The Biology of Water

The Biology of water include the pathogens like bacteria, virus, protozoa and helminthes.
Water is a carrier of thousands of biological species. Many of the species spend either their full life or part of it in aquatic environment. A healthy water system should be a host too large number of species of optimum numbers. Certain organisms due to their adverse effect on humans and plant and animal life are considered to be pollutants.

Pathogens are those organisms capable of infecting and transmitting diseases to human beings. Many pathogen species survive in water and maintain their ability to infect for considerable lengths of time. The water borne pathogens include species like bacteria, viruses, protozoa and helminthes.

Bacteria are single cell microorganisms and are the lowest form of cell life. Gastrointestinal problems are mainly due to water borne pathogenic bacteria. Cholera transmitted by *Vibrio cholera* causes vomiting and diarrhea, which can result in dehydration, and death if left untreated.

Salmonella typhi transmits typhoid, which leads to high fever and ulceration of intestines.
Disinfection of water are the only ways to eliminate cholera and typhoid. However in over crowded and poor sanitary conditions, water pollution by these bacteria result in the outbreak of these diseases.

Viruses are small biological organisms, which can be seen only with the aid of an electron microscope. Water borne viral pathogens causes poliomyelitis and infectious hepatitis. Immunization of individuals and disinfection of water will reduce the incidence of polio and hepatitis.

Protozoa are low form of animal life and are unicellular organisms. They are highly complex and are adaptable to different environment. They are widely distributed in natural waters. Protozoal infections result in gastrointestinal disorders of milder nature. *Entamoeba histolytica* and *Giardia lamblia* are examples of water borne protozoa causing gastrointestinal disorders. Disinfection and filtration are necessary for complete elimination of protozoa.

Helminthes are parasitic worms, which thrive on human or animal hosts. Consumption of water contaminated with human or animal waste containing helminthes propagates them. Helminthes are effectively destroyed by modern water treatment processes.

Physics, Chemistry and Biology of Air

Ions

At an altitude of 50 km to 100 kms considerable concentrations of electrons and positive ions such as O+, NO+ etc. exist for reasonably longer residence times. This zone of the atmosphere is called ionosphere. The UV radiations from the sun lead to the formation of ions in the ionosphere.

Particulate matter

Particles of wide range of sizes ranging from 0.1 μ to 10μ exist in the atmosphere. Highly polluted air may contain up to 105 particles per cc.

Dust, fog, ash, mist, smoke, pollen, fumes and bacteria contribute to the presence of particulate matter. Particulate matter may be either organic or inorganic in nature. Inorganic particulates are volcanic ash, fine silica dust, iron oxide, and calcium oxide, Lead etc. Organic particulates are generated from automobile exacts, fuel combustion, and solid organic matter.

Particular matter may be generated either by natural means (Volcanic eruption, wild fires, dust storms etc.) or by anthropogenic means (Automobile exhaust, fossil fuel burning, mining and quarrying and various other industrial activities).
Particulate matter is a health hazard since they enter the human beings and animals through the respiratory tract and are absorbed by them. Removal of particulate matter from the atmosphere is a very important function in air pollution control. However the particulate matter also leads to certain beneficial effects. They provide the nuclei for condensation of water vapor and cloud formation. They also contribute to maintaining a radiation and heat balance on earth.

Chemical reaction in Atmosphere

The different chemical species available in the environment undergo chemical changes by reaction with other molecules. The chemical reactions are also assisted by the solar radiation. The chemical and photochemical reactions taking place in the atmosphere depend up on the temperature, nature and concentration of the chemical species available, humidity, and intensity of sun's radiation.
The **oxides of nitrogen** (Referred to as NO*x*) viz. N2O, NO and NO2 originate from burning of fossil fuels and other anthropogenic activities. In the stratosphere, N2O decomposes photo chemically to NO which intern depletes ozone layer.

Photochemical smog can also be initiated by the dissociation of NO2 and subsequent secondary reactions with hydrocarbons and other organic compounds. The stepwise chemistry of the formation of photochemical smog is illustrated below:

(1) Nitrogen oxides generate oxygen atoms by photochemical reaction.

$$NO_2 + h \longrightarrow NO + O^*$$

(2) Oxygen atoms form hydroxyl (HO*) radicals catalyzed by particulate matter (PM)

$$O^* + O_2 + PM \longrightarrow O_3 + PM$$

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$O^* + H_2O \longrightarrow 2HO^*$$

(3) Hydroxyl radicals generate hydrocarbon radicals (R*) from hydrocarbons (RH)

$$RH + HO^* \longrightarrow H_2O + R^*$$

(4) Hydrocarbon radicals form hydrocarbon peroxides (RO)

$$R^* + O_2 \longrightarrow RO_2$$

(5) Hydrocarbon peroxides form aldehydes

$$RO_2{}^* + NO \longrightarrow NO_2 + RO^*$$

$$RO^* + O_2 \longrightarrow RCHO + HO_2{}^*$$

(6) Aldehydes form aldehyde peroxides

$$RCHO + HO^* \longrightarrow RCO^* + H_2O$$

$$RCO^* + O_2 \longrightarrow RC(O)O_2{}^*$$

(7) Aldehyde peroxides form peroxyacylnitrates (PAN)

$$RCOO^* + NO_2 \longrightarrow RCOONO_2 \text{ (PAN)}$$

Photochemical smog results in very poor visibility leading to disruption/accidents in air and road traffic. It also causes irritation to the eyes and lungs and chronic respiratory problems. Damage to plants and rubber, polymer goods are also the adverse impacts of photochemical smog.

Ozone is an important constituent in the atmosphere. At an altitude of 30 kms. This stratospheric ozone layer absorbs UV radiation from the sun and hence protects the life on earth against radiation damages like skin cancer, mutation of DNA etc.

The chemistry of ozone formation and depletion is as under:

$$O_2 + h \longrightarrow O + O$$

$$O + O_2 \longrightarrow O_3$$

This reaction is catalyzed by a third body viz. N_2 or O_2. Thus ozone is continuously formed in the stratosphere by photochemical reaction. Ozone is also destroyed by chlorine released in

To the atmosphere by natural (volcanic activity) or anthropogenic (Refrigerants containing Chloro Flouro Carbons) causes. Nitric Oxide and reactive hydroxyl radicals also contribute to ozone depletion.

$$Cl + O_3 \longrightarrow ClO + O_2$$
$$ClO + O \longrightarrow Cl + O_2$$
$$O_3 + NO \longrightarrow NO_2 + O_2$$
$$O_3 + O \longrightarrow 2O_2$$

The overall ozone depletion reaction is $2O_3 \longrightarrow 3O_2$

Biological Air Quality

In addition to the chemical constituents, biological microorganisms are also present in the atmosphere. These microorganisms are dispersed in air as **bioaerosols**, which are extremely small living organisms or fragments of living things suspended in the air. Dust mites, molds, fungi, spores, pollen, bacteria, viruses, amoebas, fragments of plant materials, and human and pet dander (skin which has been shed) are some examples. They cannot be seen without a magnifying glass or microscope. Some of the adverse impacts caused by these bioaerosols are listed below:

Viruses and bacteria, cause infections (like a cold or pneumonia). Others cause allergies. Both allergic responses and infections may be serious or even fatal. An allergic reaction occurs when a substance provokes formation of antibodies in a susceptible person. We call substances, which will cause an allergic reaction in some people *antigens* or *allergens.* Bioaerosols may cause allergic reactions on the skin or in the respiratory tract. Rashes, hay fever, asthma (tightness in the chest, difficulty in breathing), and runny noses are common allergic reactions.
A few people develop a severe allergic reaction in the lung, which can destroy lung tissue.