WATER QUALITY INDICATORS

Water quality data are used to describe the condition of a body of water, to help understand why that condition exists, and to provide some clues as to how it may be improved. Water quality indicators include physical, chemical, and biological measurements.

MACROINVERTEBRATE COMMUNITY

Aquatic macroinvertebrates are found in lakes, streams, ponds, marshes and puddles and help maintain the health of the water ecosystem by eating bacteria and dead, decaying plants and animals. Overall water quality effects which types of organisms can survive in a body of water. "Water quality" may include the amounts of dissolved oxygen and the levels of algal growth, pollutants which may be present and the pH level. Some macroinvertebrates such as stoneflies, mayflies and water boatmen require a high level of dissolved oxygen and their abundance is an indication of good water quality.

Other macroinvertebrates can survive at a lower dissolved oxygen level because they can come to the surface to get oxygen through a breathing or "snorkel" tube or carry a bubble of air with them around their bodies or under their wings. Several species of macroinvertebrates are indicative of water systems with lower dissolved oxygen levels and include aquatic worms and leeches. Lower dissolved oxygen levels are often associated with polluted waters while higher levels indicate good quality water.
There are several reasons why macroinvertebrates are used as water quality indicators:

- They are sensitive to changes in the ecosystem.
- Many live in an aquatic ecosystem for over a year.
- They cannot easily escape changes in the water quality.
- They can be collected very easily from most aquatic systems with inexpensive or homemade equipment.

DISSOLVED OXYGEN

Oxygen is essential for the survival and reproduction of aquatic organisms. If the amount of oxygen dissolved in the water falls below the minimum requirements for survival, aquatic organisms or their eggs and larvae may die. A severe example is a fish kill where all the fish in an area die. Dissolved oxygen (DO) varies greatly due to natural phenomena, resulting in daily and seasonal cycles. Different forms of pollution also can cause declines in DO. Eutrophication of lakes occurs when fertilizers allow excessive plant life to occur, followed by a cycle of dying plants and animals that deplete oxygen as they decay.

Changes in DO levels can result from temperature changes or the activity of plants and other organisms present in the water. The natural daily cycle of DO concentration is well documented. Dissolved oxygen concentrations are generally lowest in the morning, climbing throughout the day due to photosynthesis and peaking near dusk, then steadily declining during the hours of darkness.

There is also a seasonal DO cycle in which concentrations are greater in the colder, winter months and lower in the warmer, summer months. Stream flow (in freshwater) is generally lower during the summer and fall, which reduces the amount of dissolved oxygen.

PH

pH is a measure used to indicate degree of acidity of a water solution. The pH scale ranges from 0 to 14. A pH of 7 is considered neutral, with values less than 7 being acidic, and values greater than 7 being basic. Low pH values are found in natural waters rich in dissolved organic matter. The tannic acid released from the decomposition of vegetation causes the tea coloration of the water and low pH. High pH values in lakes during warmer months are associated with high plant densities. The relationship between photosynthesis and daily pH cycles is well established. Photosynthesis consumes carbon dioxide during the day, which results in a rise in pH. In the dark, phytoplankton respiration releases carbon dioxide which forms a weak acid in the water.

In productive lakes, carbon dioxide decreases to very low levels, causing the pH to rise to 9-10 SU. Continuous flushing in streams prevents the development of significant phytoplankton populations and the resultant chemical changes in water quality. A range of potential water quality problems such as mining and farming runoff can cause changes to pH. Extremes of pH (less than 6.5 or greater than 9) can be toxic to aquatic organisms.

FECAL COLIFORM BACTERIA

Coliform bacteria are present in the digestive tract and feces of all warm-blooded animals, including humans, poultry, livestock, and wild animal species. Fecal coliform bacteria are themselves generally not harmful, but their presence indicates that surface waters may contain more dangerous microbes. Diseases that can be transmitted to humans through water contaminated by improperly treated human or animal waste are the primary concern. At present, it is difficult to distinguish between waters contaminated by animal waste and those contaminated by human waste.

Public health studies have established correlations between fecal coliform numbers in recreational and drinking waters and the risk of adverse health effects. Based on these relationships, enforceable standards have been established for surface waters to protect against adverse health effects from various recreational or drinking water uses. Proper waste disposal or sewage treatment prior to discharge to surface waters minimizes this type of pollution. Restricting pets from the area may also be necessary to protect the water.

NUTRIENTS

Plant nutrients are common substances discharged to the environment by man's activities, through wastewater facilities and by agricultural, residential, and storm water runoff. The most important plant nutrients, in terms of water quality, are phosphorus and nitrogen. In general, increasing nutrient concentrations is undesirable due to the potential for accelerated growth of aquatic plants, including algae. Nuisance plant growth can create imbalances in the aquatic community, which create unpleasant conditions for human use. High densities of phytoplankton (algae) can cause wide fluctuations in pH and dissolved oxygen.

Nitrogen is a nutrient necessary for growth of all living organisms. In excessive amounts, nitrates in water cause an increase in algae growth. Algae can rob the water of dissolved oxygen and eventually can kill fish and other aquatic life. Sources of nitrates may include human and animal wastes, industrial pollutants and nonpoint-source runoff from heavily fertilized croplands and lawns. Under certain conditions high levels of nitrates (10 mg/L or more) in drinking water can be toxic to humans. High levels of nitrates in drinking water have been linked to serious illness and even death in infants.

WATER CLARITY

Small particles (soil, plankton, organic debris) become suspended in water. High concentrations of suspended solids limit light penetration through water, and cause a build up of silt on the bottom of the environment. Two methods can measure water clarity.

Turbidity is a measure of light scattering by suspended particles in the water column, provides measure of how far light can penetrate the water. The presence of clay, silt, fine organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms increases turbidity. Increasing turbidity can be an indication of increased runoff from land. It is an important consideration for drinking water as finished water has turbidity limits. State water quality standards address turbidity in waters classified for Trout. Trout require clear water with little suspended solid material. Turbidity is measured by comparing the visibility of an object through clear water compared to cloudy water.

Total Suspended Solids (TSS) are the suspended organic and inorganic particulate matter in water. Although increasing TSS can also be an indication of increased runoff from land, TSS differs from turbidity in that it is a measure of the mass of material suspended in, rather than light transmittance through, a water sample. To measure TSS, a sample of water is allowed to dry and the mass of the remaining sediments is measured. High TSS can adversely impact fish and fish food populations and damage invertebrate populations.

HEAVY METALS

Concentrations of cadmium, chromium, copper, lead, mercury, and nickel in water are routinely measured by the Department to compare to State standards intended to protect aquatic life and human health. These metals occur naturally in the environment, and many are essential trace elements for plants and animals. Human activities, such as land use changes and industrial and agricultural processes, have resulted in an increased flux of metals from land to water. Metals are released to the atmosphere from the burning of fossil fuels (coal, oil, gasoline), wastes (medical, industrial, municipal), and organic materials. The metals are then deposited on land and in waterways from the atmosphere via rainfall and attached to particulates.

Industrial and mining wastes are major sources of heavy metals, and aquatic environments are extremely sensitive to even the smallest concentrations of these materials. Serious abnormalities have been reported in many aquatic organisms. Arsenic and mercury are two common examples of heavy metals, but other similar substances and compounds can also have significant effects on an aquatic community. Persons eating fish from contaminated waterways risk health problems.

Water temperature
Aquatic organisms are dependent on certain temperature ranges for optimal health. Temperature affects many other parameters in water, including the amount of dissolved oxygen available, the types of plants and animals present, and the susceptibility of organisms to parasites, pollution and disease. Causes of temperature changes in the water include weather conditions, shade and discharges into the water from urban sources or groundwater. Temperature is measured in degrees Celsius (°C). Seasonal trends in water temperature are natural and aquatic organisms are adapted to them. Human caused fluctuations are more difficult for these organisms to adapt to.

Salinity

Salinity is a measure of the amount of salt and other dissolved solids in water. The salinity of seawater in the open ocean is remarkably constant at about 35 parts per thousand (ppt). Freshwater contains a small amount of salinity and most organisms are adapted to a narrow range of salt concentration. An exception is the salmon, whose life is spent in both fresh and sea water.

Salinity is also important because it affects chemical conditions, particularly dissolved oxygen levels. The amount of dissolved oxygen (solubility) decreases with increasing salinity. The solubility of oxygen in seawater is about 20 percent less than in freshwater of the same temperature.