**Chapter 19**

**Air Pollution**

**Lecture Outline:**

1. Atmosphere as a Resource
   1. Excluding water vapor, four gases comprise most of the atmosphere: nitrogen (78.08%), oxygen (20.95%) argon (.93%), and carbon dioxide (.04%)
   2. Other gases and particles, including pollutants, occur in much smaller concentrations
2. Types and Sources of Air Pollution
   1. Air pollution consists of gases, liquids, or solids present in the atmosphere in high enough levels to harm humans, other organisms, or materials
      1. Much of the air pollution released by humans is concentrated in densely populated urban areas
      2. *Primary air pollutants* are emitted directly into the atmosphere
      3. *Secondary air pollutants* are formed when a primary air pollutant reacts with substances normally found in the atmosphere or with other air pollutants
   2. Major classes of air pollutants
      1. *Particulate matter* consists of thousands of different solid and liquid particles suspended in the atmosphere; it can have toxic or carcinogenic effects
         1. *Solid particulate matter* – dust, soil particles, soot, lead, asbestos, etc.
         2. Liquid suspensions – mist
      2. *Nitrogen oxides* are *greenhouse gases* produced by the chemical interactions between atmospheric nitrogen and oxygen when a source of energy (i.e., fuel combustion) produces high temperatures
         1. They inhibit plant growth and aggravate health problems (i.e., asthma)
         2. They help produce photochemical smog and acid deposition
      3. *Sulfur oxides* are gases produced by chemical interactions between sulfur and oxygen; they cause acid deposition, corrode materials, and irritate respiration
      4. *Carbon oxides* tend to be colorless, odorless, tasteless greenhouse gases that are associated with global warming
      5. *Hydrocarbons* can injure respiratory tracts and cause cancer, and are important in the production of photochemical smog
      6. Ozone is a pollutant in one part of the atmosphere but an essential component in another
         1. *Stratospheric* ozone prevents much of the solar UV radiation from penetrating to the Earths’ surface
         2. Ozone in the *troposphere* is a human-made air pollutant
      7. The release of 180 *hazardous air pollutants* or *air toxics* is limited by the Clean Air Act Amendments of 1990
   3. Sources of outdoor air pollution
      1. *Mobile sources* (transportation) – automobiles/trucks
      2. *Stationary sources* (industries) – electrical power plants/industrial facilities
   4. Urban air pollution
      1. Smoke pollution primarily made up of sulfur oxides and particulate matter is often called *industrial smog*
      2. *Photochemical smog* is a brownish-orange haze formed by chemical reactions involving sunlight, nitrogen oxide, and hydrocarbons
      3. Both weather and topography affect air pollution
         1. Under normal conditions, air circulation patterns prevent toxic pollutants from increasing to dangerous levels near the ground
         2. During periods of *temperature inversion*, polluting gases and particulate matter remain trapped in high concentrations close to the ground
3. Effects of Air Pollution
   1. Air pollution injures organisms, reduces visibility, and attacks and corrodes materials such as metals, plastics, rubber, and fabrics; it is involved in acid deposition, global temperature changes, and stratospheric ozone depletion
   2. Air pollution and human health
      1. Chronic respiratory diseases (i.e., *emphysema and chronic bronchitis*) may result from exposure to air pollution during respiratory illnesses
      2. Health effects of specific air pollutants
         1. Sulfur dioxide and particulate matter irritate the respiratory tract and cause airways to constrict, impairing the lung’s ability to exchange gases
         2. Carbon monoxide binds irreversibly with iron in the blood’s hemoglobin, eliminating its ability to transport oxygen
         3. Ozone causes burning eyes, coughing, and chest discomfort; it brings on asthma attacks and suppresses the immune system
         4. It is estimated that 360 people out of every million Americans develop cancer as a result of air toxics
      3. Children and air pollution
         1. Air pollution is a greater health threat to children than it is to adults
         2. Air pollution can restrict lung development in children
         3. To obtain oxygen, children breathe about two times as much air per pound of body weight as do adults
4. Controlling Air Pollution in the United States
   1. Controlling air pollutants
      1. Historically “command and control” technologies have been used to reduce emissions
      2. To help reduce emissions, some form of *vapor recovery* is required by gasoline sellers in most urban parts of the world
      3. Lower combustion temperature in automobiles reduces the formation of nitrogen oxides
      4. Careful handling of petroleum and hydrocarbons reduces air pollution from spills and evaporation
   2. The Clean Air Act
      1. This law authorizes the EPA to set limits on the amount of specific air pollutants permitted everywhere in the U.S.
      2. The EPA has focused on six air pollutants (lead, particulate matter, sulfur dioxide, carbon monoxide, nitrogen oxides, and ozone)
   3. Other ways to improve air quality
      1. Reducing the sulfur content in gasoline
      2. Making sure minivans, sport utility vehicles, and light pickup trucks have to comply with federal emission standards
5. Ozone Depletion in the Stratosphere
   1. The relatively high concentrations of ozone in the stratosphere form a layer that shields the surface from much of the *ultraviolet radiation (UV)* coming from the sun
   2. The causes of ozone depletion
      1. Human-produced chlorine- and bromine-containing chemicals (i.e., *chlorofluorocarbons - CFCs*) lead to the accelerated destruction of ozone referred to as *stratospheric ozone thinning*
      2. Halons, methyl bromide, methyl chloroform, and carbon tetrachloride also release chlorine or bromine and thus lead to ozone depletion
   3. The effects of ozone depletion
      1. Higher levels of UV radiation reach Earth’s surface
      2. Excessive exposure to UV radiation is linked to eye cataracts, skin cancer, and weakened immunity
      3. High levels of UV radiation may also damage crops and forests
   4. Facilitating the recovery of the ozone layer
      1. The Montreal Protocol (1987) stipulated a 50% reduction of CFC production by 1998
         1. Industrial companies developed substitutes such as hydrofluorocarbons (HFCs) which do not attack ozone and hydrochlorofluorocarbons (HCFSs) which are not as destructive as CFCs
         2. Production of CFC, carbon tetrachloride, and methyl chloroform was completely phased out in the U.S. in 1996
         3. Developing countries phased out CFCs in 2005
      2. In the early 2000s, the first signs of recovery of the ozone layer were evident; the measurement of the rate of stratospheric ozone depletion was declining
6. Acid Deposition
   1. *Acid deposition* includes sulfuric and nitric acids in precipitation (*wet deposition*) as well as dry, sulfuric acid- and nitric acid-containing particles that settle out of the air (*dry deposition*)
   2. Measuring acidity
      1. An acidic solution has a pH less than 7 on the *pH scale*
      2. The pH scale is logarithmic
   3. How acid deposition develops
      1. Acid deposition occurs when sulfur dioxide and nitrogen oxides are released into the atmosphere, combine with moisture to form acids, and then are deposited on land through rain, snow, or condensate
      2. Acid deposition returns acids to the ground, causing the pH of surface waters and soil to decrease
   4. The effects of acid deposition
      1. It affects living and non-living things and corrodes metals and building materials
      2. Acid deposition and forest decline
         1. Many living trees exhibit symptoms of *forest decline*
         2. Forest decline appears to result from the combination of multiple stressors (i.e., acid deposition, tropospheric ozone, UV radiation, insect attack, drought, etc.)
   5. The politics of acid deposition
      1. It does not only occur in the locations where the gases that cause it are emitted; it does not recognize borders
      2. Pollution abatement issues are complex within one country but are magnified even more in international disputes
   6. Facilitating recovery from acid deposition
      1. Reducing emissions of sulfur dioxide and nitrogen oxides curbs acid deposition
      2. Recovery often takes decades or centuries due to altered soil chemistry
7. Air Pollution Around the World
   1. Environmental quality is usually a low priority in the race to develop
   2. Long-distance transport of air pollution
      1. Certain hazardous pollutants are distributed globally by atmospheric transport in a process known as the *global distillation effect*
         1. The air toxics involved in this effect are persistent compounds that do not readily break down and so accumulate in the environment (i.e., PCBs, DDT, etc.)
         2. The effect is more pronounced where it is colder, at higher latitudes and higher elevations
      2. Movement of air pollution over the ocean
8. Indoor Air Pollution
   1. The concentrations of certain indoor air pollutants may be two to five times greater (sometimes more than 100 times) than outdoors
      1. Examples include radon, cigarette smoke, carbon monoxide, nitrogen dioxide, formaldehyde, household pesticides, lead, cleaning solvents, ozone, and asbestos
      2. The EPA considers indoor air pollution as one of the top five environmental health risks in the U.S.
   2. Radon
      1. *Radon* is a serious indoor air pollutant in many places in highly developed countries
      2. It seep through the ground and enters building, where it can accumulate to dangerous levels
      3. It harms the human body only when it is ingested or inhaled