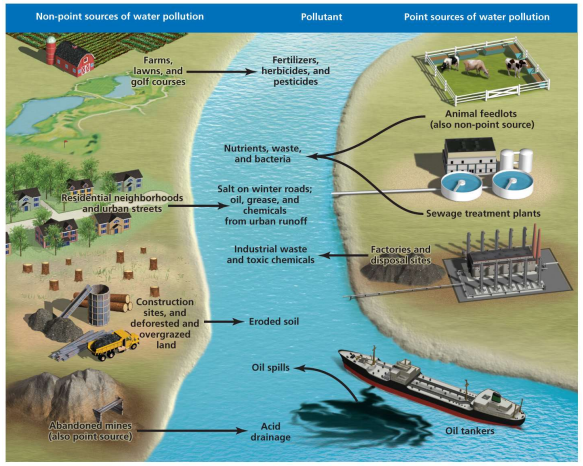
- Pollution discharged from a single source.
- Easier to identify and trace. (pipes, ditches, sewers)
- Examples: leaking tank, unlined landfill, animal feedlots, waste discharge pipe,

Nonpoint-Source Pollution

- Comes from many different sources that diffuse.
- Difficult to identify and trace.
- Examples: road or agricultural runoff, polluted precipitation, water runoff, mining, residential

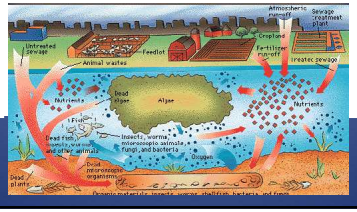


Freshwater pollution sources



Physical Water Pollutants

- **Pathogens**: disease causing organisms
- **Organic matter**: feces, food wastes
- **Organic chemicals**: pesticides, fertilizers, plastics
- **Inorganic chemicals**: acids, bases, salts
- **Heavy metals**: lead, mercury, cadmium, arsenic
- **Physical agents**: heat and suspended solids



Pathogens & Waterborne diseases

- Enters water via inadequately treated human waste & animal waste via feedlots
- Causes more human health problems than any other type of H_2O pollution
- Fecal coliform bacteria, giardiais, typhoid fever, cholera, hepatitis A/B

Solutions:

- Treat sewage
- Disinfect drinking water
- Public education to encourage personal hygiene
- Government enforcement of regulations

Cultural Eutrophication

- **Eutrophication** is when phosphates and nitrates enter the water from sewage and fertilizer runoff.
- Enriched nutrients in water
- Create algal blooms
- Decrease in dissolved oxygen
- **Cultural Eutrophication**: human caused
  - Agriculture and wastewater

2015 Lake Erie-algae bloom

Hypoxia in Coastal zones

- Hypoxia is a result of excess nutrients in the water, more specifically nitrates and phosphates.
- Introduced by runoff from agriculture or wastewater.
- Leaving behind low levels of oxygen.
- Die-offs of fish and other aquatic organisms.
- Easily form positive feedback loops.
  - dying organisms from lack of oxygen cause even more break down and less oxygen

(b) Red tide, Gulf of Carpentaria, Australia

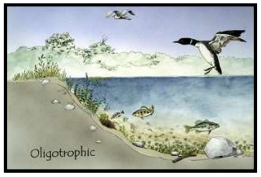
- **The Gulf of Mexico's "Dead Zone"** is currently the most notorious eutrophic body of water within the world.

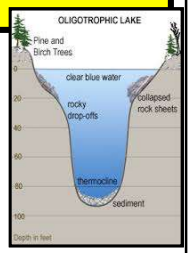
Productivity in a lake

Oligotrophic

Low amounts of nutrients Ex: P and N

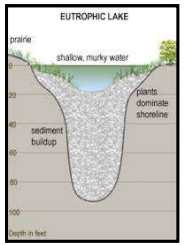
High O_2





Eutrophic

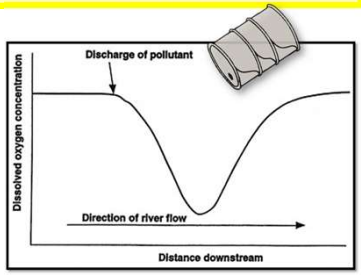
- High levels of nutrients
- Very Low O2



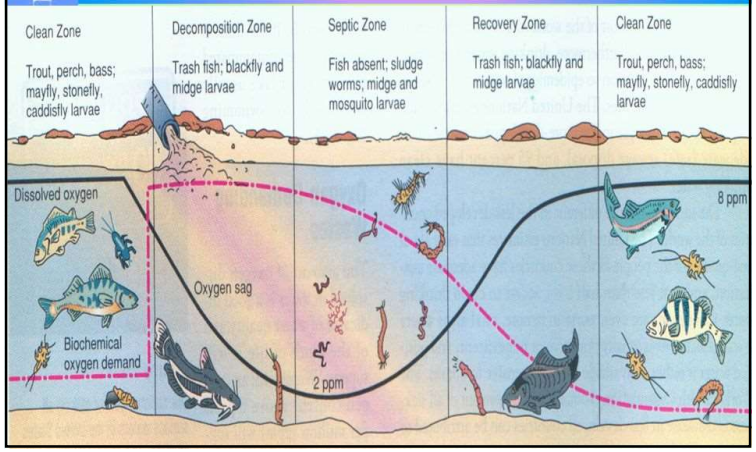
Biochemical Oxygen Demand (BOD)

- Biological Oxygen Demand is a measure of the oxygen used by microorganisms to decompose waste.
- Lower BOD values indicate the water is less polluted and higher BOD values indicate it is more polluted by wastewater. (measured in mg)
  - Example: decomposition of leaves and such might have 5 to 20 mg of oxygen vs. human waste water which might have 200 mg.

If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline.



Dissolved Oxygen Depletion



Thermal Pollution

- **Thermal pollution**: when heat is released into waterways.
- Affect concentration of dissolved oxygen.
  - Warm water does not contain as much oxygen as cold water.
- Power plants use water in their cooling systems
  - Discharge warm water back into lake or river.
  - Causes large fish kills and aquatic organisms suffocate.

Sediment pollution

- Sediment can impair aquatic ecosystems
  - Clear-cutting, mining, poor cultivation practices
- Reduce light infiltration, affecting primary producers, visual predators.
- Descripts habitats

Figure 14.18
Environmental Science
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Oil Pollution

- How oil enters water sources
  1st Natural Seeps
  2nd Consumption (motors)
  3rd Transporting
  4th Extraction

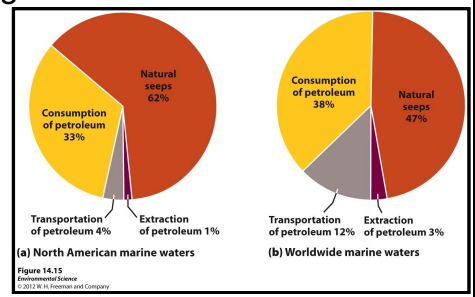

Figure 14.15
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Oil Pollution

- Organisms die from hydrocarbons in oil
- Floating oil coats feathers of birds and fur of marine mammal
- Oil washes up on the shoreline creating economic problems.
  - Fishing and tourism decreases.

Exxon and BP oil spills

Figure 14.14
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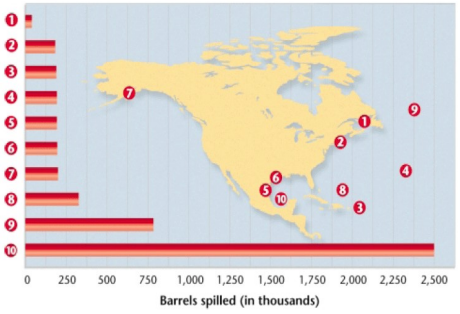
3 mins BP BP video 10 mins BP

Oil Spills



1. *Kurdistan* Gulf of St. Lawrence, Canada, 1979
2. *Argo Merchant* Nantucket, MA, 1976
3. Storage Tank Benuelan, Puerto Rico, 1978
4. *Athenian Venture* Atlantic Ocean, 1988
5. *Unnamed Tanker* Tuxpan, Mexico, 1996
6. *Burmah Agate* Galveston Bay, TX, 1979
7. *Exxon Valdez* Prince William Sound, AK, 1989
8. *Epic Colocotronis* Caribbean Sea, 1975
9. *Odyssey* North Atlantic Ocean, 1988
10. Exploratory Well Bay of Campeche, 1979

Solid Waste Pollution

- Litter reaches aquatic ecosystems.
- Negative of solid waste:
  - Intestinal blockage and choking hazards
  - Introduce toxic substances to the food chain.

Great Pacific Garbage Patch

Bottle Water

Great Pacific Garbage Patch GRGP Solution

Wastewater

- **Wastewater**: water that contains waste from homes or industry.
- Most wastewater can be treated but some toxic substances require further treatment.
- Sewage **sludge** is the solid material that remains after treatment
- Hard to dispose of so sludge can be used for fertilizer and to make bricks.

Human Wastewater

- Produced by human activities
  - Sewage from toilets, bathing & washing clothes/ dishes.
- Puts a large demand for oxygen in the water
- Can cause eutrophication
- Can carry a wide variety of disease-causing organisms.

Water-born diseases

- Cholera, Typhoid fever, Stomach flu, Diarrhea, Hepatitis

Indicator species

- Indicator species are organisms that indicate whether or not disease-causing pathogens are likely.
  - Aquatic organism
    - amphibians and macroinvertibrates
  - The best indicators for water are the Fecal-coliform bacteria (E. coli is an example)
    - Swimming and fishing water safe level=500-10,000 colonies per 100mL of water. Public Health authorities may find that any bacteria found is unsuitable for drinking standards.

Water Quality Tests

Macroinvertebrates

Coliform Bacteria

Chemical Tests

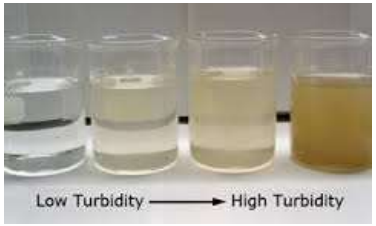
Organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate).

WHO recommends 0 colonies for drinking. **EPA** recommends max of 200 colonies for swimming (100 mL-sample).

- **pH**
- **Dissolved oxygen**
- **Nitrate**
- **Heavy metals**

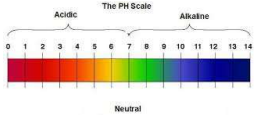
H_2O Quality Testing: PHYSICAL

- **Temperature**: impacts solubility of O_2 & tolerance of organisms
- **Turbidity**: measures the cloudiness of water; affected by sedimentation from erosion or algal blooms



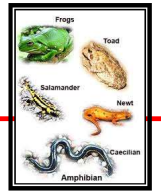
H2O Quality Testing: CHEMICAL

- pH: most organisms survive best with 6-9 pH
- Dissolved O_2: amount of O_2 gas in water dependent upon photosynthesis, temp., and flow; cold, fast water has highest amt of dissolved oxygen
- Nitrates/phosphates: provide nutrients for aquatic systems; may indicate runoff from fert., sewage, septic tank leaks, or feedlots
- Hardness: presence of common metals—Mg+2, Ca+2



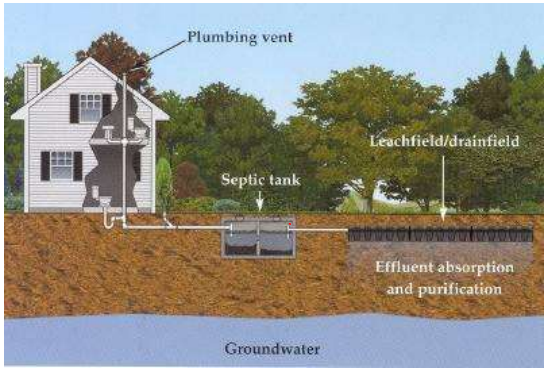
H2O Quality Testing: Biological

- Fecal coliform: fecal contamination from sewage, septic tanks, or feedlots
- Biological assessment: monitoring of organisms such as macroinvertebrates, amphibians, and certain fish species



Human Wastewater

- **Septic systems-** a large container that receives wastewater from the house.
  - Not connected to city sewers



- **Sewage Treatment Plants-** centralized plants in areas with large populations that receive wastewater via a network of underground pipes.

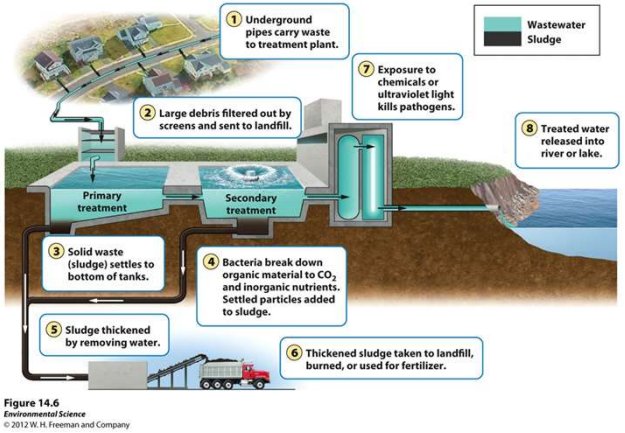
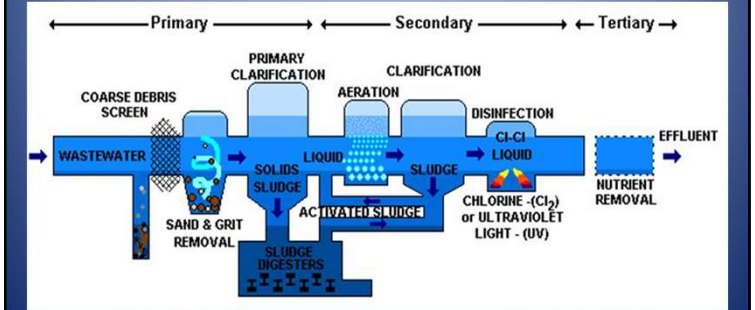


Figure 14.6
Environmental Science

Municipal Sewage Treatment

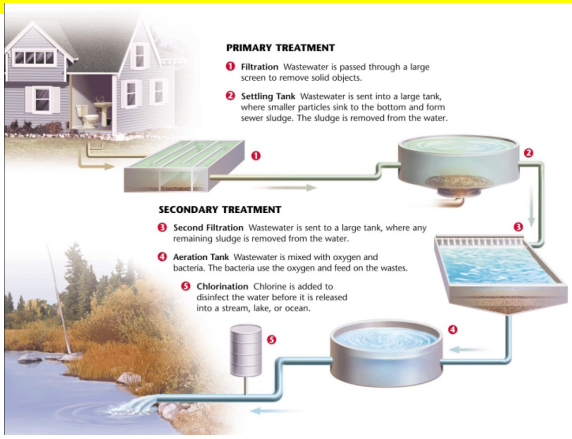
- **Primary treatment**
  - Filtration using screens or grates
  - Physical removing of large objects
  - Settling of solid waste at the bottom of tank
- **Secondary treatment : Biological Process**
  - Bacteria break down organic matter into carbon dioxide and inorganic sewage sludge (settle at the bottom)
  - Aeration: oxygen mixed with bacteria to increase feeding on waste
- **Tertiary treatment**
  - Water is treated to one or more of the following to kill bacteria:
    - Chlorine, Ozone, or UV light
  - Reduce phosphorus and nitrogen

Wastewater Treatment Process



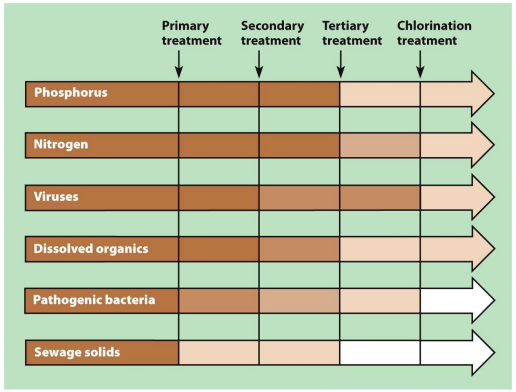
Treatment Plant Video

Wastewater Treatment Process



Wastewater Treatment Process

Municipal Sewage Treatment



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Water Laws

- **Clean Water Act (1972):** mainly regulates point-source pollution from sewage facilities and industries and finances wastewater treatment systems; issues water quality standards that define acceptable limits of various pollutants in U.S. waterways.

Water Laws

- **Safe Drinking Water Act (1974):** sets the national standards for safe drinking water; establishes maximum contaminant levels (MCL) for different elements or substances in both surface water and groundwater.