Dissolved Oxygen

(From the Alliance for the Chesapeake Bay's *RiverTrends* Manual)

Dissolved oxygen (DO) is one of the most important indicators of the quality of water for aquatic life. It is essential for all plants and animals. Oxygen availability throughout the year is influenced by other chemicals present in the water, biological processes, and temperature.

A dissolved oxygen test measures the amount of oxygen dissolved in the water. A dissolved oxygen measurement, however, does not measure the amount of dissolved oxygen the water is capable of holding at the temperature at which it was tested. Warmer water is capable of holding less dissolved oxygen than colder water. When water holds the entire DO it can hold at a given temperature, it is said to be 100 percent saturated with oxygen. If water holds half as much oxygen as it can hold at a given temperature, it is 50 percent saturated.

Most living organisms require oxygen for their basic metabolic processes. Since the existence of plants also depends on the availability of light, the oxygen-producing processes occur only near the surface or in shallow waters. Photosynthesis of aquatic plants releases oxygen into the water. Oxygen is also dissolved in water through diffusion and surface turbulence. Oxygen is poorly soluble in water, roughly 10 parts per million (ppm) at 0-2 ºC compared to almost 1700 ppm for carbon dioxide at the same temperature. When oxygen levels in the water fall below 3-5 ppm, most fish and marine organisms are stressed and cannot survive.

In general, oxygen levels during mid-day at the surface are near saturation (the maximum level sustained at the temperature) and drop as the water depth increases. Dissolved oxygen levels are an indicator of water quality. Oxygen levels may be reduced because of warm water temperatures and poor flushing. Run-off from farms or lawns containing fertilizers and other nutrients can over-fertilize aquatic plants. At first, aquatic vegetation will flourish and raise the dissolved oxygen levels found in the water. As the plants begin to die, the process of decomposition will deplete the oxygen content of the water. Eutrophication is the term used when high nutrient levels cause an excess of phytoplankton.

pH

(From the Alliance for the Chesapeake Bay's *RiverTrends* Manual)

pH is a measure of how acidic or basic (alkaline) a solution is. In any given solution, some atoms of water dissociate to form hydrogen ions (H+) and hydroxyl ions (OH-). The pH scale is a means of showing which ion has the greater concentration. At a pH of 7.0, the concentrations of hydrogen ions and hydroxyl ions are equal, and the water is said to be neutral. Pure water has a pH of 7.0. When the pH is less than 7.0, there are more hydrogen ions than hydroxyl ions, and the water is said to be acidic. When the pH is greater than 7.0, there are more hydroxyl ions than hydrogen ions, and the water is said to be basic or alkaline.

pH is defined as the negative logarithm of the hydrogen ion concentration. This means that the concentration of hydrogen ions does not increase or decrease in a linear fashion; that is, a pH of 3 is not just twice as acid as a pH of 6. Increases are in powers of 10. At pH of 5, there are 10 times more hydrogen ions than at a pH of 6. A change in pH of one whole number is therefore quite a large change.

Water dissolves mineral substances it contacts, picks up aerosols and dust from the air, receives man-made wastes, and supports photosynthetic organisms. All these processes affect pH. The buffering capacity of water, or its ability to resist pH change, is critical to aquatic life, as it determines the range of pH. Generally, the ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes as high as 9.0 or as low as 5.0. Photosynthesis by aquatic plants removes carbon dioxide from the water, which can significantly increase pH. Therefore, in waters with plant life (including planktonic algae), especially low-velocity or still waters, an increase in pH can be expected during the growing season. During the 1983 algal bloom in the Potomac River estuary, a pH of 10.0 was recorded.

The turbulence of flowing water promotes gaseous interchange between the atmosphere and water. The carbon dioxide content of water in rivers and streams is less likely to change; but activities in the watershed may affect pH. Increased leaching of soils or mineral outcrops during snowmelt or heavy precipitation affects pH downstream. Human activities such as accidental spills, agricultural runoff (pesticides, fertilizers, soil leachates), and sewer overflow may also change pH.

Temperature

(From the Alliance for the Chesapeake Bay's *RiverTrends* Manual)

Although water temperature may be one of the easiest measurements to perform, it is probably one of the most important parameters to be considered. It dramatically affects the rates of chemical and biochemical reaction within the water. Many biological, physical, and chemical principles are temperature-dependent. The most common of are: the solubility of compounds in sea water; distribution and abundance of organisms living in the watershed; rates of chemical reactions; water density; inversions and mixing; and current movements.

Temperature affects feeding, reproduction, and metabolism of aquatic animals; even a week or two of high temperatures may make streams and other shallow water unsuitable for sensitive aquatic organisms, even though temperatures are within tolerable levels throughout the rest of the year. Not only do different species have different requirements, but optimum habitat temperatures may change depending on the stage of life. Fish larvae and eggs usually have narrower temperature requirements than do adult fish.

Causes of temperature change include: weather changes, removal of stream bank vegetation that provides shade; construction of dams and other impoundments; discharge of heated water from industry; urban storm water; and groundwater flows to streams.

Water Clarity

(From the Alliance for the Chesapeake Bay's *RiverTrends* Manual)

Material that becomes mixed and suspended in water will reduce its clarity and make the water *turbid (*dirty). In summer, plankton are growing and multiplying rapidly in the warm, nutrient-rich water. During periods of heavy rain, run-off from land can carry large amounts of silt into streams. Silt is often related to nutrient enrichment of a river because nutrients such as phosphorus cling to soil particles. Fine sediment can become re-suspended in more shallow waters during heavy winds and tidal action. In addition, unprotected shoreline will erode and contribute suspended particles to the water. In shallow areas, wind-generated waves and boat wakes stir up sediments. Wind and boat generated waves breaking on shore also contribute to turbidity.

Turbidity affects fish and aquatic life in the following ways:

- Suspended materials interfere with the penetration of sunlight. Submerged aquatic vegetation (SAV) needs light for photosynthesis. If suspended particles "block out" light, photosynthesis, which produces oxygen for fish and aquatic life, will be reduced. SAV provides essential food, nursery areas, shelter and habitat for diverse communities of shellfish, waterfowl and fish. If light levels become too low, photosynthesis may stop altogether and algae will die.

- Sediment buries eggs and benthic (bottom dwelling) organisms' habitat.

- Large amounts of suspended matter may clog the gills of fish and shellfish and kill them directly.

- Fish cannot see very well in turbid water and so may have difficulty finding food.