Chapter 19:

Water Pollution and Treatment

Jake Rajs/stone/Getty Images

Overview

- Water Pollution
- Biochemical Oxygen Demand (BOD)
- Nutrients
- Waterborne Disease
- Oil
- Sediment
- Acid Mine Drainage
- Surface-Water Pollution
- Groundwater Pollution
- Wastewater Treatment
- Land Application of Wastewater

Water Pollution

- An epidemic of cholera in Haiti following the 2010 earthquake.
- Waterborne disease is especially likely following natural disasters such as floods and earthquakes or from runoffs, leaks or population increase etc.
- Degradation of water quality
- Based on
  - Intended use of the water
  - How far the water departs from the norm
  - Its effects on public health
  - Its ecological impacts

Water Pollution

- Water pollutants include
  - Heavy metals
  - Sediment
  - Certain radioactive isotopes
  - Heat
  - Fecal coliform bacteria
  - Phosphorus
  - Nitrogen
  - Sodium, and other useful (even necessary) elements
  - Pathogenic bacteria and viruses

Dinodia/The Image Works

Water Pollution

- Primary water pollution problem is the lack of clean, disease-free drinking water
  - Outbreaks of waterborne disease affects several billion people worldwide
- All segments of society may contribute to water pollution
- Increasing population may cause
  - Introduction of more pollutants
  - Increased demands on finite water resources

Table 19.1 SOME SOURCES AND PROCESSES OF WATER POLLUTION

SURFACE WATER	GROUNDWATER
Urban runoff (oil, chemicals, organic matter, etc.) (U, I, M) Agricultural runoff (oil, metals, fertilizers, pesticides, etc.) (A)	Leaks from waste-disposal sites (chemicals, radioactive materials, etc.) (I, M)
Accidental spills of chemicals including oil (U, R, I, A, M)	Leaks from buried tanks and pipes (gasoline, oil, etc.) (I, A, M)
Radioactive materials (often involving truck or train accidents) (I, M)	Seepage from agricultural activities (nitrates, heavy metals, pesticides, herbicides, etc.) (A)
Runoff (solvents, chemicals, etc.) from industrial sites (factories, refineries, mines, etc.) (I, M)	Saltwater intrusion into coastal aquifers (U, R, I, M) Seepage from cesspools and septic systems (R)
Leaks from surface storage tanks or pipelines (gasoline, oil, etc.) (I, A, M)	Seepage from acid-rich water from mines (I) Seepage from mine waste piles (I)
Sediment from a variety of sources, including agricultural lands and construction sites (U, R, I, A, M)	Seepage of pesticides, herbicide nutrients, and so on from urban areas (U)
Air fallout (particles, pesticides, metals, etc.) into rivers, lakes, oceans (U, R, I, A, M)	Seepage from accidental spills (e.g., train or truck accidents) (I, M)
	Inadvertent seepage of solvents and other chemicals including radioactive materials from industrial sites or small businesses (I, M)

Source: U.S. Environmental Protection Agency.
U = urban; R = rural; I = industrial; A = agricultural; M = military.

Water Pollution

- EPA sets thresholds and limits on some but not all pollutants
  - 700 identified drinking water contaminants

Table 19.2 NATIONAL DRINKING-WATER STANDARDS

CONTAMINANT	MAXIMUM CONTAMINANT LEVEL (MG/L)
Inorganics	
Arsenic	0.05
Cadmium	0.01
Lead	0.015 action level[a]
Mercury	0.002
Selenium	0.01
Organic chemicals	
Pesticides	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Herbicides	
2,4-D	0.1
2,4,S-TP	0.01
Silvex	0.01
Volatile organic chemicals	
Benzene	0.005
Carbon tetrachloride	0.005
Trichloroethylene	0.005
Vinyl chloride	0.002
Microbiological organisms	
Fecal coliform bacteria	1 cell/100 ml

[a] Action level is related to the treatment of water to reduce lead to a safe level. There is no maximum contaminant level for lead.

Source: U.S. Environmental Protection Agency.

Table 19.3 CATEGORIES OF WATER POLLUTANTS

POLLUTANT CATEGORY	EXAMPLES OF SOURCES	COMMENTS
Dead organic matter	Raw sewage, agricultural waste, urban garbage	Produces biochemical oxygen demand and diseases.
Pathogens	Human and animal excrement and urine	Examples: Recent cholera epidemics in South America and Africa; 1993 epidemic of cryptosporidiosis in Milwaukee, Wisconsin. See discussion of fecal coliform bacteria in Section 22.3.
Drugs	Urban wastewater, painkillers, birth control pills, antidepressants, antibiotics	Pharmaceuticals flushed through our sewage treatment plants are contaminating our rivers and groundwater. Hormone residues or hormone mimickers are thought to be causing genetic problems in aquatic animals.
Organic chemicals	Agricultural use of pesticides and herbicides (Chapter 11); industrial processes that produce dioxin (Chapter 10)	Potential to cause significant ecological damage and human health problems. Many of these chemicals pose hazardous-waste problems (Chapter 23).
Nutrients	Phosphorus and nitrogen from agricultural and urban land use (fertilizers) and wastewater from sewage treatment	Major cause of artificial eutrophication. Nitrates in groundwater and surface waters can cause pollution and damage to ecosystems and people.
Heavy metals	Agricultural, urban, and industrial use of mercury, lead, selenium, cadmium, and so on (Chapter 10)	Example: Mercury from industrial processes that is discharged into water (Chapter 10). Heavy metals can cause significant ecosystem damage and human health problems
Acids	Sulfuric acid (H_2SO_4) from coal and some metal mines; industrial processes that dispose of acids improperly	Acid mine drainage is a major water pollution problem in many coal mining areas, damaging ecosystems and spoiling water resources.
Sediment	Runoff from construction sites, agricultural runoff, and natural erosion	Reduces water quality and results in loss of soil resources.
Heat (thermal pollution)	Warm to hot water from power plants and other industrial facilities	Causes ecosystem disruption (Chapter 10).
Radioactivity	Contamination by nuclear power industry, military, and natural sources (Chapter 17)	Often related to storage of radioactive waste. Health effects vigorously debated (Chapters 10 and 17).

Water Filtering from Natural Environment or Ecosystem

Water withdrawn from surface or groundwater sources is treated by filtering and chlorinating before distribution to urban users. Sometimes it is possible to use the natural environment to filter the water as a service function, saving treatment cost.

The water from the Catskills has historically been of high quality and was once regarded as one of the largest municipal water supplies in the United States that did not require extensive filtering.


oote boe/Alamy Images

In the past, the water from the Catskills was filtered very effectively by natural processes.

When rain or melting snow drips from trees or melts on slopes in the spring, some of it infiltrates the soil and moves down into the rocks below as groundwater.

Some emerges to feed streams that flow into reservoirs. During its journey, the water enters into a number of physical and chemical processes that naturally treat and filter the water.

These natural service functions (also called ecosystem services).

Dissolved Oxygen

- Bacteria in stream decompose dead organic matter (e.g. dead leaves)
  - Decomposition requires oxygen
  - More bacteria decomposition = less oxygen in the water available to fish and other organisms
  - Oxygen can be decreased to a point where aquatic organisms die
- A stream with a low dissolved oxygen (DO) is considered polluted

Biochemical Oxygen Demand (BOD) <5 mg/l

- Amount of oxygen required for biochemical decomposition
- Measure of the amount of oxygen consumed by microorganisms as they break down organic matter (via incubation)
- Routinely measured as part of water quality at wastewater treatment plants
- Approximately 33% of all BOD in streams results from agricultural activities

Biochemical Oxygen Demand (BOD)

- Source of organic matter include
  - Natural sources
  - Agricultural runoff
  - Urban sewage
- U.S. EPA defines the threshold for water pollution alert as
  - DO levels of less than 5 mg/L

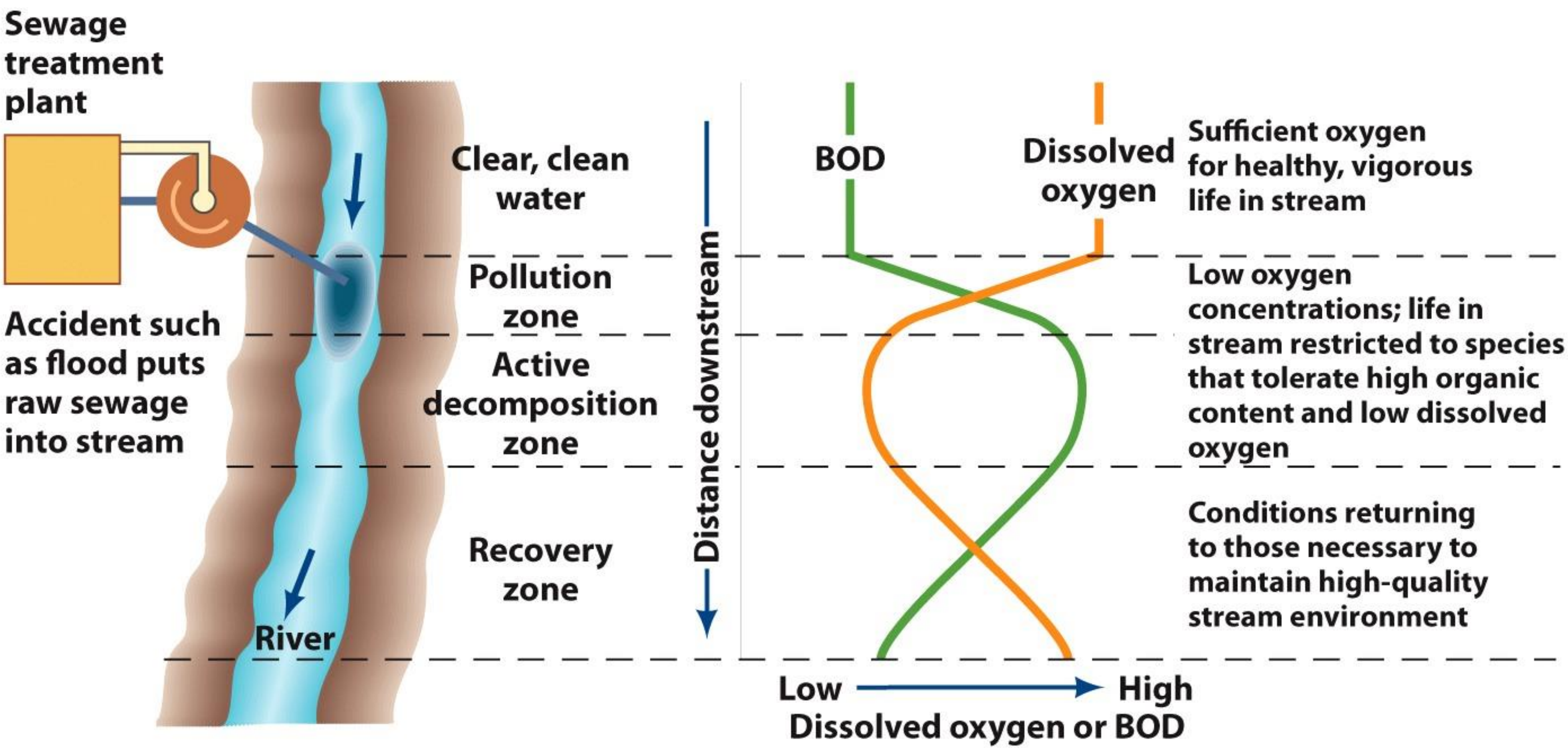
Ben Osborne/Stone/Getty Images

Pollution-control officer measuring oxygen content of the River Severn near Shrewsbury, England.

Biochemical Oxygen Demand (BOD)

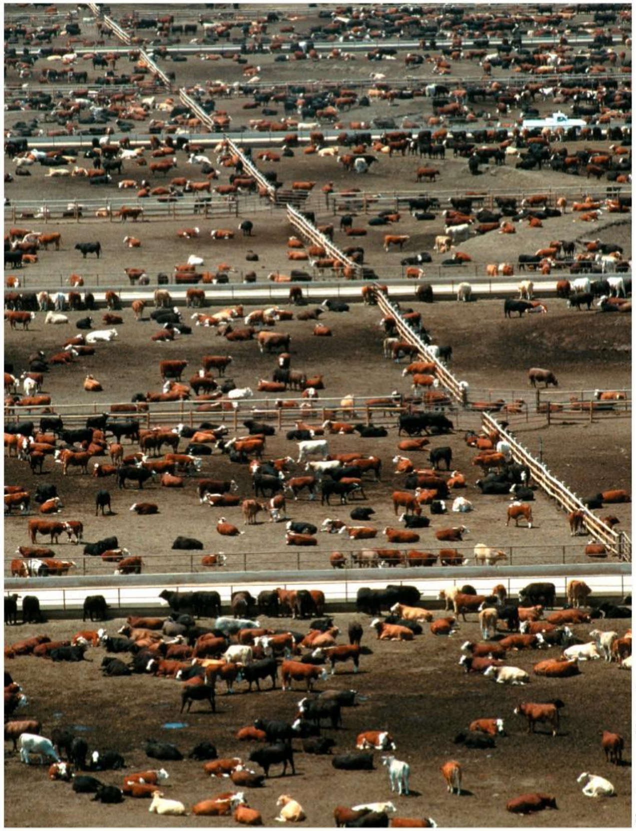
- Three zones are identified after a spill
  - First zone—pollution zone
    - High BOD
  - Second zone—active decomposition zone
    - Dissolved oxygen content reaches a minimum
  - Third zone—recovery zone
    - Dissolved oxygen increases and the BOD is reduced

The relationship between dissolved oxygen and biochemical oxygen demand (BOD) for a stream after the input of sewage.



Nutrients

- Two important nutrients that cause water pollution are phosphorous and nitrogen
  - Highest levels found in agricultural areas (90%) from fertilizers, farmlands etc.
  - From domestic animals, cattle as their excrete include large quantities of N and P.
  - In urban areas the source is: detergents, fertilizers and sewage treatment plants


Glowimages/Getty Images

Aerial view of world's largest feedlot in CO.
High numbers of cattle in small areas have the potential to pollute both surface water and groundwater because of runoff and infiltration of urine.

Eutrophication & Ecosystem Effect

- Process by which a body of water develops a high concentration of nutrients
  - Nutrients cause a large growth in aquatic plants and photosynthetic bacteria and algae (they can form surface mat, shade the water and block the sunlight, reduced photosynthesis results)
  - High populations of bacteria and algae naturally die off (less O_2)
    - Input of organic matter into water = more nutrient load to the body of water
  - Continued decomposition lowers oxygen content to point where aquatic organisms die with phosphorous poisoning.

Eutrophication

- Oligotrophic lake
  - Lake with relatively low concentration of nutrients required by life
  - Clear water
  - Low abundance of aquatic life
- Eutrophic lake
  - Lake with high concentration of nutrients
  - Often with mats of algae and murky water
  - Abundance of life

Eutrophication

- Cultural eutrophication
  - Human processes that add nutrients to water
- Solution—ensure that high concentrations of nutrients do not enter water
  - Use phosphate-free detergents
  - Control nitrogen runoff
  - Dispose or reuse treated wastewater
  - Employ advanced water treatment methods
  - Use of special filters and chemicals to remove excess nutrients

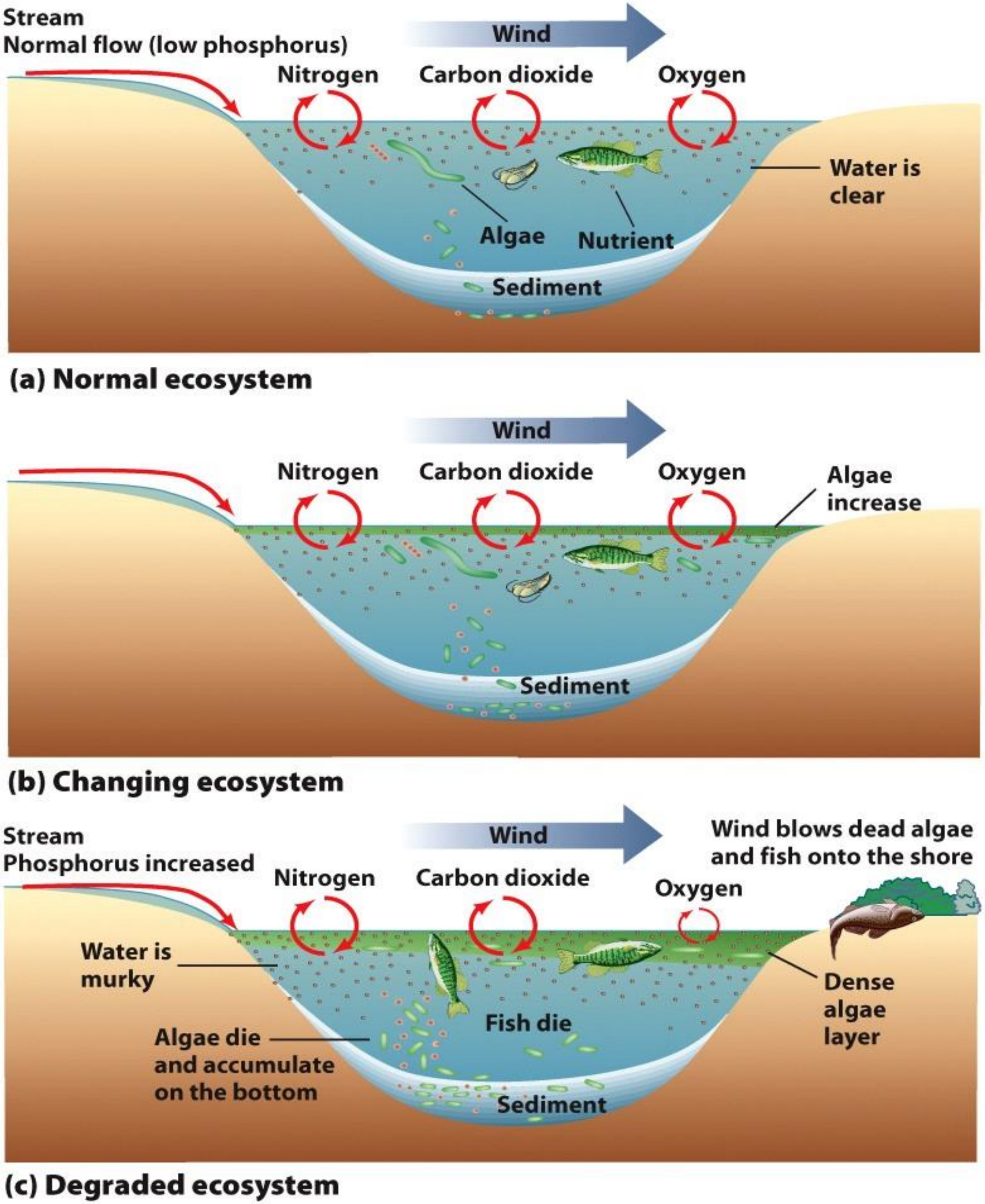


FIGURE 19.8 The eutrophication of a lake.

(a) In an oligotrophic, or low nutrient, lake, the abundance of green algae is low, the water clear.

(b) Phosphorus is added to streams and enters the lake. Algae growth is stimulated, and a dense layer forms.

(c) The algae layer becomes so dense that the algae at the bottom die. Bacteria feed on the dead algae and use up the oxygen.

Finally, fish die from lack of oxygen.

Waterborne Diseases

- Primary water pollution problem globally especially in underdeveloped countries
  - Effects vary from an upset stomach to death
  - Example cholera—a serious waterborne disease
    - Haiti earthquake in 2010
    - Cholera epidemic caused widespread suffering
    - Hundreds of thousands of people hospitalized
    - 8000 died
- Public-health programs have largely eliminated such epidemics by treating drinking water to remove disease-carrying microorganisms and not allowing sewage to contaminate drinking water supplies

Fecal Coliform Bacteria

- Fecal coliform bacteria used as indicator of disease. Its presence indicates that fecal matter is present
  - Some species of this bacteria are a normal constituent of human and animal intestines
  - Others are not
    - *Escherichia coli (E. coli)* is deadly to humans—outbreaks result from eating contaminated meat

U.S. EPA thresholds levels

200 cells/100 ml of water for swimming

0 cells/100ml of water for drinking water

Identifying sources of *E. coli* in water is necessary so that aggressive action can be taken to eliminate pollutants before they reach our waterways and beaches.

DNA fingerprinting studies can be done on *E. coli* and other living pathogens to identify sources of harmful pollutants.

Table 19.4 RECENT OUTBREAKS OF *E. COLI 0157* INFECTIONS[a]

YEAR	WHERE	SOURCE	COMMENT
1993	Washington State (fast-food restaurant)	Meat	5 children died; several hundred illnesses
1998	Georgia (water park)	Water in park pools	26 illnesses in children
1998	Town in Wyoming	Water supply	1 death
2000	Walkerton, Canada	Water supply	5 deaths
2006	23 states	Spinach	5 deaths; over 100 illnesses
2007	Hawaii (restaurant)	Lettuce	several illnesses (mostly tourists)
2009	Across the U.S.	Peanut butter	several deaths; several hundred illnesses
2009	29 states	Raw cookie dough	65 illnesses
2010	Several states, especially California, Colorado and N. Carolina	Raw eggs	at least 1,500 illnesses; 500 million eggs recalled

[a] *E. coli* 0157, a strain of *E. coli* bacteria, has been responsible for many human illnesses and deaths. *E. coli 0157* produces strong toxins in humans that may lead to bloody diarrhea, dehydration, kidney failure, and death.

Oil

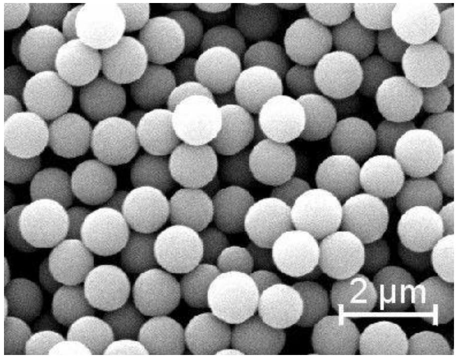
- Large spills on land and water make headlines (2010 Spill in Gulf of Mexico)
- Normal shipping activities release more oil over a period of years than is released by a single spill
- Potential threats from abandoned oil wells that have been plugged and forgotten
  - Plugs may eventually fail
  - Oil and natural gas may seep to the surface to pollute water resources

Exxon Valdez: Prince William Sound, AK

- March 24, 1989—Exxon Valdez ran aground
- Alaskan crude oil that had been delivered to the *Valdez* through the Trans-Alaska Pipeline poured out of the vessel's ruptured tanks at about 20,000 barrels per hour.
  - Ruptured tanks dumped 250,000 barrels of oil into sound
- Spilled into one of the most pristine and ecologically-rich marine environments
- Long-term effects of the spill uncertain

Sediment

- Sediment consisting of rock and mineral fragments
  - Ranging in size from gravel (>2mm) to finer sand, silt and clay to even finer particles and colloidal particles (microscopic solid particles suspended in a fluid e.g., Aerosols, Emulsions, Foams and Gels).
  - Cause sediment pollution
  - By volume and mass, greatest water pollutant
- It chokes streams; fills lakes, reservoirs, ponds, canals, drainage ditches, and harbors; buries vegetation; and generally creates a nuisance that is difficult to remove.



https://www.online-sciences.com/wp-content/uploads/2014/07/The-soil-type.jpg

Sediment

- Twofold problem
  - Erosion (gradual loss such as: worn away by glaciers, rocks or sea; changing of surface by friction; thermal expansion/contraction)
  - Reduces the quality of water resource it enters
- Land use affects erosion and sedimentation
  - Forested areas more stable
  - Agricultural practices can lead to large soil loss
  - Large quantities of sediment lost during construction phase of urbanization

For example, salmon lay their eggs in gravel on the bottom of rivers and streams. But the gravel has to be uniform in size and of a certain range of sizes. Erosion events can change the characteristic of the sediment and turn an active salmon stream into a poor one for these fish.

Acid Mine Drainage

- Refers to water with high concentration of sulfuric acid that drains from mines
- Coal mines—pyrite (iron sulfide), (Cu, Z & Pb)
  - When pyrite comes into contact with oxygen and water it creates sulfuric acid
- Water runs through the mine tailings
  - This acidic water then runs off into natural waterways or the groundwater
- In addition, pyrite is associated with metallic sulfide deposits, which, when weathered, also produce sulfuric acid. The acid is produced when surface water or shallow groundwater runs through or moves into and out of mines or tailings

FIGURE 19.12 Aerial view of an acid mine drainage holding pond adjacent to an iron mine (located in the mountains of southwestern Colorado).

Acid Mine Drainage

If the acidic water runs off to a natural stream, pond, or lake, significant pollution and ecological damage may result.

The acidic water is toxic to the plants and animals of an aquatic ecosystem; it damages biological productivity, and fish and other aquatic life may die.

Acidic water can also seep into and pollute groundwater.

Even abandoned mines can cause serious problems.

$$4\ FeS_2 + 15\ O_2 + 14\ H_2O \rightarrow 4\ Fe\ (OH)_3\ \ 8\ H_2SO_4$$

$$\text{Pyrite} + \text{Oxygen} + \text{Water} \rightarrow \text{Ferric Hydroxide} + \text{Sulfuric Acid}$$

Acid Mine Drainage-Solution

One solution being used in Tar Creek (mine in USA) and other areas is a passive treatment method that uses naturally occurring chemical and/or biological reactions in controlled environments to treat acid mine drainage.

The simplest and least expensive method is to divert acidic water to an open limestone channel, where it reacts with crushed limestone and the acid is neutralized. A general reaction that neutralizes the acid is

$$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$$

$$\text{Sulfuric Acid} + \text{Calcium Carbonate (crushed limestone)}$$
$$\rightarrow \text{Calcium Sulfate} + \text{Water} + \text{Carbon Dioxide}$$

- Another solution is to divert the acidic water to a bioreactor (an elongated trough) containing sulfate-reducing bacteria and a bacteria nutrient to encourage bacterial growth.
- The sulfate-reducing bacteria are held in cells that have a honeycomb structure, forcing the acidic water to follow a tortuous path through the bacteria-laden cells of the reactor.
- Complex biochemical reactions between the acidic water and bacteria in the reactor produce metal sulfides and in the process reduce the sulfuric acid content of the water.
- Both methods result in cleaner water with a lower concentration of acid being released into the environment.

Surface-Water Pollution

- Pollution of surface waters
  - Too much of an undesirable or harmful substance flows into a body of water
  - Substance exceeds the natural ability of that water body to:
    - Remove the undesirable material
    - Dilute it to a harmless concentration
    - Convert it to a harmless form

Surface-Water Pollution

- Emitted from point or nonpoint source
- Point source pollutant
  - Distinct and confined
  - Pipes from municipal or industrial sites that empty into a stream or river

Photoshot Holdings Ltd/Alamy

FIGURE 19.13 This pipe is a point source of chemical pollution from an industrial site entering a river in England.

Surface-Water Pollution

- Nonpoint source pollutant
  - Diffused and intermittent
  - Example: runoff
  - Influenced by land use, climate, hydrology, topography, native vegetation, and geology
  - Difficult to monitor and control

Surface-Water Pollution

- Two traditional approaches to dealing with surface water pollution
  - To reduce the sources
  - To treat the water to remove pollutants or convert them to forms that can be disposed of safely
- Two new approaches
  - Nanotechnology
  - Bioengineering

New Technologies

- Nanotechnology
  - Uses extremely small particles to “capture” heavy metals (lead, mercury or arsenic) in water
- Bioengineering (collect urban runoff and store it in landscapes that allow water to be used by plants and to infiltrate the soil for additional natural filtration)
  - “Closed-loop” local landscape
      - Bioretention facility
    - Does not permit water to leave certain area
    - Helps reduce cultural eutrophication
    - Laws and gardens planted; Native vegetation replaced by rooftops, parking lots, streets and sidewalks
    - RAIN GARDERN: Direct water to landscape
    - Island in parking lots
    - Wetland applications

Urban Runoff Neutralization

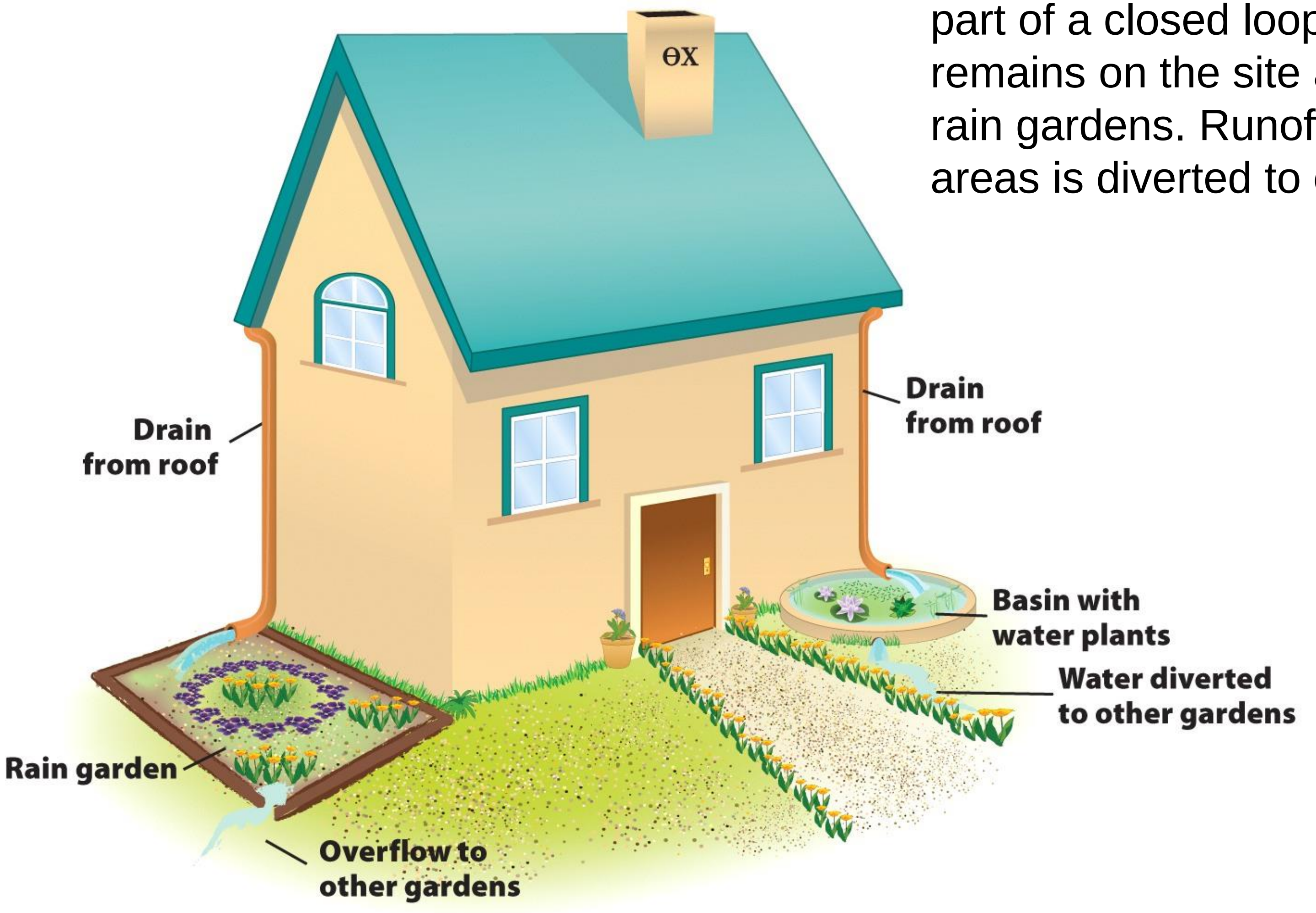


FIGURE 19.16 Water from roof runoff is part of a closed loop where water remains on the site and is used in rain gardens. Runoff from parking areas is diverted to other gardens.

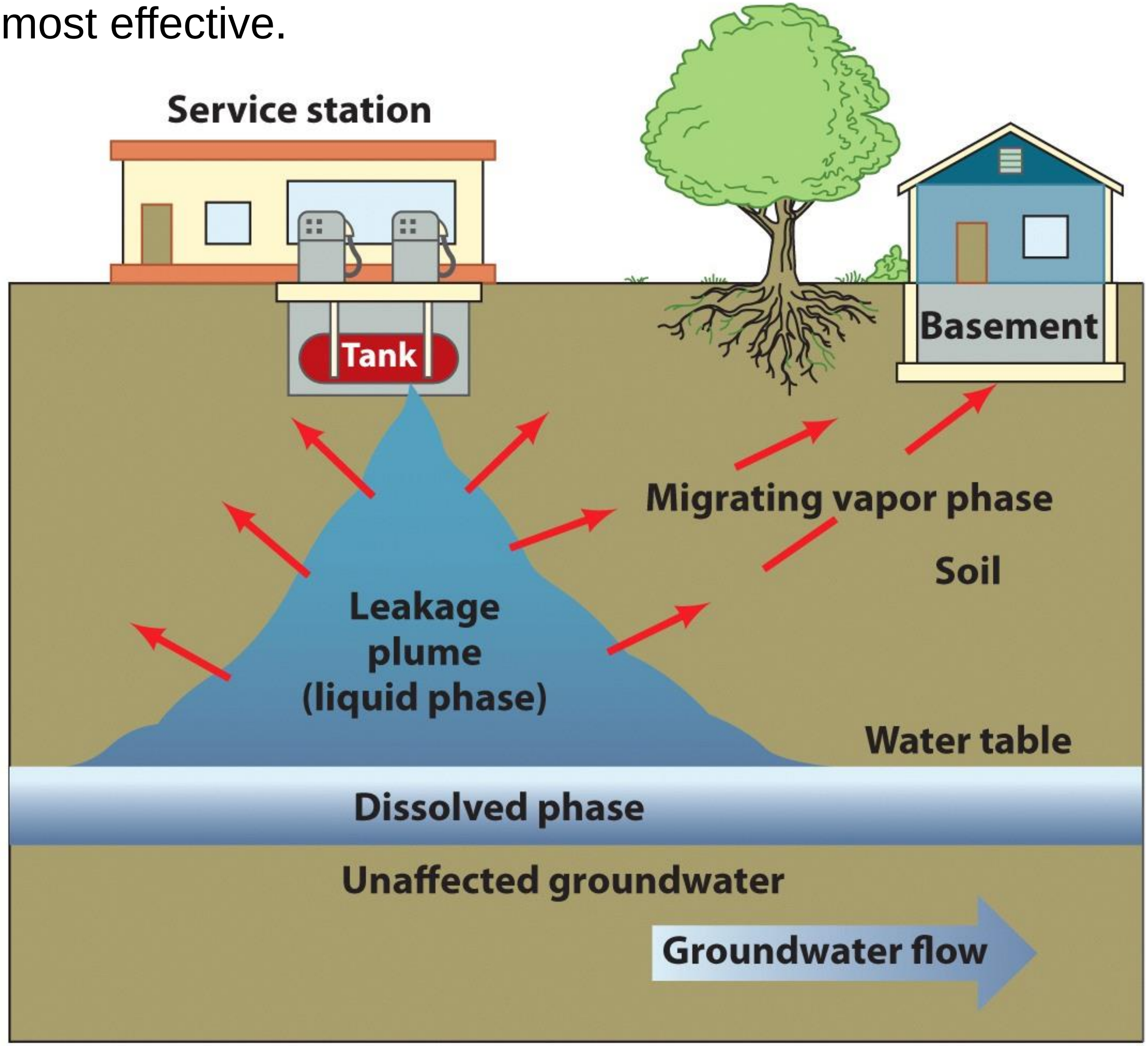
Groundwater Pollution

- ~Half of all people in U.S. depend on groundwater for drinking
  - Long believed to be pure and safe to drink
  - Can be contaminated from a number of sources
  - May become worse as human population pressures increase
- The hazard presented by a particular groundwater pollutant depends on several factors, including the concentration or toxicity of the pollutant in the environment and the degree of exposure of people or other organisms to the pollutants.

Principles of Groundwater Pollution: An Example

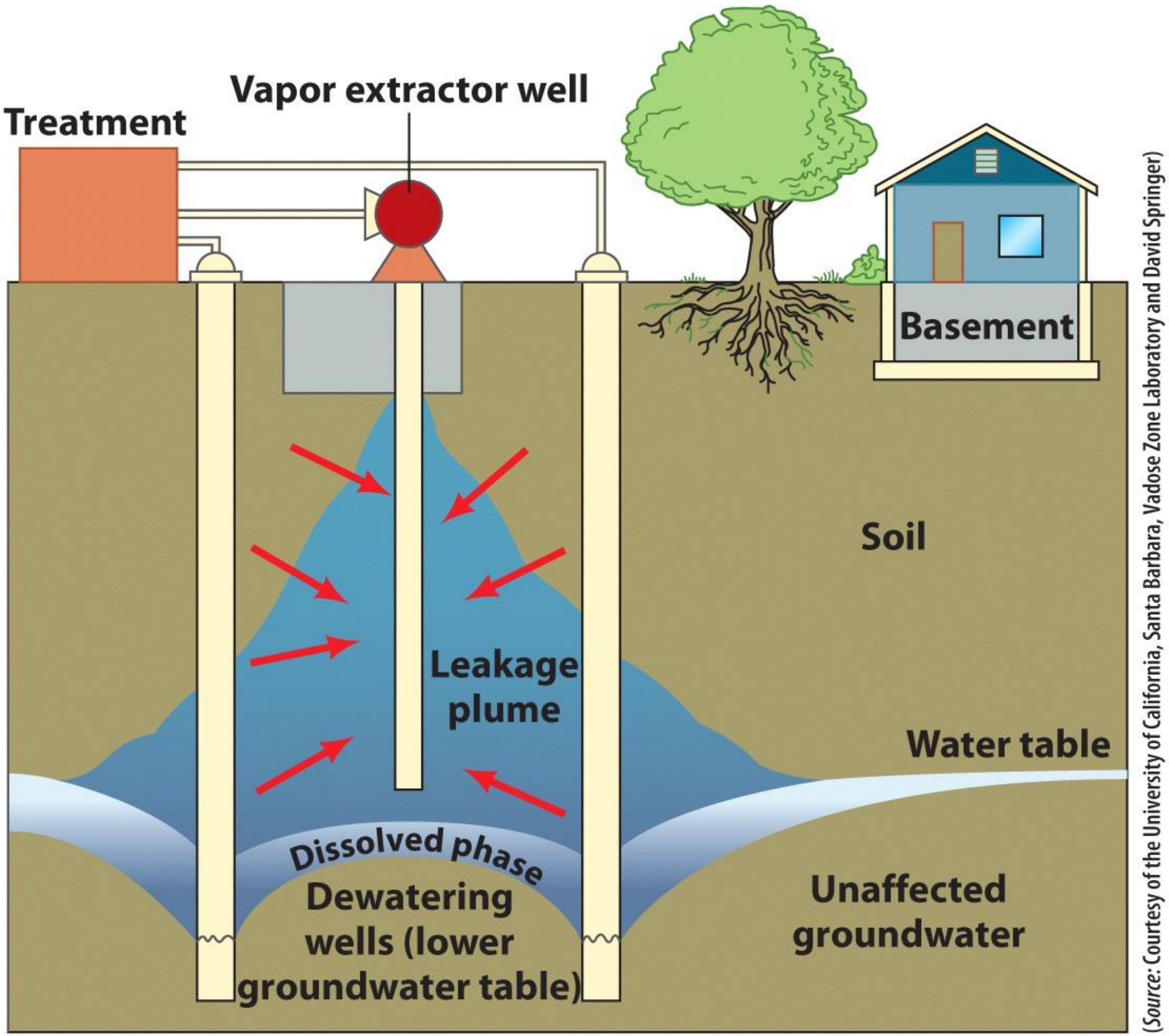
- Pollution leaking from buried gasoline tanks from service stations
  - Widespread problem
  - Thousands of old tanks removed and surrounding groundwater and soil treated
    - Disposal of soil
    - Vapor extraction of water
    - Use of microorganisms (bioremediation)

FIGURE 19.18 Diagram illustrating (a) a leak from a buried gasoline tank. Notice that the liquid gasoline and the vapor from the gasoline are above the water table; a small amount dissolves into the water. All three phases of the pollutant (liquid, vapor, and dissolved) float on the denser groundwater. The extraction well takes advantage of this situation. The function of the dewatering wells is to pull the pollutants in where the extraction is most effective.



(Source: Courtesy of the University of California, Santa Barbara, Vadose Zone Laboratory and David Springer)

(b) possible remediation using a vapor extractor system.



Principles of Groundwater Pollution

- Important points about groundwater pollutants
  - Some pollutants, such as gasoline, are lighter than water and float on the groundwater
  - Some pollutants have multiple phases: liquid, vapor, and dissolved
  - Some pollutants are heavier than water and sink or move downward through groundwater
  - Method used to treat must take into account the physical and chemical properties of the pollutant and how these interact with water
  - Emphasis should be on preventing pollutants from entering groundwater in the first place

Principles of Groundwater Pollution: An Example

- Difference between groundwater and surface-water pollution
  - Groundwater lacks oxygen but may provide environment for anaerobic bacteria
  - Channels through which groundwater moves often small and variable
    - Movement is slow and opportunity for dispersion and dilution limited

Wastewater Treatment

- Water used for industrial and municipal purposes is often degraded during use
  - Addition of suspended solids, salts, nutrients, bacteria, and oxygen-demanding material
  - Water must be treated before released
- Wastewater treatment
  - $20 billion a year industry
  - Conventional methods; septic tanks and centralized treatment

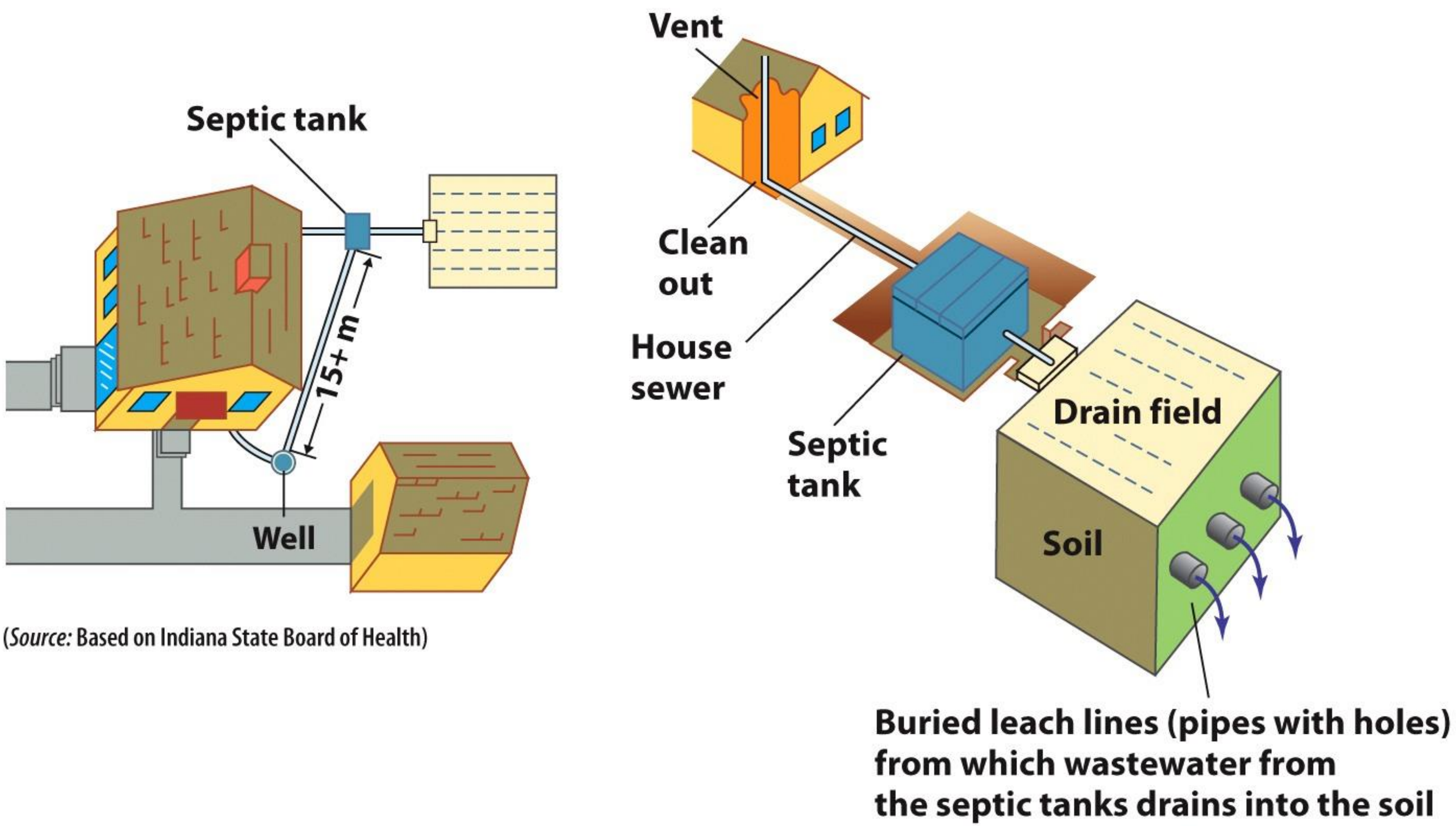
Septic-Tank Disposal Systems

- Common in many rural areas and outlying areas of cities
- Basic parts of septic-tank disposal system
  - Sewer line from house to underground tank
  - Tank to separate solids from liquids
    - Digest and store solids
    - Liquid sent to absorption field
  - By the time liquid reaches any fresh water, it should be safe

FIGURE 19.20 Septic-tank sewage system and location of the drain field with respect to the house and well.

Septic Tank separates solids from liquids and store organic matter (retention)

Clarified liquid sent to drain field (Absorption Field) – surrounding soils for Natural Oxidative Filtration.



(*Source:* Based on Indiana State Board of Health)

Septic-Tank Disposal Systems

- Absorption fields may fail for several reasons
  - Failure to pump out tank when full of solids
  - Poor soil drainage
    - Effluent can rise to surface in wet weather
- Solutions to septic system problems include
  - Siting septic tanks on well-drained soils
  - Making sure systems are large enough
  - Practicing proper maintenance

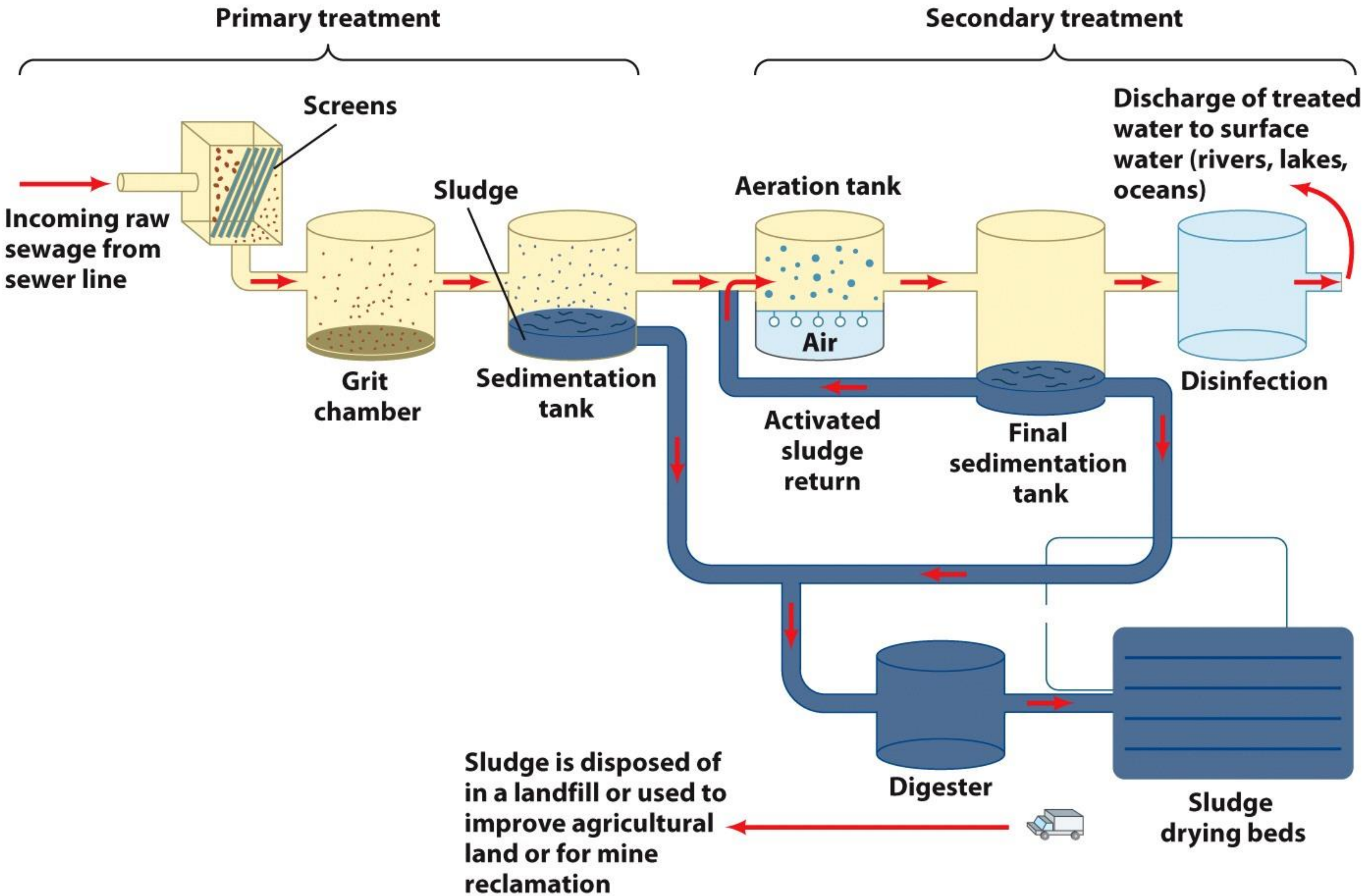
Wastewater Treatment Plants (Cities)

- Specially designed plants that accept municipal sewage from homes, businesses and industrial sites
- Wastewater delivered to plant by network of pipes
- Treated water discharged into surface waters
  - Main purpose is to break down and reduce BOD and kill bacteria with chlorine

Centralized Wastewater Treatment Plants

- Methods usually divided into three categories
  - Primary treatment
  - Secondary treatment
  - Advanced wastewater treatment
  - Chlorination
- Primary and secondary required by law

FIGURE 19.21 Diagram of sewage treatment processes. The use of digesters is relatively new, and many older treatment plants do not have them.



Primary Treatment

- Raw sewage enters plant
- Passes through series of screens
  - Remove large floating organic material
- Enters a grit chamber
  - Sand, small stones and grit removed
- Enters sedimentation tank
  - Particulate matter settles out to form a sludge
- Sludge is removed and transported to a digester
- Primary treatment removes ~35% of BOD

Secondary Treatment

- Most common treatment—activated sludge
- Wastewater from primary sedimentation tank enters the aeration tank
  - Aerobic bacteria consume organic material (BOD) in the waste
- Wastewater then enters the final sedimentation tank
  - Sludge settles out
  - Some activated sludge reused in aeration
- Most of the sludge transported to digester (where methane produces from chemical reactions via anaerobic bacteria and used as fuel for plants or to heat buildings)
- Wastewater from final tank is disinfected with chlorine and discharged

Secondary Treatment

- Secondary treatment removes ~90% of BOD
- Sludge from the digester is dried and disposed of in a landfill or applied to improve soil
- In some instances, treatment plants in urban and industrial areas contain many pollutants, such as heavy metals, that are not removed in the treatment process.

Advanced Wastewater Treatment

- Additional pollutants can be removed by adding more treatment steps
  - Sand filters, carbon filters and chemicals applied to assist removal process
- Treated water can then be used for agricultural or municipal irrigation
  - Such as for golf courses and city parks

Chlorine Treatment

- Chlorine is very effective in killing pathogens and avoid waterborne diseases
  - Chlorine treatment by-products may pose hazard to fish and cancer risk to humans
  - The degree of risk is controversial and is currently being debated

Wastewater and Wetlands

- Natural and constructed wetlands can treat wastewater
- Effective in treating
  - Municipal wastewater from primary or secondary treatment plants (BOD, pathogens, phosphorus, nitrate, suspended solids and metals)
  - Storm water runoff (metals, nitrate, BOD, pesticides, oils)

Wastewater and Wetlands

- Effective in treating (continued)
  - Industrial wastewater (metals, acids, oils, solvents)
  - Agricultural wastewater and runoff (BOD, nitrate, pesticides, suspended solids)
  - Mining waters (metals, acidic water, sulfates)
  - Groundwater seeping from landfills (BOD, metals, oils, pesticides)

Louisiana Coastal Wetlands

- State of Louisiana
  - Leader in development of advanced treatment
- Nitrogen and phosphorus rich wastewater increases the production of wetland plants
  - Improving water quality
  - Helping wetlands accrete
- Significant economic savings each year

Courtesy John Day, Louisiana State University

Courtesy John Day, Louisiana State University

Constructed Wetlands

- Wetlands constructed in arid regions to treat poor quality water
- Example: Avondale, AZ
  - Wetland treatment facility for agricultural wastewater sited in residential community
    - Naturally occurring bacteria break down nitrates
  - Designed to treat 4.5 million gal/day

Chapter Summary

- The primary water pollution problem in the world today is the lack of disease-free drinking water
- Water pollution is degradation of quality that renders water unusable for its intended purpose
- Major categories of water pollutants include
  - Disease-causing organisms
  - Dead organic material
  - Heavy metals
  - Organic chemicals
  - Acids
  - Sediment
  - Heat
  - Radioactivity

Chapter Summary

- Sources of pollutants may be:
  - Point sources—such as pipes that discharge into a body of water
  - Nonpoint sources—such as runoff, which are diffused and intermittent
- Eutrophication is a natural or human-induced increase in the concentration of nutrients, such as phosphorus and nitrogen, required for living things
  - High concentration of such nutrients may cause a population explosion of bacteria and photosynthetic algae
  - As the bacteria and algae die and decay, the concentration of dissolved oxygen in the water is lowered, leading to the death of fish and other water-dwelling organisms that need oxygen to survive

Chapter Summary

- Sediment is a twofold problem
  - Soil is lost through erosion
  - Water quality suffers when sediment enters a body of water
- Acid mine drainage is a serious water pollution problem
  - Water and oxygen react with sulfide minerals associated with coal or metal sulfide deposits and form sulfuric acid
  - Acidic water draining from mines or tailings pollutes streams and other bodies of water, damaging aquatic ecosystems and degrading water quality
- Urban processes, such as, waste disposal in landfills, application of fertilizers, and dumping of chemicals such as motor oil and paint, contribute to shallow aquifer contamination
- Overpumping of aquifers near the ocean may cause saltwater to rise closer to the surface, contaminating the water resource by a process called saltwater intrusion

Chapter Summary

- Conventional wastewater treatment plants
  - Include primary, secondary, and, occasionally, advanced treatment
- In some locations, natural ecosystems, such as wetlands and soils, are being used as part of the treatment process
- Water reuse is the norm for millions of people living along rivers where sewage treatment plants discharge treated wastewater back into the river
  - People who withdraw river water downstream are reusing some of the treated wastewater
- Industrial reuse of water is the norm for many factories

Chapter Summary

- Deliberate use of treated wastewater for irrigating agricultural lands, parks, golf courses, etc. is growing rapidly as demand for water increases
- Use of treated wastewater that is applied to the land and later withdrawn as a municipal water source is becoming more common
- Cleanup and treatment of polluted waters
  - Expensive
  - May not be completely successful
  - Environmental damage may result before a pollution problem is identified and treated
- Focus on preventing pollutants from even entering water is the current goal of much water-quality legislation