

Unit 6 Topics

Unit 6: Pollution

- VI. A. Pollution Types 1. Air pollution (Sources — primary and secondary; major air pollutants; measurement units; smog; acid deposition — causes and effects; heat islands and temperature inversions; indoor air pollution; remediation and reduction strategies; Clean Air Act and other relevant laws) 2. Noise pollution (Sources; effects; control measures)
- VII. A. Stratospheric Ozone (Formation of stratospheric ozone; ultraviolet radiation; causes of ozone depletion; effects of ozone depletion; strategies for reducing ozone depletion; relevant laws and treaties)
- VI. A. Pollution Types 3. Water pollution (Types; sources, causes, and effects; cultural eutrophication; groundwater pollution; maintaining water quality; water purification; sewage treatment/septic systems; Clean Water Act and other relevant laws) 4. Solid waste (Types; disposal; reduction)
- VI. B. Impacts on the Environment and Human Health 1. Hazards to human health (Environmental risk analysis; acute and chronic effects; dose-response relationships; air pollutants; smoking and other risks) 2. Hazardous chemicals in the environment (Types of hazardous waste; treatment/disposal of hazardous waste; cleanup of contaminated sites; biomagnification; relevant laws)

Unit 6 Outline

Chapter 19 - Air Pollution

Outline

Structure and science of the atmosphere

- A. The atmosphere consists of several layers with different temperatures, pressures, and composition
 - 1. The atmosphere is a thin layer of gases divided into several spherical sublayers.
 - 2. Density and atmospheric pressure vary throughout the atmosphere due to gravitational forces that pull the gas molecules toward the earth's surface. Air at sea level has a higher density than air at the top of a mountain.
 - 3. Atmospheric pressure is a measure of the mass per unit of air. It decreases with altitude.
- B. About 75-80% of the earth's air mass is found in the troposphere, the atmospheric layer closest to the earth's surface.
 - 1. This layer extends about 11 miles above sea level at the equator and about 5 mile above the poles.
 - 2. About 99% of the volume of air is made up of nitrogen (78%) and oxygen (21%) with the rest consisting of water vapor, argon, carbon dioxide and traces of several other gases.
 - 3. This layer is also responsible for short-term weather and long-term climate.
- C. The stratosphere is the second layer of the atmosphere and extends from 11-30 miles above the earth's surface.
 - 1. The concentration of ozone in this layer is much higher than in the troposphere.
 - 2. Ozone is produced when oxygen molecules interact with ultraviolet radiation ($3 \text{ O}_2 + \text{UV} \rightarrow 2 \text{ O}_3$). This "global sunscreen" keeps about 95% of the sun's harmful UV radiation from reaching the earth's surface.
 - 3. This ozone layer protects us from sunburn, cataracts, cancer of skin and eye and damage to our immune system.
 - 4. There is evidence of a decrease in "good" ozone in the stratosphere and increase in "bad" ozone in the troposphere.

Air Pollution

- A. Air pollutants come mostly from natural sources and from burning fossil fuels.
- B. Primary pollutants are pollutants emitted into the air. They can react with one another and/or with air to form secondary pollutants.
- C. Major air pollutants include carbon oxides, nitrogen oxides, particulates, volatile organic compounds, ozone, and radon.

Urban Outdoor Air Pollution

- A. Outdoor air pollution comes mostly from natural sources and burning fossil fuels in vehicles and power and industrial plants.
 - 1. Chemicals in the atmosphere in concentrations high enough to affect climate, materials, and health are what constitute air pollution.
 - 2. Natural sources of air pollution such as dust particles, organic chemicals released by plant decay; forest fires, etc. rarely reach harmful levels.
 - 3. Increased use of fossil fuels has greatly increased the amount of air pollution, especially in urban areas where people, cars and industry are concentrated.
 - 4. Outdoor air pollutants are classified into two categories: primary pollutants that enter directly into the troposphere (soot, carbon monoxide, nitric oxides), and secondary pollutants that may form when primary pollutants interact with one another or with the air to form new pollutants (nitric acid).
 - 5. Cities generally have higher pollution levels than rural areas. Winds can carry these pollutants away from their source to other areas.
 - 6. Indoor air pollutants come from infiltration of outside air, chemicals used or produced inside buildings.
 - 7. Air pollution is classified as a high-risk human health problem.
 - 8. Most people exposed to poor air live in developing countries.
 - 9. Six conventional air pollutants have maximum standards of allowable concentrations set by governments of developed countries.
- B. Photochemical smog is formed by the reaction of nitrogen oxides and volatile hydrocarbons under the influence of sunlight.
 - 1. A photochemical reaction is any chemical reaction activated by light.
 - 2. Photochemical smog contains more than 100 primary and secondary pollutants.
 - 3. Nitrogen dioxide found in photochemical smog is a yellow-brown gas with a noxious odor and causes a brownish haze to form.
 - 4. Some NO_2 reacts with hydrocarbons to produce a mixture of ozone, nitric acid, aldehydes, peroxyacyl nitrates (PANs) and other pollutants.
 - 5. These substances are photochemical oxidants and can irritate the respiratory tract, damage crops and trees.
 - 6. Photochemical smog is more common in cities in warm, dry, sunny areas.
- C. Industrial smog is a mixture of sulfur dioxide, droplets of sulfuric acid, and a variety of suspended solid particles emitted by burning coal and oil.
 - 1. When coal is burned it is converted to carbon dioxide and carbon monoxide and unburned carbon particles (soot).
 - 2. Coal and oil also contain sulfur that is then converted to sulfur dioxide.
 - 3. Reactions with water vapor changes sulfur dioxide to sulfuric acid in several steps. These droplets can then react with ammonia in the atmosphere to form ammonium sulfate. These various components give the air a gray color.
 - 4. Most countries have adopted pollution controls, but several countries with industrialized urban areas have serious smog problems.
- D. Outdoor air pollution can be reduced by precipitation, sea spray, and winds and increased by urban buildings, mountains, and high temperatures.
 - 1. Five factors help reduce outdoor air pollution: heavy particles settle out of atmosphere due to gravity; rain and snow; salty sea spray; winds; and chemical reactions of pollutants. Each of these factors helps remove pollutants, but they are then deposited elsewhere.
 - 2. Six factors can increase outdoor air pollution: urban buildings; hills and mountains; higher temperatures; VOC emissions from certain trees and plants; the grasshopper effect where volatile compounds are carried from tropical or temperate areas to the poles; and temperature inversions.
- E. A layer of warm air sitting on top of a layer of cool air near the ground can prevent outdoor pollutants from rising and dispersing.
 - 1. Turbulence, caused by the mixing of warm and cold air disperses air pollutants.
 - 2. A temperature inversion, where a layer of warm air sits over a layer of cold air prevents the mixing and dense, colder air becomes stagnant and accumulates more pollutants.
 - 3. Two areas are particularly susceptible to inversions:
 - a. a city located in a valley surrounded by mountains that experiences cloudy, cold weather part of the year
 - b. a sunny climate, light winds, mountains on three sides and several million people and vehicles (Los Angeles basin).
- F. Much of Southeastern Asia has a huge brown cloud of industrial smog from coal burning.
 - 1. The rapid industrialization of China and India is repeating what had existed in Europe and the U.S. as part of the industrial revolution during the 19th and early 20th century.
 - 2. Solar energy reaching the earth is reduced 2-15% in some areas.
 - 3. Rice crops may be reduced 3-10% by this in India's winter harvests.
 - 4. Crops, trees and life in lakes are being damaged.
 - 5. This may also be an important contributor to premature deaths from respiratory diseases.
 - 6. This huge brown cloud also seems to be causing changes in regional climate, warming some areas and cooling others. There are also shifting rainfall patterns.
 - 7. The good news is that this problem can be greatly reduced by setting standards for coal-burning industries, changing to

cleaner burning gas, using catalytic converters on cars. China has begun to do this, as has Delhi, India.

Acid Deposition

- A. Sulfur dioxide, nitrogen oxides, and particulates react in the atmosphere to produce acidic chemicals that travel long distances before coming back to earth.
 - 1. Tall smokestacks reduce local pollution, but can increase regional pollution.
 - 2. Acidic particles remain in the atmosphere for 2-14 days, depending on the prevailing winds, precipitation, and other weather patterns.
 - 3. The acidic substances return to earth in one of two forms:
 - a. wet deposition as acidic rain, snow, fog, and cloud vapor with a pH less than 5.6.
 - b. dry deposition as acidic particles
 - 4. Acid deposition is a problem in areas downwind from coal-burning facilities and urban areas.
 - 5. Some areas have basic compounds in the soil that act to buffer or neutralize some acidic deposits.
 - 6. Many acid-producing chemicals generated in one country end up in other countries due to prevailing winds.
- B. Acid deposition can cause or worsen respiratory disease, attack metallic and stone objects, decrease atmospheric visibility, and kill fish.
 - 1. Large amount of money are spent each year to clean and repair monuments and statues damages by acid deposition.
 - 2. Acid deposition also decreases atmospheric visibility.
 - 3. Acidified lakes have fish kill and aluminum ions are released into the water by the lower pH (4.5 or less).
 - 4. Many lakes in northern Europe and the eastern U.S. have few, if any, fish due to decreased pH.
- C. Acid deposition can deplete some soil nutrients, release toxic ions into soil, and weaken plants that become susceptible to other stresses.
 - 1. Effect of acid deposition on plants is caused partly by chemical interaction in the soils.
 - 2. There may be an initial growth stimulus from added nitrogen and sulfur, but continued deposition leaches essential magnesium and calcium salts from the soil and lowers plant productivity.
 - 3. Herbivores that eat these plants can also develop calcium deficiencies.
 - 4. Synergistic effects may occur when the plants are exposed to several pollutants simultaneously.
 - 5. Acid can also dissolve aluminum, cadmium, and mercury ions from the soil. These ions are toxic to plants and animals.
 - 6. Acid loving mosses may be stimulated to grow and harm trees by holding quantities of water and killing mycorrhizal fungi needed by the trees.
 - 7. Weakened trees are more susceptible to diseases.
 - 8. The mountaintop trees are those that are most harmed by acidic rain because they are also growing in thin soils.
- D. Progress has been made in reducing acid deposition in the U.S., but there is a long way to go.
 - 1. The 1990 amendments to the Clean Air Act have lead to significant reductions in SO₂ and NO_x emissions from coal-fired power and industrial plants.
 - 2. Acid deposition has accelerated leaching of ions such as calcium and magnesium from soils in some areas, which could lead to a decrease in tree growth.
 - 3. Acid deposition has also increased concentrations of toxic forms of aluminum in some soil and in lakes and streams.
 - 4. It is predicted that an additional 80% reduction in SO₂ emissions would be needed to allow northeastern streams and lakes to recover from the effects of acid deposition.
- E. A number of prevention and control methods can reduce acid deposition, but they are politically difficult to implement.
 - 1. The best approaches are those that reduce or eliminate emissions of SO₂, NO_x and particulates.
 - 2. Use of low sulfur coal is both good and bad, it lowers the amount of SO₂ released but because more must be burned to generate the same amount of electricity, it emits more mercury, CO₂, and radioactive particles.
 - 3. Controlling acid deposition is a politically controversial issue.
 - 4. Inclusion of environmental and health costs to the current cost of coal would give a more realistic picture.
 - 5. Approaches to neutralize acid lakes include adding limestone or lime to the water or soil or adding a small amount of phosphate fertilizer, this approach is being evaluated.

Indoor Air Pollution

- A. Indoor air pollution is usually a much greater threat to human health than outdoor air pollution.
 - 1. EPA studies have shown that:
 - a. Levels of 11 common pollutants are 2-5 times greater inside homes and commercial buildings than outside.
 - b. Inside cars in traffic-clogged areas the pollution may be 18 times higher than outside.
 - c. Health risks are magnified because people usually spend 70-98% of their time indoors or in vehicles.
 - 2. Pesticide residues brought in on shoes can collect in carpets and many paints and sprays contain potentially harmful organic solvents.
 - 3. Living organisms' excrement, from organisms like dust mites and cockroaches, play a role in the almost threefold increase in asthma cases between 1972 and 2002.
 - 4. Toxic airborne spores of molds and mildew that grow under houses and on inside walls can cause headaches, allergic

reactions, and aggravate asthma and other respiratory diseases.

5. Sick-building syndrome has been linked to various air pollutants, and new buildings are apt to be more prone to this than old building due to less air exchange.
 6. The EPA lists the four most dangerous indoor air pollutants in developed countries as cigarette smoke, formaldehyde, radioactive radon-222 gas, and very small fine and ultrafine particles.
 7. In developing countries as many as 2.8 million people die prematurely each year from breathing elevated levels of indoor smoke and particulates.
- B. Formaldehyde is the chemical that causes most people in developed countries difficulty. It is used to manufacture common household materials.
- C. Radon-222 gas is found in some soils and rocks and can seep into some homes and increase the risk of lung cancer.
1. Radon is produced by the radioactive decay of uranium-238.
 2. Radon gas tends to be pulled into homes because of the slightly lower atmospheric pressure inside most homes.
 3. Radon is thought to be the second leading cause of lung cancer deaths each year in the U.S.
 4. The EPA and the Surgeon General's Office recommended that everyone living in a detached home, a townhouse or the first 3 levels of an apartment building test for radon.
 5. Remedies include sealing cracks in foundation and walls, increase ventilation and use a fan for cross ventilation.

Health Effects of Air Pollution

- A. The respiratory system has several ways to help protect you from air pollution.
1. Hairs in the nose filter out large particles. Sticky mucus lines the respiratory trap to capture smaller particles and some dissolved gases.
 2. Sneezing and coughing expel contaminated air and mucus.
 3. Prolonged or acute exposure to air pollutants can overload or break down the natural defenses.
 4. Several respiratory diseases can develop such as asthma, lung cancer, chronic bronchitis and emphysema.
 5. People with respiratory diseases, older adults, infants, pregnant women, and people with heart disease are especially vulnerable to air pollution
- B. Each year, air pollution kills about 3 million people, mostly from indoor air pollution in developing countries.
1. Air pollution deaths in the U.S. range from 150,000 to 350,000 people per year.
 2. A large diesel-powered bulldozer produces as much air pollution as 26 cars.
 3. The EPA proposed emission standards for diesel-powered vehicles that go into effect in 2007 with full compliance by 2012. It is thought that this will reduce diesel-fuel emissions by 90%.
 4. There is a connection between international trade and air pollution in which diesel engines from cargo ships and idling trucks emit large amounts of pollution.

Preventing and Reducing Air Pollution

- A. Clean Air Acts in the United States have greatly reduced outdoor air pollution from six major pollutants.
1. The U.S. Congress passed Clean Air Acts in 1970, 1977, and 1990.
 2. National air quality standards (NAAQS) were established for six outdoor criteria pollutants.
 3. Two limits were established: a primary standard is set to protect human health and a secondary standard is set to prevent environmental and property damage.
 4. EPA has established national emission standards for 188 hazardous air pollutants (HAPs) that may cause serious health and ecological effects. These include neurotoxins, carcinogens, mutagens, teratogens, and others.
 5. In 2005, the EPA proposed requiring industries to report their HAP emissions every other year and raising threshold for reporting these chemical tenfold.
 6. Great news:
 - a. According to a 2005 EPA report, combined emissions of the six criteria air pollutants decreased by 54% between 1970 and 2004; energy consumption, miles traveled and population increase.
 - b. Between 1970 and 2004, emissions from the six major air pollutants decreased: 98% for lead, 56% for carbon monoxide, 55% for volatile organic compounds, 79% for suspended particulate matter, 52% for sulfur dioxide, and 30% for NO_x.
 7. Bad news:
 - a. After dropping in the 1980s, photochemical smog levels did not decline between 1993 and 2004 due to a failure to reduce ground-level ozone concentrations
 - b. In 2003, more than 170 million people or 59% of the population, lived in areas where air is unhealthy to breathe for part of the year due primarily to ozone and particulates.
 - c. Despite more than two decades of reducing carcinogenic emissions from cars and factories, in 2006, the EPA reported that residents of some urban areas of New York and California are exposed to twice the cancer risk from outdoor air pollution as the national average.
- B. Outdoor air pollution in the U.S. has been reduced since 1970.
1. U.S. citizens insisted that laws be passed and enforced to improve air quality, and the country was affluent enough to

- afford the controls and improvements.
- 2. Scientists point out several deficiencies in the Clean Air Act; they include:
 - a. The U.S. continues to mostly rely on cleanup rather than prevention.
 - b. The U.S. Congress has failed to increase fuel-efficiency standard for cars, SUVs, and light trucks.
 - c. Regulation of emissions from motorcycles and two-cycle gasoline engines remains inadequate.
 - d. There is little or no regulation of air pollution from oceangoing ships in American ports.
 - e. Airports are exempt from any air pollution regulations.
 - f. The Act does not regulate emissions of carbon dioxide.
 - g. Urban ozone levels are still too high in many areas.
 - h. The Act has failed to deal seriously with indoor air pollution.
 - i. There is a need for better enforcement of the Clean Air Act.
- C. Allowing producers of air pollutants to buy and sell government air pollution allotments in the marketplace can help reduce emissions.
 - 1. The Clean Air Act of 1990 allows an emissions trading policy that permits companies to buy and sell SO₂ pollution rights.
 - 2. This cap-and-trade approach may be an improvement over command-and-control as long as it reduces SO₂ emissions. The cap would gradually be lowered.
 - 3. These pollution credits may be purchased by anyone and then not used if they so desire.
 - 4. This method allows "hot spots" to continue to exist. Spot monitoring to check for emissions should be done.
 - 5. Between 1990 and 2002 this scheme reduced SO₂ emissions by 35% in the U.S.
 - 6. Emissions trading has been expanded to include NO_x, particulate emissions, and volatile organic compounds, and for the combined emissions of SO₂, NO_x, and mercury from coal-burning power plants.
- D. There are a number of ways to prevent and control air pollution from coal-burning facilities and motor vehicles.
 - 1. Figure 19-17 summarizes ways to reduce emissions of sulfur oxides, nitrogen oxides, and particulate matter from stationary sources like power plants.
 - 2. Output approaches like electrostatic precipitators, and wet scrubbers are used on coal plants.
 - 3. Input approaches include reduced sulfur coal, coal gasification and fluidized-bed combustion.
 - 4. Between 1980 and 2002, emissions of sulfur dioxides from U.S. electric power plant decreased by 40% and NO_x by 30% and soot by 75%.
 - 5. Because of the Clean Air Act, a new car today in the United States emits 75% less pollution than did pre-1970 cars.
- E. Indoor air pollution is a greater threat to human health, but little effort has been spent on reducing it.
 - 1. Figure 19-20 suggests several ways to reduce indoor air pollution.
 - 2. In developing countries indoor air pollution can be reduced by use of clay or metal stoves and venting to the outside, and by use of solar cookers in sunny areas. This would also reduce deforestation.
- F. There is a need to focus on preventing air pollution of all types.
 - 1. At present there is an output approach to controlling pollution.
 - 2. We need to shift focus to preventing air pollution.
 - 3. Figure 19-22 shows ways to prevent air pollution over the next 30-40 years.
 - 4. Figure 19-21 lists ways to reduce your exposure to indoor air pollution.

Summary

1. The layers of the atmosphere are the troposphere, stratosphere, mesosphere, and thermosphere.
2. Major classes of air pollutants include carbon, sulfur, and nitrogen oxides, volatile organic compounds, suspended particulate matter, photochemical oxidants, radioactive substances, and hazardous chemicals that can cause health problems. Primary sources of these pollutants include cars, industry, and natural phenomena such as volcanic eruptions.
3. The two types of smog are the photochemical and the industrial or gray-air smog.
4. Acid deposition includes wet deposition of acidic rain, snow, fog, and cloud vapor with pH less than 5.6, and dry deposition of acidic particles. The solution to this problem is prevention that reduces emissions of acidic nitrogen and sulfur oxides, and particulates.
5. Harmful effects of air pollution include various respiratory diseases, premature deaths, damage to plants, and materials such as buildings, cars, statues, etc.
6. We can reduce air pollution through prevention and cleanup, including low sulfur coal, shifting to less polluting fuels, removal of pollutants after combustion, use of mass transit or alternative transportation, improving fuel efficiency, and tax incentives.

Chapter 21 - Water Pollution

Outline

Water Pollution: Sources, Types, and Effects

- A. Water is polluted by infectious bacteria, inorganic and organic chemicals, and excess heat.
 - 1. Water pollution is any chemical, biological, or physical change in water quality that has a harmful effect on living organisms.
 - 2. Table 21-1 lists the major classes of water pollutants and their major human sources and harmful effects.
 - 3. The WHO estimates that 3.2 million people die prematurely each year from waterborne diseases.
- B. Scientists monitor water quality by using bacterial counts, chemical analysis, and indicator organisms.
 - 1. One method of measuring water quality involves measuring the number of colonies of fecal coliform bacteria present in a water sample.
 - 2. Drinking water should not contain any colonies/ 100 milliliters and safe swimming water should not have more than 200 colonies/100 milliliters.
 - 3. A new field of science called bacterial source tracking (BST) uses molecular biology techniques to determine subtle differences in strains of *E. coli* based on their animal host.
 - 4. Scientists measure biological oxygen demand (BOD), the amount of dissolved oxygen consumed by aquatic decomposers.
 - 5. Chemical analysis includes checking inorganic and organic chemicals present, sediment content and turbidity of water.
 - 6. Indicator species are living organisms that are monitored to determine levels of pollution.
 - 7. Genetic techniques are being used to develop organisms that will glow in the presence of specific pollutants such as toxic heavy metals in the ocean and carcinogens in food.
- C. Water pollution can come from a single source or from a variety of dispersed sources.
 - 1. Point sources discharge pollutants at specific locations through drain pipes, ditches, or sewer lines into bodies of surface water.
 - 2. These sources are easy to identify, monitor, and regulate.
 - 3. Non-point sources are scattered and diffuse and can't be traced to any single site of discharge. Such things as runoff from croplands, livestock feedlots, etc., are non-point sources.
 - 4. It is difficult and expensive to identify and control these discharges from diffuse sources.
- D. The leading sources of water pollution are agriculture, industries, and mining.
 - 1. Agricultural activities are the leading cause of water pollution from erosion, and overgrazing, fertilizers and pesticides and excess silt from irrigated soils.
 - 2. Industrial facilities are another large source of water pollution and mining is a third source.
- E. Common diseases are transmitted to humans through contaminated drinking water (Table 21-2).
 - 1. The World Health Organization (WHO) estimates that 3.2 million people, most of whom are children, die prematurely every year from infectious diseases spread by contaminated water or lack of water for adequate hygiene.
 - 2. The United Nations estimate that it would cost \$23 billion per year over 8-10 years to bring low-cost and safe drinking water and sanitation to the 2.4 billion people who do not have it.

Pollution of Freshwater Streams

- A. Streams can recover from moderate levels of degradable water pollutants if the flows are not reduced
 - 1. A combination of dilution and biodegradation can allow recovery of stream pollution if they are not overloaded, or have reduced flow due to damming, agricultural diversion, or drought.
 - 2. The breakdown of pollutants by bacteria creates an oxygen sag curve. Organisms that have a high oxygen demand can't survive in the curve.
 - 3. Volume of the stream, volume of wastes entering, flow rate, temperature, and pH levels all affect how great a sag curve is produced.
- B. Most developed have reduced point source pollution, but toxic chemicals and pollution from nonpoint sources are still problems.
 - 1. The U.S. has managed to avoid increase in pollution from point sources in most streams.
 - 2. There have been several examples of amazing clean-up of rivers such as the Cuyahoga River in Ohio, and the Thames River in Great Britain.
 - 3. There are still examples of large fish kills and contamination of drinking water from releases of chemicals from industry and mining, and also from nonpoint runoff of fertilizers and pesticides.
- C. Stream pollution in most developing countries is a serious and growing problem. Half of the world's 500 major rivers are heavily polluted and most of them run through developing countries where waste treatment is minimal or nonexistent.
- D. Religious beliefs, cultural traditions, poverty, little economic development, and a large population interact to cause severe pollution of the Ganges River in India.
 - 1. About 350 million people live in the Ganges River basin with little treatment of sewage produced by them.
 - 2. Hindu beliefs add pollution to the air when bodies are cremated and to the water when partially cremated or non-cremated bodies are thrown into the river in order to find their way to heaven.

3. The government is working to clean up the river by building waste treatment plants in the 29 large cities along the Ganges and by building electric crematoriums on its banks. It has also introduced snapping turtles as body scavengers.
4. Most of these plans are not yet in place, and religious and cultural conditions are difficult to change.

Pollution of Freshwater Lakes

- A. Lakes have little flow and so are less effective at diluting pollutants that enter them.
 1. Lakes and reservoirs are often stratified into layers with little vertical mixing and they also have very little flow occurring. It may take from 1-100 years to flush and change water in lakes and reservoirs.
 2. Lakes and reservoirs are much more vulnerable to runoff contamination of all kinds of materials.
 3. Chemical concentrations build up as they pass through the food webs in lakes.
- B. Human activities can overload lakes with plant nutrients that reduce dissolved oxygen and kill some aquatic species.
 1. Natural nutrient enrichment of lakes from runoff is called eutrophication. The amount of natural eutrophication depends on the composition of the surrounding drainage basin.
 2. Natural eutrophication can enrich the abundance of desirable organisms, but cultural eutrophication occurs near urban or agricultural areas and can lead to serious pollution problems.
 3. During hot weather or drought, "blooms" of organisms can reduce lake productivity.
 4. Reduced sunlight, and the subsequent decomposition of the "blooms" increase populations of bacteria and decreases dissolved oxygen available. Fish kills can occur and the problem can become so bad that anaerobic bacteria take over.
 5. The EPA states the about 1/3rd of 100,000 medium to large lakes and 85% of large lakes near major population centers in the AU.S. have some amount of cultural eutrophication.
 6. Cultural eutrophication also occurs in coastal water, enclosed estuaries and bays due to runoff.
 7. Cultural eutrophication can be reduced or prevented by banning or limiting phosphates in detergents and using advanced treatment methods to remove nitrates and phosphates from wastewater, and by use of soil conservation to reduce runoff.
 8. Clean up of lakes includes removing excess weeds, controlling plant growth and pumping air through lakes and reservoirs to avoid oxygen depletion.
 9. Pollution prevention is less expensive than control methods.
- C. An example of lake recovery is Lake Washington in Seattle, Washington.
 1. Recovery occurred in about 4 years once sewage was diverted from the lake because the lake hadn't filled with weeds and sediment, and it had not become shallow. Diversion was to Puget Sound where there is rapid exchange of water to dilute the sewage.
 2. There is concern about Puget Sound due to increased urban runoff and the population of the area grows rapidly.
 3. The best way is to prevent most waste from reaching either body of water.

Pollution of Groundwater

- A. Groundwater is vulnerable to contamination because it can't effectively cleanse itself and dilute and disperse pollutants
 1. Spilling gasoline, oil, paint thinners and other organics onto the ground can contaminate groundwater.
 2. Experts rate groundwater pollution as a low-risk ecological problem, it is rated as a high-risk health problem.
 3. Contaminated water in the aquifer will slowly flow along and create a plume of contaminated water.
 4. Contaminants in groundwater are not diluted or dispersed because this water moves usually less than 0.3 meter, or 1 foot per day.
 5. Factors such as lower oxygen content, colder temperature of the water and smaller populations of decomposing bacteria mean that cleansing is extremely slow.
 6. It can take hundreds of years to cleanse degradable wastes, nondegradable wastes are there permanently.
- B. The extent of groundwater contamination is generally unknown since there has been little tracking and testing done on aquifers.
 1. EPA and U.S. Geological Survey figures state that one or more organic chemicals contaminate about 45% of municipal groundwater supplies in the U.S.
 2. Some 26,000 industrial waste ponds and lagoons in the U.S. do not have a liner to prevent toxic waste seepage.
 3. A great many of the underground storage tanks containing organic solvents have been found to have leaks.
 4. Determining the extent of a leak is costly and the cost of cleanup is more costly yet.
 5. In China and India millions of people drink water contaminated with high levels of fluoride that cause back and neck damage and dental problems.
 6. Nitrates can also contaminate groundwater, especially in agricultural areas. Nitrates converting to nitrites in the body can cause various forms of cancer, and in babies under 6 months old causes "blue baby syndrome" because the blood can't carry sufficient oxygen to the cells.
 7. Arsenic is released into drinking water when a well is drilled into arsenic-rich soils and rock. WHO estimates that more than 112 million people drink water containing 5-100 times the recommended level of 10 parts/billion.
 8. Bangladesh has a serious problem with arsenic, but the UN and several NGOs have started a program to assess wells and mark those that are too contaminated with red paint.
 9. The 1-ppb level is considered to still be too high a level for safe drinking water.

- C. Prevention is the most effective and affordable way to protect groundwater from pollutants.
1. Figure 22-10 lists ways to prevent and clean up groundwater contamination, not an easy task nor cheap.
 2. Underground tanks in the U.S. and some other developed countries are now strictly regulated. Old, leaky tanks are being removed and the surrounding soils are being treated.

Ocean Pollution

- A. Oceans can disperse and break down large quantities of degradable pollutants if they are not overloaded.
1. Raw sewage, sludge, oil and some degradable industrial wastes can be degraded, especially in deep-water areas.
 2. Some marine animals have been less affected by pollutants than expected.
 3. There is controversy as to whether this is a viable solution to the problem.
- B. Pollution of coastal water near heavily populated areas is a serious problem.
1. About 40% of the world's population lives on or within 62 miles of the coast and this puts a tremendous burden on the wetlands, estuaries, coral reefs and mangrove swamps found along the coast.
 2. In most coastal developing countries and some developed countries sewage is dumped into the sea without treatment. This causes beach pollution and shellfish contamination.
 3. Human viruses (not removed by waste treatment) have been found in coastal waters.
 4. Nutrient enrichment from nitrate and phosphate runoffs have caused harmful algal blooms, called red, brown and green toxic tides. Toxins from these algae kill fish, fish-eating birds and poison seafood.
 5. Extensive non-point runoffs have caused seasonal, large oxygen-depleted zones in temperate coastal waters due to oxygen depletion. The second largest of these zones forms each summer at the mouth of the Mississippi River in the Gulf of Mexico.
 6. Experiments with very fine clay particles are being done to determine if this will pull the algae out of the water and reduce the pollution.
 7. Preventive measures to reduce the number and size of these oxygen-depleted zones include reduction of nitrogen inputs from various sources, planting forest and grasslands to soak up excess nitrogen, restore coastal wetlands, improve sewage treatment, and require further reduction of NO_x emissions and phase in forms of renewable energy to replace fossil fuels.
- C. Pollutants from six states contaminate the shallow Chesapeake Bay estuary, but cooperative efforts have reduced some of the pollution inputs.
1. Human activities and increase in the human population in the Bay area has contributed to pollution of the Bay.
 2. A huge drainage basin adds both point and nonpoint pollutants to the waters. The bay is shallow and so only 1% of the waste that enters is flushed into the Atlantic Ocean.
 3. Commercial harvest of oysters, crabs, and fish have fallen sharply since 1960 because of overfishing, pollution and disease.
 4. Point sources account for about 60% of the phosphates. Nonpoint sources account for about 60% of the nitrates.
 5. In 1983, the U.S. started an integrated coastal management plan that works with citizen groups, state legislatures, and the federal government to reduce pollution using a number of strategies such as reduction of runoff, upgrading waste treatment plants, better monitoring of industrial discharges and banning phosphates from detergents.
 6. Between 1985 and 2000 there has been a 27% decline in phosphorus levels, 16% drop in nitrogen levels and a recovery of grasses growing on the bottom of the bay.
 7. Reduction in funding has slowed the progress of cleanup in the bay, but it demonstrates what can be done with cooperation of diverse groups.
- D. Introduction of disease-resistant oysters into the Chesapeake Bay could greatly reduce water pollution because oysters filter algae and silt from water.
1. Oysters were once a natural filtration system for the bay and recycled the entire volume of the bay in 3-4 days.
 2. Over-harvesting, coupled with two parasitic oyster diseases reduced the oyster population to about 1% of its population. It now takes the oyster population about a year to filter the bay's water.
 3. Several ways to reintroduce oysters into the bay are being considered.
- E. Parts of the world's oceans are dump sites for a variety of toxic materials, sewage, and garbage from ships.
1. Dumping industrial wastes off U.S. coasts has stopped, but large quantities of dredge spoils are still legally dumped at 110 sites in the Atlantic, Pacific, and Gulf Coasts of the U.S.
 2. Many countries also dump sewage sludge into the ocean.
 3. Since 1992, the U.S. has banned this practice.
 4. Fifty countries with at least 80% of the world's merchant fleet have agreed not to dump sewage and garbage at sea.
 5. The London Dumping Convention of 1972 stated that 100 countries agreed not to dump highly toxic pollutants and high-level radioactive wastes in the open sea. In 1994 it became a permanent ban.
- F. Most ocean pollution comes from human activities on land such as changing and dumping motor oil.
1. Crude petroleum and refined petroleum reach the ocean from a number of sources.
 2. More oil is actually released from day-to-day activities such as oil wells offshore, leaks from pipelines, tankers being washed out, loading and unloading of tankers and leaks from pipelines and storage tanks.
 3. Studies show that most ocean oil pollution comes from activities on land.

- G. Oil pollution can have a number of harmful ecological and economic effects, but most disappear within 3-15 years.
 - 1. A number of factors are important when determining the effects of oil on ocean ecosystems.
 - 2. Volatile organic hydrocarbons in oil kill some aquatic organisms, especially the larval forms.
 - 3. Tar-like globs coat bird feathers and fur of marine mammals and these organisms then either drown or die from loss of body heat.
 - 4. Bottom-dwelling organisms are killed when heavy components sink to the sea floor.
 - 5. Recovery from crude oil exposure may only take 3 years for most organisms, but recovery from refined oil products takes 10-15 years. Recovery in cold waters takes longer.
 - 6. Oil slicks on shore also negatively impact the local economy.
- H. Only about 15% of the oil spilled can be recovered with current techniques, so prevention is the best strategy.
 - 1. Methods available include mechanical methods such as floating booms, skimmers and absorbent devices.
 - 2. Chemical methods use coagulating agents for clumping oil and dispersing agents to break up slicks. Fire can also burn off floating oil.
 - 3. Biological methods are being developed to utilize bacteria that are able to degrade oil. It is less expensive and more effective than other methods.
 - 4. The Oil Pollution Act of 1990 set up a trust fund of \$1million per spill for cleanup. By 2015 all oil tankers operating in U.S. waters must be double hulled.
- I. Preventing or reducing pollution from the land and from streams is the key to protecting the oceans.
 - 1. Figure 22-14 lists ways suggested to prevent and reduce excessive pollution of coastal waters.
 - 2. Ocean pollution control must be linked with land-use and air pollution policies to be effective.

Preventing and Reducing Surface Water Pollution

- A. Reduce non-point pollution by preventing it from reaching bodies of surface water.
 - 1. Agricultural non-point pollution can be reduced by reducing soil erosion, reforestation of watersheds, keep cover crops on farmland, reduce fertilizer use or use slow-release fertilizer and plant buffer zones between farmland and surface water nearby.
 - 2. Rely more on biological control methods rather than pesticides.
 - 3. In 2002 a federal court forced EPA to uphold the intent of the Clean Water Act and require 15,500 of the largest feedlots to apply for EPA permits. This means that these “factories” will have to obey the same pollution controls that are used by other industries since 1972.
 - 4. Research on how to use animal wastes more effectively is underway.
- B. Most developing countries do not have laws to set water pollution standards.
 - 1. The Clean Water Act sets standards for allowed levels of key water pollutants and requires polluters to obtain permits that specify the amounts of pollutants they can discharge into aquatic systems.
 - 2. EPA is experimenting with a discharge trading policy that would allow a permit holder to purchase unused credits from another permit holder.
 - 3. There are good and bad point to credit trading, such as a possible buildup of pollutants in areas where credits are bought.
 - 4. Most cities in developing countries discharge 80-90% of untreated sewage into rivers, lakes and streams used for drinking water, bathing, and washing clothes.
- C. Septic tanks and various levels of sewage treatment can reduce point-source water pollution.
 - 1. About 1/4th of homes in the U.S. are served by septic tanks.
 - 2. Most urban areas are served by sewage treatment plants.
 - 3. Some 1,200 cities have combined storm runoff and sewer lines because it is cheaper. These systems can overflow and discharge untreated sewage directly into surface water with too many users or when there is a heavy storm.
 - 4. Aging sewer systems, and combined sewer systems in the U.S. are estimated to cost \$10 billion a year for 10 years to install dual systems, add capacity, and repair the aging sewer network.
 - 5. Raw sewage generally undergoes one or two levels of treatment.
 - 6. Primary sewage treatment is a physical process that removes grit, floating objects and suspended solids. A settling tank allows suspended solids to settle out as sludge.
 - 7. Primary treatment removes about 60% of suspended solids and 30-4-% of organic wastes, but no phosphates, nitrates, salts, radioisotopes, or pesticides.
 - 8. Secondary sewage treatment is a biological process where aerobic bacteria remove up to 90% of dissolved and biodegradable, oxygen-demanding organic wastes.
 - 9. A combination of primary and secondary treatment removes 95-97% of the suspended solids and oxygen-demanding organic wastes, 70% of most toxic metal compounds, 70% of phosphorus, 50% of nitrogen and 5% of dissolved salts.
 - 10. Most U.S. cities have combined primary and secondary sewage treatment plants. A number of cities have been in violation at times, and 34 East Coast cities screen out large floating objects and discharge sewage into coastal waters.
 - 11. Tertiary sewage treatments is a third level of cleanup. Here a combination of chemical and physical processes remove specific pollutants left by the other methods. This is expensive and used to treat only 5% of the wastewater in the U.S.
 - 12. Water is bleached to remove colors and then disinfected to kill disease-causing bacteria and some viruses. Chlorination is

the usual method of disinfection.

13. Ozonation and use of ultraviolet light is increasing as the method of disinfection.

- D. Sewage sludge can be used as a soil conditioner, but may cause health problems if it contains infectious bacteria or toxic chemicals.
 - 1. Sludge is a thick, gooey mixture of bacteria, solids and chemicals and metals when industrial and household wastes are combined.
 - 2. Some sludge undergoes anaerobic digestion to decompose the organic materials and produce compost.
 - 3. About 36% of these biosolids are used to fertilize farmland, forests, golf courses, cemeteries, etc. The rest is added to landfills or incinerated.
 - 4. Composting sludge to recycle the plant nutrients makes good ecological sense, but removing infectious bacteria, toxic chemicals and metals is expensive and seldom done in the U.S.
 - 5. It is thought that a number of health problems may be due to using sludge to fertilize crops in the U.S.
- E. Preventing toxic chemicals from reaching sewage treatment plants would eliminate these from sludge and water that is discharged.
 - 1. Require industries and businesses to remove toxic and hazardous wastes from water sent to sewage treatment plants, encourage reduction or elimination of toxic chemical use and waste.
 - 2. Have households switch to waterless composting toilet systems maintained by professionals. These systems would be cheaper to install and maintain since they do not need underground pipes.
- F. Natural and artificial wetlands and other ecological systems can be used to treat sewage.
 - 1. These systems are a low-tech, low-cost alternative to expensive waste treatment plants.
 - 2. Sewage goes to sedimentation tanks where solids settle as sludge that is removed. The liquid is pumped to oxidation ponds, bacteria break down remaining wastes. After a month, water is released to an artificial marsh where plants and bacteria filter and cleanse.
 - 3. Mark Nelson developed a small, low-tech, inexpensive artificial wetland system for use in developing countries at hotels, restaurants, and homes. It removes 99.9% of fecal coliform bacteria and over 80% of the nitrates and phosphates from sewage. The water thus cleaned could be used for garden irrigation, flush toilets and save water.
 - 4. Genetic engineering is developing a bioreactor where modified bacteria will consume pesticides.
 - 5. Without large investments in building adequate sanitation facilities more people will have inadequate sanitation.
- G. Water pollution laws have significantly improved water quality in many U.S. streams and lakes, but more needs to be done.
 - 1. Between 1992 and 2002 American communities served by water systems meeting federal guidelines increased from 79% to 94%.
 - 2. Fishable and swimmable streams increased from 36% to 60% of those tested.
 - 3. Topsoil loss through runoff was cut by 111 billion metric tons annually.
 - 4. Annual wetland losses decreased by 80%.
 - 5. In 2000, 40% of streams and 45% of lakes surveyed were too polluted for swimming or fishing. This figure could be much higher since only 19% of stream lengths, 43% of lake and reservoir areas, and 36% of estuaries have been tested for water quality.
 - 6. Animal waste and waste lagoons continue to be a problem.
 - 7. Often fish caught in streams and lakes are unsafe to eat because of high levels of pesticides, mercury and other toxic substances.
 - 8. In 2003 the EPA found that at least half of the 6,000 largest industrial facilities have been illegally discharging toxic and biological wastes into waterways for years with impunity.
- H. There is controversy of strengthening the Clean Water Act.
 - 1. A 2001 report by EPA's inspector general calls for strengthening the Clean water Act.
 - 2. Suggestions include increased funding, increased authority to control nonpoint pollution, modernize monitoring system, increase compliance with the law and strengthen programs.
 - 3. Work on integrating watershed and airshed planning to protect ground and surface water sources.
 - 4. Halt the loss of wetlands, increase standards for wetland restoration and create new wetlands before filling existing ones.
 - 5. Farmers feel they should be compensated for property value losses that result from federal regulations protecting wetlands.

Drinking Water Quality

- A. Centralized water treatment plants can provide safe drinking water for city dwellers. Water is settled, filtered and chlorinated to meet government drinking standards.
- B. The U.S. is upgrading on water purification and delivery systems. This is such a vast system that it is hard to secure, but also difficult to adequately poison. Both chemical and biological indicators are being developed to indicate a contamination problem.
- C. Several simple, inexpensive ways for individuals and villages to purify drinking water have been developed.
 - 1. Exposure of contaminated water to intense sunlight in a clear plastic bottle is one method. It takes as little as 3 hours to kill bacteria in the sun and heat.

2. Cholera incidences have been cut in half in Bangladesh by filtering water through strips of cloth.
3. A third method is to add a small amount of chlorine to a plastic or clay storage vessel with a small mouth, cap, and a spigot. This has cut the rate of diarrheal disease in half in countries where it is used.
- D. About 54 countries have standards for safe drinking water.
 1. Levels have been established called maximum contaminant levels, for any pollutants that may adversely affect human health.
 2. Privately owned wells don't have to meet these standards.
 3. Health scientists want the standards to be strengthened.
 4. Certain industries want to weaken the Safe Drinking Water Act.
- E. Some bottled water is not as pure as tap water and costs much more.
 1. Bottled water is vastly more expensive than tap water and about 1/4th of it is tap water, 1/3rd of it is contaminated with bacteria, and various harmful organic chemicals contaminate about 1/5th of it.
 2. Use of bottled water also can cause environmental problems from all the throw away plastic bottles.
 3. Manufacture of the bottles releases toxic gases and liquids.
 4. Before buying costly home purification systems, have water tested by an independent company.
 5. Be sure to check out claims by a company that they are EPA approved because the EPA registers devices, but neither tests nor approves them.
- F. We need to shift priorities from controlling to preventing and reducing water pollution and will require bottom-up political action by individuals and groups.
 1. Bottom-up political pressure on elected officials has reduced point-source water pollution.
 2. A shift needs to be made to how we can prevent water pollution in the first place. See figure 22-19.
 3. Prevention of water pollution will take action from individuals and groups to pressure elected officials.

Summary

1. Water pollutants include infectious agents from human or animal wastes, oxygen-demanding wastes from sewage, paper mills, and food processing, inorganic chemicals from surface runoff, industrial effluents, and household cleaners, organic chemicals from oil, plastics, pesticides, and detergents, sediment from erosion, and thermal pollution from power plant cooling.
2. Water pollution problems in streams and lakes relate to chemical and biological pollutants with the greater problems being cultural eutrophication.
3. Groundwater pollution is caused by leaks from waste ponds and underground storage tanks, chemical dumping or spilling, surface runoff, and fertilizers. It can be prevented by finding substitutes for toxic chemicals, installing monitoring wells near landfills and underground tanks, requiring leak detectors on underground tanks, banning hazardous waste disposal in landfills and injection wells, and storing harmful liquids in aboveground tanks.
4. Water pollution of oceans relates to nitrogen oxide from industry and cars, heavy metals from effluents, toxic sediment, sewage, runoff of pesticides, manure, fertilizers, and red tides from excess nitrogen.
5. Reduction or prevention of water pollution can be achieved through reduction of use of toxic pollutants, banning of ocean dumping of sludge, protection of sensitive areas from oil drilling and oil transport, regulation of coastal development, and regulation of sewage treatment.
6. The U.S. Safe Drinking Water Act of 1974 requires that drinking water contain less than the maximum contaminant levels for any pollutants that may have adverse effects on human health. Restructuring of water treatment systems, enforcing current regulations, banning the use of lead in new structures, and chemical tests and biological indicators can be used to make drinking water safer.

Chapter 22 - Solid and Hazardous Waste

Outline

Wasting Resources

Solid waste is another kind of resource; the United States is not utilizing this resource well. The affluence of the United States is reflected in the fact that less than 4.6% of the world's population produces 33% of the world's solid waste.

- A. Solid waste is unwanted/discarded material that is not liquid/gaseous.
 1. For the most part, good and services produce this waste indirectly.
 2. Municipal solid waste (garbage/trash) comes mostly from homes and workplaces.
- B. Solid waste is a sign of a society's waste of its resources: aluminum, tires, disposable diapers, e-waste, plastic bottles, edible

food, etc. Electronic waste (e-waste) is the fastest growing type of solid waste.

Integrated Waste Management

- A. One method to reduce waste and pollution is to implement waste management. This high-waste approach accepts waste production as a result of economic growth.
 - 1. It attempts to reduce environmental harm.
 - 2. It transfers the waste from one part of the environment to another.
- B. One method is waste reduction. This low-waste approach sees solid waste as a potential resource, which should be reused, recycled, or composted.
 - 1. It discourages waste production in the first place.
 - 2. It encourages waste reduction and prevention.
 - 3. Waste reduction saves matter and energy resources, reduces pollution, helps protect biodiversity, and saves money.
 - 4. Waste reduction is based on the five Rs:
 - a. Refuse
 - b. Reduce
 - c. Reuse
 - d. Repurpose
 - e. Recycle
- C. To cut waste production and promote sustainability, we must reduce consumption and redesign our products. These are the eight priorities based on the five Rs.
 - 1. Consume less.
 - 2. Redesign manufacturing processes and products to use less material and energy.
 - 3. Redesign manufacturing processes to produce less waste and pollution.
 - 4. Develop products which are easily repaired, reused, remanufactured, composted, or recycled.
 - 5. Shift from selling goods to selling or leasing the services they provide.
 - 6. Eliminate or reduce unnecessary packaging.
 - 7. Fee-per-bag system of waste collection
 - 8. Cradle to grave responsibility

Reuse

Reusing products helps reduce resource use, waste and pollution; it also saves money.

- A. Developing countries reuse their products; but there is a health hazard for the poor.
- B. U. S. e-waste goes to developing countries where workers are exposed to toxic metals, dioxins, etc.
- C. Large city dumps expose scavengers to toxins and infectious diseases.
- D. Refillable containers create jobs, costs less for the product, and lessen waste.
- E. Shopping bags, food containers, pallets, and tools can be reused/borrowed.

Recycling

Recycling collects waste materials, turn them into useful products, and sells the new products.

- A. Recycling is one of two types--it involves reprocessing discarded solid materials into new, useful products; secondary recycling involves converting materials into different products.
- B. Five types of materials can be recycled: paper products, glass, aluminum, steel, and some plastics.
- C. Recycling saves money and creates jobs, more than burning or landfilling wastes.
- D. Pre-consumer/internal waste is generated from a manufacturing process that is recycled. Post-consumer/external waste is generated by consumer use of products.
- E. Composting biodegradable organic wastes is a great way to mimic nature.
- F. Solid waste recycling can be done in a materials-recovery facility (MRF). Machines shred and separate the mixed waste and sell raw materials to manufacturers. The wastes are recycled and/or burned to produce energy; but such plants are expensive. They, also, must process a large input of garbage.
- G. Source Separation recycling relies on households and businesses to separate their trash; these are collected and sold to other dealers.
 - 1. This produces less air and water pollution.
 - 2. This method has less startup costs and operating costs.
 - 3. It saves more energy and provides more jobs than MRFs.
 - 4. Pay-as-you-throw (PAUT) waste collection systems charge for the mixed waste that is picked up but not for the recycled, separated materials.
- H. Plastic recycling is not feasible because of these problems.
 - 1. Plastics are difficult to isolate in different materials.
 - 2. Not much individual plastic resin is recoverable per product.
 - 3. Recycled resin is much more expensive than virgin plastic resin.

- I. A new polymer, polylactide (PLA), made by Cargill and Dow is being used to produce plastic containers, which can be composted for a soil conditioner.
- J. The economics of recycling depends on the cost one counts.
 - 1. The economic, environmental, and health benefits far outweigh the costs of recycling.
 - 2. But some materials cost more than it is worth.
- K. Factors, which hinder reuse and recycling, are:
 - 1. The cost of a product does not include harmful environmental health costs in its life cycle.
 - 2. Resource-extracting industries receive government tax breaks and subsidies while recycle and reuse industries do not.
 - 3. Landfill charges are low in the U.S.
 - 4. The demand and price for recycled materials fluctuates so there is less interest in committing to this method.
- L. There are tradeoffs in recycling--both advantages and disadvantages to recycling solid waste.

Burning and Burying Solid Waste

- A. Municipal solid waste is burned in waste-to-energy incinerators, which produces steam for heating or producing electricity.
- B. The advantages and disadvantages of burning solid waste are: (given in Figure 24-13)
 - 1. High operating costs
 - 2. Air pollution concerns
 - 3. Citizen opposition to the process
- C. Most solid waste is buried in landfills, which will leak toxic liquids into the soil and water.
 - 1. Open dumps in the ground hold garbage; sometimes it is covered with dirt.
 - 2. Sanitary landfills spread the solid waste out in thin layers, compact it, and cover it daily with clay/plastic foam. Modern landfills line the bottom with an impermeable liner, which collects leachate; rainwater is contaminated as it percolates through the solid waste. The leachate is collected, stored in tanks and then sent to a sewage treatment plant. But all landfills will eventually leak contaminants.
- D. There is a difficult dilemma in dealing with the more than 800 million used tires that have accumulated in large dumps and vacant lots and the approximately 273 million more tires discarded each year
 - 1. Tires and negative health and environmental effects
 - 2. There are several methods being used to reuse and recycle used tires.

Hazardous Waste

Hazardous waste is discarded solid or liquid material that may explode and/or release toxic fumes. The two largest classes of hazardous wastes are organic compounds (such as pesticides, PCBs and dioxins) and toxic heavy metals (such as lead, mercury and arsenic)

- A. The Resource Conservation and Recovery Act (RCRA) regulates about 5% of the U.S. hazardous waste.
- B. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA/Superfund program) was passed in 1980.
 - 1. The law identifies hazardous waste sites
 - 2. The law provides for clean-up of these sites on a priority basis.
 - 3. The worst sites go on a National Priorities List (NPL) and are scheduled for total cleanup.
 - 4. There are, also, laws that provide for cleaning up brownfields, abandoned sites contaminated with hazardous wastes like factories, gas stations, junk yards, etc.
- C. Chemical and biological methods can be used to reduce the toxicity of hazardous wastes or to remove them.
 - 1. Treatment facilities can detoxify hazardous and toxic wastes.
 - 2. One biological treatment, bioremediation, uses bacteria and enzymes to help destroy hazardous or toxic substances. They are converted to harmless compounds in the process.
 - 3. Phytoremediation uses natural or genetically engineered plants to absorb, filter and remove contaminants from polluted water and soil. The advantages and disadvantages of phytoremediation are: (Figure 22-17)
- D. Hazardous waste regulation in the United States.
 - 1. Both the Resource Conservation and Recovery Act and the Superfund Act were supported to deal with hazardous wastes.
 - 2. Brownfields are contaminated industrial/commercial sites.

Dealing With Hazardous Waste

- A. An Integrated Management of Hazardous Waste involves producing less and then recycling, reusing, detoxifying, burnings and buying what is produced
- B. Physical, chemical, and biological methods and incineration and the plasma torch can be used to remove hazardous wastes or reduce their toxicity
- C. Deep-well disposal pumps liquid hazardous waste into dry, porous geologic formations far beneath water sources. Many scientists believe current regulations for deep-well disposal are inadequate.
- D. Surface impoundments are depressions excavated into the earth, like ponds, pits or lagoons, which are used to store liquid hazardous wastes. With evaporation, the wastes settle and become more concentrated. EPA studies found this method

inadequate.

- E. In secure hazardous waste landfills, liquid and solid hazardous waste are stored in drums or other containers and buried. Carefully designed aboveground buildings can be used to store hazardous waste; the waste is contained in the upper floor; on the lower floor, leaks can, then, be easily identified.
- F. All of these methods have disadvantages and advantages and their ability to protect groundwater is probably limited.

Toxic Lead and Mercury

- A. Lead is a toxic metal and poses environmental threats in many countries, especially to the nervous systems of children.
 - 1. Lead poisoning can produce palsy, partial paralysis, blindness, mental retardation, hyperactivity, hearing damage, and behavioral disorders. Such poisoning is a risk in many places of the world.
 - 2. Methods to protect children from lead poisoning include: (figure 24-25).
- B. Mercury is released through burning coal and incineration of wastes.
 - 1. Mercury can be found in high levels in some types of fish.
 - 2. In the US up to 300,00 babies born each year are in risk of cerebral palsy, delayed onset of walking and talking, learning disabilities, loss of memory, and impaired coordination due to exposure to methylmercury while still in the womb.
 - 3. Methods of preventing mercury poisoning include: (figure 24-27).

Achieving a Low-Waste Society

Environmental injustice has been practiced by placing hazardous treatment plants, incinerators, and landfills in communities populated by minority populations in the United States.

- A. Opposition to such has grown so that local, grass-root groups have successfully opposed the construction of such facilities. Health risks for people living near these facilities are much higher than for the general population.
- B. Environmental Justice means that every person is entitled to protection from environmental hazards regardless of race, gender, age, national origin income, social class or any other factors
- C. In 2000, a global treaty to control twelve persistent organic pollutants (POPs) was developed. To be made effective, fifty countries must ratify the treaty.
 - 1. POPs are toxic chemicals stored in the fatty tissue of humans and other organisms.
 - 2. Twelve chemicals, the dirty dozen, need to be phased out, detoxified and/or isolated.
- D. There are four principles for transitioning to a low-waste society:
 - 1. Everything is connected.
 - 2. There is no place to send wastes “away.”
 - 3. Diluting waste is not the solution to pollution.
 - 4. The best solution is to prevent waste and pollution and, then, reuse/recycle the materials that we use.
 - 5. It is necessary to detoxify the US economy.

Summary

- 1. Solid waste is any unwanted or discarded material that is not a liquid or a gas. Thirty-three percent of the world’s solid waste is produced by one country – the United States – which represents 4.6% of the world’s population.
- 2. Waste management, waste reduction, reduced usage and pollution prevention can all be used to reduce, reuse, or recycle solid waste.
- 3. The advantages of burning waste include reduction of trash volume, minimizing the need for landfills, and lowering water pollution. The disadvantages include high cost, air pollution, producing toxic ash, and encouraging waste production. The advantages of burying wastes include safety, wastes can be retrieved, ease of application, and low cost. Disadvantages include leaks and spills, existing fractures or earthquakes can cause waste escape, and encouraging waste production.
- 4. Hazardous waste is any discarded solid or liquid material that is toxic, ignitable, corrosive, or reactive enough to explode or release toxic fumes. We can use a pollution prevention or waste reduction approach to reduce production and manage existing hazardous waste mostly by burning or burying it.
- 5. Physical methods such as filtering and distilling, chemical reactions, bioremediation, phytoremediation, and plasma torches can all be used to detoxify hazardous waste.
- 6. Advantages of burning hazardous waste include reduction of waste volume, minimizing the need for storage space and lowering water pollution. The disadvantages include air pollutants such as toxic dioxins and production of toxic ash that must be stored. Advantages of burying hazardous waste include safety, wastes can be retrieved, ease of application, and low cost. Disadvantages include leaks and spills, existing fractures or earthquakes can cause waste escape, and encouraging waste production.
- 7. We can prevent lead poisoning through reduces use of lead gasoline and waste incineration, testing blood by age 1, and by

banning lead solder, glazing, and candles containing lead. Mercury pollution can be prevented by reducing waste incineration, removing mercury from coal, using natural gas in the place of coal, and phasing out use of mercury in all products unless they are recycled. Dioxin pollution can be prevented by reducing waste incineration, banning the use of chlorine for bleaching paper, eliminating chlorinated hydrocarbon compounds burned in iron ore sintering plants and cement kilns, and testing of livestock forage and feed.

8. The United States regulates hazardous waste through the 1976 *Resource Conservation and Recovery Act* that was amended in 1984.
9. Transition to a more sustainable low-waste society involves preventing the building of new incinerators, landfills, and treatment plants, as well as a focus on pollution prevention and the use of the precautionary principle.

Chapter 18 - Environmental Hazards and Human Health

Outline

Risk and Hazards

- A. A risk is a measure of your likelihood of suffering harm from a hazard.
 1. Such a hazard may cause injury, disease, economic loss, or environmental damage.
 2. Risk assessment is projected as a probability: a mathematical statement about how likely it is that harm will result from a hazard. It gives the estimate of an event's actually happening.
 3. Risk management involves deciding whether or how to reduce a particular risk to a certain level and at what cost.
- B. There are four major types of hazards.
 1. Biological hazards come from more than 1400 pathogens (bacteria, viruses, parasites, protozoa, and fungi) that can infect humans
 2. Chemical hazards from harmful chemicals in air, water, soil and food.
 3. Physical hazards such as fire, earthquake, volcanic eruption, flood, tornado, and hurricane.
 4. Cultural hazards such as smoking, unsafe working conditions, poor diet, drugs, drinking, driving, criminal assault, unsafe sex, and poverty.

Biological hazards: disease in developed and developing countries

- A. Diseases not caused by living organisms do not spread from one person to another, while those caused by living organisms such as bacteria and viruses can spread from person to person.
 1. Non-transmissible disease tend to develop slowly, have multiple causes, are not caused by living organisms, and do not spread from one person to another. Examples are cancer, diabetes, asthma, malnutrition and blood vessel disorders.
 2. Transmissible disease is caused by a living organism and can spread from one to another. Infectious agents/pathogens are spread in air, water, food, body fluids, by some insects and by vectors.
 3. The World Health Organization estimates that each year the world's seven deadliest infectious diseases kill 13.6 million people-most of them poor people in developing countries. This amounts to about 37,000 mostly preventable deaths every day.
 4. There is concern about bioterrorism, which involves the deliberate release of disease-causing bacteria or viruses into the air, water supply, or food supply of concentrated urban populations.
 5. Mixed news is that death from infectious diseases has decreased, but many bacteria have developed immunity to widely used antibiotics.
- B. Rapidly producing infectious bacteria are becoming genetically resistant to widely used antibiotics.
 1. The bacteria can transfer this resistance to nonresistant bacteria.
 2. Human travel and trade spread bacteria rapidly across the globe.
 3. Doctors overuse antibiotics.
 4. The availability of antibiotics in many countries without a prescription.
 5. Resistance to antibiotics has increased because of antibiotics being used in livestock and dairy animals to control disease and promote growth.
 6. Overuse of pesticides increases pesticide resistant insects and other carriers of bacterial diseases.
 7. Public pressure has caused some phasing out of antibiotic use in cattle.
 8. Each year, some 2 million people pick up preventable infections while they are in U.S. hospitals.
- C. Tuberculosis kills 1.7 million people per year and could kill 25 million more people by 2020.
 1. Tuberculosis is a silent global epidemic since many people do not know that they have been infected.
 2. Several factors account for the recent increase in TB:
 - a. lack of screening, and control programs, especially in developing countries where 95% of the new cases occur
 - b. increased population growth, urbanization, and air travel means greater contact between people

- c. there are genetically resistant strains of TB to almost all effective antibiotics
 - d. the spread of AIDS weakens the immune system and allows the TB bacteria to multiply
- 3. There must be early detection and treatment of people with active TB to slow the spread of the disease.
- D. Flu, HIV, and hepatitis B viruses infect and kill many people each year than highly publicized West Nile and SARS viruses.
 - 1. The influenza or flu virus is the biggest killer. It is responsible for the deaths of about 1 million people a year.
 - 2. The second biggest killer is HIV, transmitted in a variety of ways. (See the Core Case Study on p. 418 for facts regarding the global HIV/AIDS epidemic). Globally it infects about 4.9 million new people a year. The resulting complications from AIDS kill about 3 million people annually. The World Health Organization has suggested a five-point strategy to slow the spread of HIV/AIDS.
 - a. Shrink the number of people capable of infecting others by quickly reducing the number of new infections below the number of deaths.
 - b. Concentrate on the groups that are most likely to spread the disease such as truck drivers, sex workers and soldiers.
 - c. Provide free HIV testing
 - d. Use mass advertising and education for adults and schoolchildren
 - e. Provide free or low-cost drugs to slow the progress of the disease.
 - 3. The third largest killer is the hepatitis B virus (HBV) that damages liver and kills about 1 million people each year. It is transmitted by the same methods as HIV.
 - 4. Health officials are concerned about the emergence of West Nile virus and severe acute respiratory syndrome (SARS) in recent years.
- E. Malaria kills about 2 million people per year and has probably killed more people than all of the wars ever fought. Malaria is caused by a parasite that is spread by the bites of certain mosquitoes.
 - 1. It is caused by four species of protozoan parasites in the genus *Plasmodium*.
 - 2. The parasite circulates from mosquito to human and back to mosquito.
 - 3. The cycle repeats until immunity develops, treatment is given, or the victim dies.
 - 4. During the 1950s and 1960s, the spread of malaria was sharply curtailed by draining of swamplands and marshes, spraying breeding areas with insecticides, and using drugs to kill the parasite in the bloodstream. Since 1970, however, malaria has come roaring back as most species of the *Anopheles* mosquito have become genetically resistant to most insecticides.
 - 5. Researchers are currently working to develop new anti-malarial drugs, vaccines, and biological controls for the mosquitoes.
 - 6. Currently prevention is the best method to control its spread. Methods include fixing leaking water pipes, using mosquito netting, cultivate fish that feed on mosquito larvae, plant trees that soak up water in marshy areas and use zinc and vitamin A supplements to boost resistance in children.
- F. There are a number of ways to reduce the incidence of infectious diseases if the world is willing to provide the necessary funds and assistance.
 - 1. Global death rate dropped by about 2/3rds between 1970 and 2000. The number of children immunized between 1971 and 2000 went from 10% to 84% and saved an estimated 10 million lives a year.
 - 2. To reduce the incidence of infectious disease, we now use oral rehydration therapy to replace water in victims of diarrheal diseases, which cause about one-fourth of all deaths of children younger than age 5.
 - 3. Only about 10% of global medical research and development money is spent on preventing infectious diseases in developing countries, even though more people worldwide suffer and die from these diseases than all other diseases combined.
- G. Mostly because of human activities, infectious diseases are moving at increasing rates from one animal species to another and from one animal species to humans.
 - 1. Infectious diseases that are transmitted from wild and domesticated animals to humans include avian flu, SARS, West Nile virus, Hantavirus, and Lyme disease.
 - 2. Ecological or conservation medicine is a new field devoted to tracking down these connections between wildlife and humans.
 - 3. The clearing and fragmentation of forests has played a major role in exposing humans to new types of infectious disease.
 - 4. Understanding the connections between human activities and ecosystem functioning is a key to preventing or slowing the spread of infectious organisms from wild and domesticated animals to humans.

Chemical hazards

- A. Toxic and hazardous chemicals can harm or kill.
 - 1. A toxic chemical can cause temporary or permanent harm or death to humans or animals.
 - 2. A hazardous chemical can harm because it is flammable or explosive or because it irritates or damages skin or lungs or induces allergic reactions.
 - 3. There are three major types of potentially toxic agents.
 - a. Mutagens are chemicals or ionizing radiation that cause or increase the frequency of random mutations in the DNA molecules. It is generally accepted that there is no safe threshold for exposure to harmful mutagens.

- b. Teratogens are chemicals that cause harm or birth defects to a fetus or embryo. Alcohol and thalidomide are examples of teratogens.
 - c. Carcinogens are chemicals or ionizing radiation that cause or promote cancer.
- B. Long-term exposure to some chemicals at low doses may disrupt the body's immune, nervous, and endocrine systems.
 - 1. The immune system consists of specialized cells and tissues that protect the body against disease and harmful substances. It forms antibodies that make invading agents harmless.
 - 2. Neurotoxins are types of poisons that attack the nervous system that consists of the brain, spinal cord, and peripheral nerves.
 - 3. The endocrine system is a complex glandular system that releases small amounts of hormones into the bloodstream of vertebrates. Low levels of these chemicals turn on and off bodily systems controlling sexual reproduction, growth, development, learning ability, and behavior.
 - 4. There is concern that certain synthetic chemicals can mimic hormones and that low-level exposure to these hormonally active agents (HAAs) can disrupt the endocrine system.
 - 5. These HAAs may
 - a. disrupt human immune functions
 - b. have adverse reproductive and developmental effects on vertebrates exposed to them
 - c. act as thyroid disrupters and cause growth, weight, brain, and behavioral disorders
 - d. disrupt the human endocrine and nervous systems and cause or promote certain types of cancers
- C. The world's worst industrial accident occurred in 1984 at a pesticide plant in Bhopal, India.
 - 1. An explosion in an underground storage tank released a large quantity of highly toxic methyl isocyanate (MIC) gas, used to produce carbamate pesticides.
 - 2. MIC was converted to the more deadly hydrogen cyanide gas in the atmosphere.
 - 3. Indian officials and other groups put the death toll between 15,000-20,000 people.
 - 4. A lawsuit relating to the Union Carbide plant in Bhopal still continues 20 years after the initial accident.

Toxicology: assessing chemical hazards

- A. Factors determining the harm caused by exposure to a chemical include the amount of exposure (dose), the frequency of exposure, the person who is exposed, the effectiveness of the body's detoxification systems, and one's genetic makeup.
 - 1. Toxicity measures how harmful a substance is in causing injury, illness, or death to a living organism. Several factors to consider are:
 - a. Dose, the amount of a substance a person is exposed to
 - b. Frequency of exposure
 - c. Age and size of the individual exposed
 - d. The health of the body's detoxification system
 - e. Genetic makeup of the individual is also important for determining sensitivity to a toxin.
 - 2. Five major factors can affect the harm caused by a substance:
 - a. Solubility. Water-soluble toxins can move throughout the environment. Oil- or fat-soluble toxins (generally organic compounds) can penetrate the membranes surrounding an organism's cells and accumulate in the body.
 - b. Persistence of a substance is also important. Some substances resist breakdown and remain in the environment a long time and can have long-lasting harmful effects.
 - c. Bioaccumulation is a third factor. Molecules are absorbed and stored in the body at higher than normal levels.
 - d. Biomagnification is where toxins accumulate at greater levels as they are moved up from one trophic level to the next higher one.
 - e. Chemical interactions can decrease or multiply the harmful effects of a toxin. An antagonistic interaction reduces the harmful effect while a synergistic interaction multiplies the harmful effects.
 - 3. The effects of a chemical can be chronic or acute. An acute effect is immediate; a chronic effect is a long-lasting consequence from exposure to a harmful substance. The type and amount of health damage from exposure to a chemical is called the response.
 - 4. The basic concept of toxicology is that any synthetic or natural chemical can be harmful if ingested in a large enough quantity.
 - 5. The critical question is, how much exposure to a particular toxic chemical causes a harmful response? It is different for each individual.
 - 6. The body has three major mechanisms for reducing the harmful effects of some chemicals:
 - a. It can break down, dilute, or excrete small amounts of most toxins to keep them from reaching harmful levels.
 - b. Certain enzymes can sometimes repair damage to DNA and protein molecules.
 - c. Cells in certain parts of the body (skin, gastrointestinal tract, lungs and blood vessels) can reproduce fast enough to replace damaged cells.
 - 7. A poison or toxin is a chemical that adversely affects the health of a human or animal by causing injury, illness, or death.
- B. Trace amounts of chemicals in the environment or your body may or may not be harmful. Should we be concerned about trace amounts of various chemicals in air, water, food, and our bodies? The honest answer is we do not know.

1. Some scientists think that trace levels of most chemicals are not harmful.
 2. Other scientists feel we need to evaluate the long-term harm caused by exposure to low doses of many new synthetic chemicals.
 3. Natural chemicals in the environment are sometimes thought to be safe, but this is a false impression since nature has an arsenal of harmful chemicals for defense also.
- C. Under existing laws, most chemicals are considered innocent until proven guilty, and estimating their toxicity to establish guilt is difficult, uncertain, and expensive.
- D. Some scientists and health officials say that preliminary but not conclusive evidence that a chemical causes significant harm should spur preventative action but others disagree.
1. Some scientists, especially those in European Union countries, are pushing for much greater emphasis on pollution prevention, which is based on the precautionary principle.
 2. In 2000, negotiators in the European Union agreed to a global treaty that would ban or phase out use of 12 of the most notorious persistent organic chemicals (POPs), also called the dirty dozen.
 3. Manufacturers and businesses contend that widespread application of the precautionary principle would make it too expensive and almost impossible to introduce any new chemical or technology.

Summary

1. Major types of hazards faced by humans include cultural, physical, chemical, and biological hazards.
2. Toxicology is the scientific field that measures the degree of harm a hazardous agent can cause. Scientists measure toxicity based on dosage, solubility, persistence, bioaccumulation, biomagnification, and chemical interactions.
3. Chemical hazards include agents that are flammable or explosive, damage or irritate lungs or skin, interrupt oxygen uptake, and cause allergies. Chemical hazards are defined by their toxicity, the person's acute and chronic reactions to it, and its pervasiveness in the environment.
4. The types of disease threatening people in developing countries are primarily infectious diseases of childhood while those threatening people in developed countries tend to be chronic diseases of adults, such as heart disease, stroke, cancer, and respiratory conditions.