Dissolved Oxygen

B. Sc. Part-I, Practical, Lecture-I

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. In limnology (the study of lakes), dissolved oxygen is an essential factor second only to water itself. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality.

Non-compound oxygen, or free oxygen (O_2), is oxygen that is not bonded to any other element. Dissolved oxygen is the presence of these free O_2 molecules within water. The bonded oxygen molecule in water (H_2O) is in a compound and does not count toward dissolved oxygen levels. One can imagine that free oxygen molecules dissolve in water much the way salt or sugar does when it is stirred.

Dissolved oxygen is important to many forms of aquatic life. Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. These organisms use oxygen in respiration, similar to organisms on land. Fish and crustaceans obtain oxygen for respiration through their gills, while plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. The amount of dissolved oxygen needed varies in different organism. Bottom feeders, crabs, oysters and worms need minimal amounts of oxygen (1-6 mg/L), while shallow water fish need higher levels (4-15 mg/L).

Microbes such as bacteria and fungi also require dissolved oxygen. These organisms use DO to decompose organic material at the bottom of a body of water. Microbial decomposition is an important contributor to nutrient recycling. However, if there is an excess of decaying organic material (from dying algae and other organisms), in a body of water with infrequent or no turnover (also known as stratification), the oxygen at lower water levels will get used up quicker.

Source of DO

How dissolved oxygen enters water

Dissolved oxygen enters water through the air or as a plant by-product. From the air, oxygen can slowly diffuse across the water's surface from the surrounding atmosphere, or be mixed in quickly through aeration, whether natural or man-made. The aeration of water can be caused by wind (creating waves), rapids, waterfalls, ground water discharge or other forms or other forms of running water.

Dissolved oxygen is also produced as a waste product of photosynthesis from phytoplankton, algae, seaweed and other aquatic plants.

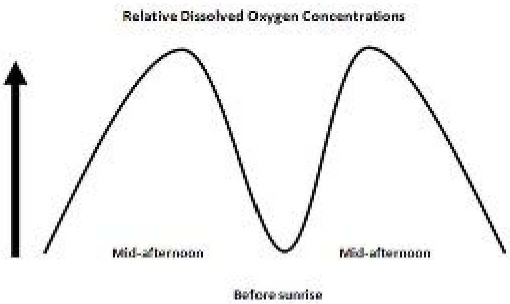
Factors Affecting Dissolved Oxygen Concentrations in Water

Abiotic Factors

The amount of oxygen that can be dissolved in water depends on several factors, including water temperature, the amount of dissolved salts present in the water (salinity), and atmospheric pressure. On a relative scale, the amount of oxygen dissolved in saturated water will be greater in cooler waters than in warmer ones. Higher water temperatures result in increased molecular vibrations, essentially reducing the amount of space available between water molecules. The capacity of water to hold DO also decreases as the salinity increases. This results from more effective competition of the salts for intermolecular spaces due to their ionic charges. Altitude also affects the amount of DO in water due to differing densities of O_2 available for dissolution. Because atmospheric O_2 is less dense at higher altitudes, saturation DO concentrations will be lower than in water at sea level where atmospheric O_2 is denser.

Biotic Factors

Aquatic plants and algae also contribute dissolved oxygen to water bodies during daylight hours through photosynthesis. The first step of photosynthesis splits two water molecules (H_2O) into two hydrogen (H_2) molecules and one oxygen (O_2) molecule; the O_2 is released into the water for underwater photosynthetic organisms. While this does represent O_2 input into the water, the net effect on DO concentrations is usually very small or neutral because comparable amounts of DO are consumed by these same organisms at night through respiration, when photosynthesis is not actively occurring. Aerobic respiration consumes oxygen to extract energy from energy-rich carbon compounds needed for sustaining life, ultimately oxidizing the carbon-to-carbon dioxide (CO_2) and reducing the O_2 to H_2O. Thus, dissolved oxygen concentrations will typically be highest in the mid-to-late afternoon when photosynthesis rates are greatest, and will reach the lowest concentrations just before the sun rises the next morning due to respiration needs. This fluctuation pattern is referred to as the "diurnal oxygen cycle".



Dissolved oxygen concentrations are lowest just before the sun rises and highest when photosynthesis rates are the greatest (i.e., when the sun is closest to the photosynthesizing organisms). Credit: Chris Wilson, UF/IFAS

In addition to the respiration needs of photosynthetic organisms during darkness, oxygen within the system is also consumed through aerobic respiration by other organisms, including aquatic vertebrates and invertebrates and bacterial and fungal communities involved in degrading dead plants and animals. Biological Oxygen Demand (BOD) is a measure of the potential for DO within a water body to become depleted and possibly become anaerobic due to the biodegradation of organic matter by microbial organisms.