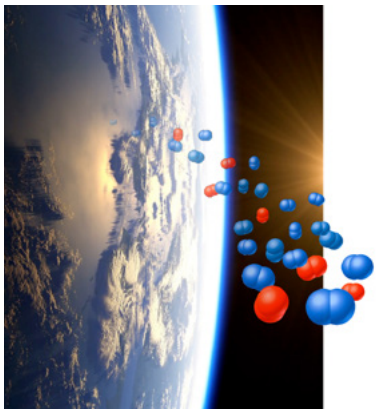
Chapter 16: Detailed Summary

Water and Air Resources



We live on a planet of water, but only about 0.66% of Earth's water is available to us as fresh water. This amount of water is made available to us by the hydrologic cycle, which is the sun-and gravity driven movement of water from the oceans, to the atmosphere, to the land, and back to the ocean. Water that seeps into the ground is called groundwater. A body of groundwater accessible to us is called an aquifer. In the United States, aquifers contain about 35 times the total volume of water in fresh water lakes, rivers, and streams combined. As groundwater is removed, the spaces between soil particles collapse and the ground surface is lowered—it subsides.

Each day the rate we consume water is about 20 percent the rate at which fresh water is replenished. This percentage, however, is only an average. In many drier regions of the western United States, water usage already exceeds the rate at which aquifers in the region are recharged. As a result, water tables are sinking. Water conservation measures, however, have shown that our overall rate of water consumption has remained about the same for the past decade despite a growing population. The bulk of this water savings has been the result of improved irrigation techniques and the retirement of older coal-fired power plants.

Point source pollution comes from a well-defined location, such as a wastewater treatment plant. Nonpoint source pollution originates at diverse locations, oil residue on streets being one example. When rivers and lakes become polluted, they can be cleaned because they are accessible. When groundwater becomes polluted, however, it can be a lifetime before contaminants are removed, not only because the groundwater is so inaccessible but also because the flow rate of many aquifers is extremely slow.

Aerobic bacteria decompose organic matter only in the presence of oxygen, O_2. Anaerobic bacteria can decompose organic matter in the absence of oxygen. The products of aerobic decomposition include odorless products such as carbon dioxide and water. Anaerobic decomposition, by contrast, results in many foul-smelling products such as hydrogen sulfide and gaseous amines. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen consumed by aerobic bacteria in water. As more organic matter is introduced, the BOD increases, resulting in a drop in the amount of dissolved oxygen. If too much organic matter is introduced, say through the outfall of sewage, dissolved oxygen levels can get so low that aquatic organisms start to die. Inorganic wastes, such as nitrates, added to lakes can serve as nutrients for algae, which may proliferate. The overgrowth, called eutrophication, also reduces the concentration of dissolved oxygen. An advanced integrated pond system is a method of treating sewage wastewater. This system works by allowing algae to proliferate in a series of wastewater containing ponds. The algae consumes the organic matter of the wastewater, which is actively stirred to prevent a build-up of algae at the surface.

The initial step to treating sewage at a wastewater treatment plant is to screen out most of the water insolubles. Screened wastewater is then sent to primary treatment, which involves allowing the wastewater to settle. Sludge is drained from the bottom of the basin and sent to a landfill. The wastewater effluent may undergo secondary treatment, which involves aerating the wastewater thus promoting aerobic decomposition of residual organic matter. Subsequent tertiary treatment may involve filtering the wastewater through a bed of finely powdered carbon. Most all wastewater is treated with disinfecting chlorine gas, Cl_2 or ozone, O_3, prior to being released into the environment.

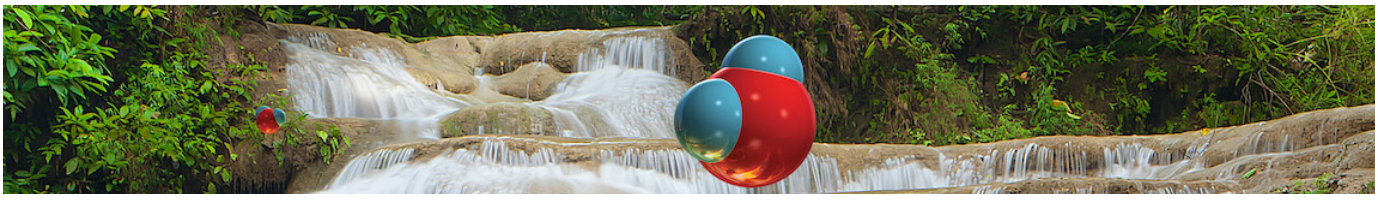
If it weren't for gravity, our gaseous air molecules would fly off into outer space. If it weren't for the energy they obtain from the Sun, these air molecules would lie on the surface of the planet in a solid phase. The combination of both Earth's gravity and the Sun's heat results in the atmosphere as we know it. As high as the sky may seem, in proportion to the size of our planet, the atmosphere is actually quite thin—about as thin as an apple skin is to an apple. The weight of this air, relative to us, however, is most significant. We experience the air's weight as atmospheric pressure. At sea level you are at the bottom of an ocean of air. Climb a mountain and you are no longer so deep in the air, which means that the atmospheric pressure on you becomes less.

The lowest layer of the atmosphere up to about 10 km is the troposphere. The troposphere contains about 90 percent of the atmosphere's mass and it is where weather occurs. Jets fly just above the troposphere for a smooth and fuel-efficient ride. Above the troposphere is the stratosphere, which is where the ozone layer is found.

To stem the human production of air pollutants, the United States passed the Clean Air Act in 1970. Since then, there have been a number of amendments added to make this act more comprehensive. An aerosol is a tiny airborne particle coated with a thin layer of water, which serves as the medium for a host of chemical reactions involving air pollutants. Larger solid particles, called particulates, tend to settle to the ground faster, but while airborne they, like aerosols, obscure visibility.

Industrial smog is produced largely from the combustion of coal and oil and is high in particulates. Its main chemical ingredient is sulfur dioxide, which within aerosols transforms into sulfuric acid. Photochemical smog consists of pollutants that participate in chemical reactions induced by sunlight. Upon exposure to sunlight, for example, nitrogen dioxide transforms into nitric acid. The function of a car's catalytic converter is primarily to reduce the output of photochemical smog.

Another atmospheric problem created by humans is global warming. Carbon dioxide in the atmosphere allows visible solar radiation from the Sun to pass through to Earth. This solar energy is transformed into infrared radiation, which the carbon dioxide prevents from escaping back into outer space. This greenhouse effect is a natural phenomenon and without it Earth's average temperature would be a chilly –18°C. As we pump more carbon dioxide into the atmosphere we enhance the greenhouse effect, which, in turn, makes the temperature on Earth's surface that much warmer. How much warmer is the subject of much research.



Summary of Terms

Aerobic Bacteria Bacteria able to decompose organic matter only in the presence of oxygen.

Aerosol A moisture-coated microscopic airborne particle up to 0.01 millimeter in diameter that is a site for many atmospheric chemical reactions.

Anaerobic Bacteria Bacteria able to decompose organic matter in the absence of oxygen.

Aquifer A soil layer in which groundwater may flow.

Atmospheric Pressure The pressure exerted on any object immersed in the atmosphere.

Biochemical Oxygen Demand A measure of the amount of oxygen consumed by aerobic bacteria in water.

Eutrophication The process whereby inorganic wastes in water fertilize algae and plants growing in the water and the resulting overgrowth reduces the dissolved oxygen concentration of the water.

Greenhouse Effect The process by which visible light from the sun is absorbed by the Earth, which then emits infrared energy that cannot escape and so warms the atmosphere.

Hydrologic Cycle The natural circulation of water throughout our planet.

Industrial Smog Visible airborne pollution containing large amounts of particulates and sulfur dioxide and produced largely from the combustion of coal and oil.

Leachate A solution formed by water that has percolated through a solid-waste disposal site and picked up water-soluble substances.

Nonpoint Source A pollution source in which the pollutants originate at different and often nonspecific locations.

Particulate An airborne particle having a diameter greater than 0.01 millimeter.

Point Source A specific, well-defined location where pollutants enter a body of water.

Photochemical Smog Airborne pollution consisting of pollutants that participate in chemical reactions induced by sunlight.

Stratosphere The atmospheric layer that lies just above the troposphere and contains the ozone layer.

Troposphere The atmospheric layer closest to the Earth's surface, containing 90 percent of the atmosphere's mass and essentially all water vapor and clouds.

Water Table The upper boundary of a soil's zone of saturation, which is the area where every space between soil particles is filled with water.