Acidity

Acidity of water is its quantitative capacity to react with a strong base to a designated pH. Acidity is a measure of an aggregate property of water and can be interpreted in terms of specific substances only when the chemical composition of the sample is known (19th Edition, Standard Methods, 1995)

Alkalinity

The Alkalinity or the buffering capacity of a stream refers to how well it can neutralize acidic pollution and resist changes in pH. Alkalinity measures the amount of alkaline compounds in the water, such as carbonates, bicarbonates and hydroxides. These compounds are natural buffers that can remove excess hydrogen, or H+, ions (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

BOD

The Biological Oxygen Demand, or BOD, is the amount of oxygen consumed by bacteria in the decomposition of organic material. It also includes the oxygen required for the oxidation of various chemical in the water, such as sulfides, ferrous iron and ammonia. While a dissolved oxygen test tells you how much oxygen is available, a BOD test tells you how much oxygen is being consumed.

BOD is determined by measuring the dissolved oxygen level in a freshly collected sample and comparing it to the dissolved oxygen level in a sample that was collected at the same time but incubated under specific conditions for a certain number of days. The difference in the oxygen readings between the two samples in the BOD is recorded in units of mg/L.

Unpolluted, natural waters should have a BOD of 5 mg/L or less. Raw sewage may have BOD levels ranging from 150 – 300 mg/L (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

CBOD

Carbonaceous biochemical oxygen demand, or CBOD, measures the amount of demand that is oxidized by carbon. CBOD is a fraction of the BOD that excludes the nitrogenous oxygen demand by the addition of nitrogen inhibitors during the analysis (19th Edition, Standard Methods, 1995).

COD

The chemical oxygen demand, or COD, is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. For samples from a specific source, COD can be related empirically to BOD, organic carbon, or organic matter. The test is useful for monitoring and control after correlation has been established.

Oxidation of most organic compounds is 95 to 100 percent of the theoretical value. Ammonia, present either in the waste or liberated from nitrogen-containing organic matter, is not oxidized in the absence of significant concentration of free chloride ions (19th Edition, Standard Methods, 1995).

Conductivity

Conductivity is a measure of how well water can pass an electrical current. It is an indirect measure of the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron and aluminum. The presence of these substances increases the conductivity of a body of water. Organic substances like oil, alcohol, and sugar do not conduct electricity very well, and thus have a low conductivity in water.

Inorganic dissolved solids are essential ingredients for aquatic life. They regulate the flow of water in and out of organisms' cells and are building blocks of the molecules necessary for life. A high concentration of dissolved solids, however, can cause water balance problems for aquatic organisms and decrease dissolved oxygen levels (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Dissolved Oxygen

The amount of Dissolved Oxygen, or DO, in water is expressed as a concentration. A concentration is the amount of in weight of a particular substance per a given volume of liquid. The DO concentration in a stream is the mass of the oxygen gas present, in milligrams per liter of water. Milligrams per liter, or mg/L, can also be expressed as parts per million, or ppm.

The concentration of dissolved oxygen in a stream is affected by many factors:

Temperature: Oxygen is more easily dissolved in cold water.

Flow: Oxygen concentrations vary with the volume and velocity of water flowing in a stream. Faster flowing white water areas tend to be more oxygen rich because more oxygen enters the water from the atmosphere in those areas than in slower, stagnant areas.

Aquatic Plants: The presence of aquatic plants in a stream affects the dissolved oxygen concentration. Green plants release oxygen into the water during photosynthesis. Photosynthesis occurs during the day when the sun is out and ceases at night. Thus in streams with significant populations of algae and other aquatic plants, the dissolved oxygen concentration may fluctuated daily, reaching its highest levels in the late afternoon. Because plants, like animals, also take in oxygen, dissolved oxygen levels may drop significantly by early morning.

Altitude: Oxygen in more easily dissolved into water at low altitudes that at high altitudes.

Dissolved or suspended solids: Oxygen is also more easily dissolved into water with low levels of dissolved or suspended solids.

Human Activities Affecting DO:

Removal of riparian vegetation may lower oxygen concentrations due to increased water temperature resulting from a lack of canopy shade and increased suspended solids resulting from erosion of bare soil.

Typical urban human activities may lower oxygen concentrations. Runoff from impervious surfaces bearing salts, sediments and other pollutants increases the amount of suspended and dissolved solids in stream water.

Organic wastes and other nutrient inputs from sewage and industrial discharges, septic tanks and agricultural and urban runoff can result in decreased oxygen levels. Nutrient input often lead to excessive algal growth. When the algae die, the organic matter is decomposed by bacteria. Bacterial decomposition consumes a great deal of oxygen.

Dams may pose an oxygen supply problem when they release waters from the bottom of their reservoirs into streams and rivers. Although the water on the bottom is cooler than the warm water on top, it may be low in oxygen if large amounts of organic matter has fallen to the bottom and has been decomposed by bacteria.

Usually streams with high dissolved oxygen concentrations (greater than 8 mg/L for Ozark streams) are considered healthy streams. They are able to support a greater diversity of aquatic organisms. They are typified by cold, clear water, with enough riffles to provide sufficient mixing of atmospheric oxygen into the water.

In streams that have been impacted by any of the above factors, summer is usually the most crucial time for dissolved oxygen levels because stream flows tend to lessen and water temperatures tend to increase.

In general, DO levels less than 3 mg/L are stressful to most aquatic organisms. Most fish die at 1-2 mg/L. However, fish can move away from low DO areas. Water with low DO from 2 – 0.5 mg/L are considered hypoxic; waters with less than 0.5 mg/L are anoxic.

Because the temperature of the stream can vary daily, and even hourly, it is important to factor out the effect of temperature when analyzing the DO levels in a sample of water. This is achieved by considering the saturation value. Saturation is the maximum level of DO that would be present in the water at a specific temperature, in the absence of other influences. Once you know the temperature of the water in your stream you can use an oxygen saturation table to determine the maximum DO concentration. You can calculate the percent saturation by comparing the maximum saturation value (provided in the table) with your actual measured DO result. Simply divide your measured DO result by the maximum saturation value.

For example, if your stream temperature is 8 degrees C, your maximum saturation value would be 11.83 mg/L. If your DO reading was 8.5 mg/L, your percent saturation would be 8.50/11.83=71.9 percent. Since a healthy stream is considered to be 90-100 percent saturated, your sample indicates that something else besides temperature is affecting oxygen levels adversely (examples: suspended or dissolved solids, or bacteria decomposition). (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Fecal Coliform

Human and animal wastes carried to stream systems are sources of pathogenic or disease-causing, bacteria and viruses. The disease causing organisms are accompanied by other common types of nonpathogenic bacteria found in animal intestines, such as fecal coliform bacteria, enterococci bacteria, and escherichia coli, or E. coli bacteria.

Fecal coliform, enterococci, and E. coli bacteria are not usually disease-causing agents themselves. However, high concentrations suggest the presence of disease-causing organisms. Fecal coliform, enterococci, and E. coli bacteria are used as indicator organisms; they indicated the probability of finding pathogenic organisms in a stream.

To measure indicator bacteria, water samples must be collected in sterilized containers. The samples are forced through a filter and incubated at a specific temperature for a certain amount of time. The resulting colonies that form during incubation are counted and recorded as the number of colony producing units per 100 mL of water (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Hardness

Hardness is frequently used as an assessment of the quality of water supplies. The hardness of a water is governed by the content of calcium and magnesium salts (temporary hardness), largely combined with bicarbonate and carbonate and with sulfates, chlorides, and other anions of mineral acids (permanent hardness) (Limnology, Wetzel, 1983) .

Metals

The effects of metals in water and wastewater range from beneficial through troublesome to dangerously toxic. Some metals are essential, others may adversely affect water consumers, wastewater treatment systems, and receiving waters. Some metals may be either beneficial or toxic, depending on concentration (19th Edition, Standard Methods, 1995). .

The primary mechanism for toxicity to organisms that live in the water column is by absorption to or uptake across the gills: this physiological process requires metal to be in a dissolved form. This is not to say that particulate metal is nontoxic, only that particulate metal appears to exhibit substantially less toxicity than does dissolved metal (U.S. EPA).

Dissolved: Those metals of an unacidified sample that pass through a 0.45 micrometer membrane filter and is thought to better represent the bioavailable fraction of metal in the water column than does total recoverable metal

Recoverable: Those metals that are not tightly bound and are biologically available to aquatic organisms

Total: Includes all metals, inorganically and organically bound, both dissolved and particulate. Will give a unrealistic high value of those metals that are biological available to aquatic organisms.

Not all metals are acutely toxic in small concentrations. The "heavy metals" include copper, or Cu, iron, or Fe, cadmium, or Cd, zinc, or Zn, mercury, or Hg, and lead, or Pb, and are the most toxic to aquatic organisms. Some water quality characteristics which affect metal toxicity include temperature, pH, hardness, alkalinity, suspended solids, redox potential and dissolved organic carbon. Metals can bind to many organic and inorganic compounds which reduces the toxicity of the metal.

Nitrogen

Nitrogen is important to all life. Nitrogen in the atmosphere or in the soil can go through many complex chemical and biological changes. It can be combined into living and non-living material and return back to the soil or air in a continuing cycle called the nitrogen cycle.

Nitrogen occurs in natural waters in various forms, including nitrate, or NO3, nitrite, or NO2, and ammonia, or NH3. Nitrate is the most common form tested. Test results are usually expressed as nitrate-nitrogen, or NO3-N, which simply means nitrogen in the form of nitrate. Ammonia is the least stable form of nitrogen and thus difficult to measure accurately. Nitrite is less stable and usually present in much lower amounts than nitrate.

These three compounds are interrelated through the process of nitrification, the biological oxidation of ammonia to nitrate. In this process nitrite is produced as an intermediate product.

Order of decreasing oxidation state:

Nitrate → Nitrite → Ammonia → Organic Nitrogen

(stable) → → →→ → →→ → →(Unstable)

In relatively stable, oxygenated natural water systems the oxidation of nitrite to nitrate is rapid, but the conversion of $NH_3$to NO_2^- is the rate limiting step in the total process. (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Nitrogen as Ammonia

Ammonia, or NH_3: It is one of the most important pollutants in the aquatic environment because of its relatively highly toxic nature and its ubiquity in surface water systems. It is discharged in large quantities in industrial, municipal and agricultural waste waters. In aqueous solutions, ammonia assumes two chemical forms: NH_4^+ - ionized (less/nontoxic) and NH_3 - unionized (toxic).

The relative concentration of ionized and unionized ammonia in a given ammonia solution are principally a function of pH, temperature and ionic strength of the aqueous solution (Fundamentals of Aquatic Toxicology, 1985):

Total NH_3: Total ammonia is the sum of the NH_3 and NH_4^+.

(Fundamentals of Aquatic Toxicology, 1985).

Nitrogen as Nitrate

Nitrate, or NO_3^-: Generally occurs in trace quantities in surface water. It is the essential nutrient for many photosynthetic autotrophs and has been identified as the growth limit nutrient. It is only found in small amounts in fresh domestic wastewater, but in effluent of nitrifying biological treatment plants, nitrate may be found in concentrations up to 30 mg nitrate as nitrogen/L (19th Edition, Standard Methods, 1995). Nitrate is a less serious environmental problem, it can be found in relatively high concentrations where it is relatively nontoxic to aquatic organisms. When nitrate concentrations become excessive, however, and other essential nutrient factors are present, eutrophication and associated algal blooms can be become a problem (Fundamentals of Aquatic Toxicology, 1985).

Nitrogen as Nitrite

Nitrite, or NO_2^-: Nitrite is extremely toxic to aquatic life, however, is usually present only in trace amounts in most natural freshwater systems because it is rapidly oxidized to nitrate. In sewage treatment plants using nitrification process to convert ammonia to nitrate, the process may be impeded, causing discharge of nitrite at elevated concentrations into receiving waters.

The conversion process is affected by several factors, including pH, temperature and dissolved oxygen, number of nitrifying bacteria and presence of inhibiting coTmpounds. Total ammonia in wastewater treatment systems consists of NH_3- plus NH_4^+. If pH of the solution increases either naturally or by addition of a base, the concentration of unionized NH_3 increases. It impedes the conversion of nitrite to nitrate, causing nitrite to accumulate. When the pH decreases, as NH_4^+ and NO_2 are oxidized an increase in HNO_2 concentration occurs. Nitrous acid inhibits both nitrobacteria and nitrosomanads bacteria – this inhibition can result in an increase in nitrite. As pH increases the toxicity in terms of NO_2 as N decreases and the toxicity in terms of HNO_2 as N increases. (Fundamentals of Aquatic Toxicology, 1985).

Nitrogen as Total Kjeldahl

Organic nitrogen and ammonia can be determined together and have been referred to as "Kjeldahl nitrogen, or TKN," a term that reflects the technique used in their determination (19th Edition, Standard Methods, 1995).

Nitrogen, Organic

Organic Nitrogen:It is the byproduct of living organisms. It includes such natural materials as proteins and peptides, nucleic acids and urea, and numerous synthetic organic materials. Typical organic nitrogen concentrations vary from a few hundred micrograms per liter in some lakes to more than 20 mg/L in raw sewage (19th edition, Standard Methods, 1995).

Phosphorus

Phosphorus is often the limiting nutrient for plant growth, meaning it is in short supply relative to nitrogen. Phosphorus usually occurs in nature as phosphate, which is a phosphorous atom combined with four oxygen atoms, or PO_4^{-3}. Phosphate that is bound to plant or animal tissue is known as organic phosphate. Phosphate that is not associated with organic material is known as inorganic phosphate. Both forms are present in aquatic systems and may be either dissolved in water or suspended (attached to particles in the water column).

Inorganic phosphate is often referred to as orthophosphate or reactive phosphorous. It is the form most readily available to plants, and thus may be the most useful indicator of immediate potential problems with excessive plant and algal growth.

Testing for total phosphorous (both inorganic and organic phosphate) provides you with a more complete measure of all the phosphorus that is actually in the water (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

pH

pH is an important limiting chemical factor for aquatic life. If the water in a stream is too acidic or basic, the H^+ or OH^- ion activity may disrupt aquatic organisms biochemical reactions by either harming or killing the stream organisms.

pH is expressed in a scale with ranges from 1 to 14. A solution with a pH less than 7 has more H^+ activity than OH^-, and is considered acidic. A solution with a pH value greater than 7 has more OH^- activity than H^+, and is considered basic. The pH scale is logarithmic, meaning that as you go up and down the scale, the values change in factors of ten. A one-point pH change indicates the strength of the acid or base has increased or decreased tenfold.

Streams generally have a pH values ranging between 6 and 9, depending upon the presence of dissolved substances that come from bedrock, soils and other materials in the watershed.

Changes in pH can change the aspects of water chemistry. For example, as pH increases, smaller amounts of ammonia are needed to reach a level that is toxic to fish. As pH decreases, the concentration of metal may increase because higher acidity increases their ability to be dissolved from sediments into the water (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Solids, Total

Total Solids is a measure of the suspended and dissolved solids in a body of water. Thus, it is related to both conductivity and turbidity. To measure total suspended and dissolved solids, a sample of water is placed in a drying oven to evaporate the water, leaving the solids. To measure dissolved solids, the sample is filtered before it is dried and weighed. To calculate the suspended solids, the weight of the dissolved solids is subtracted from the total solids (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Temperature

Water Temperature is a controlling factor for aquatic life: it controls the rate of metabolic activities, reproductive activities and therefore, life cycles. If stream temperatures increase, decrease or fluctuate too widely, metabolic activities may speed up, slow down, malfunction, or stop altogether.

There are many factors that can influence the stream temperature. Water temperatures can fluctuate seasonally, daily, and even hourly, especially in smaller sized streams. Spring discharges and overhanging canopy of stream vegetation provides shade and helps buffer the effects of temperature changes. Water temperature is also influenced by the quantity and velocity of stream flow. The sun has much less effect in warming the waters of streams with greater and swifter flows than of streams with smaller, slower flows.

Temperature affects the concentration of dissolved oxygen in a water body. Oxygen is more easily dissolved in cold water (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .

Turbidity

Turbidity is a measure of the cloudiness of water. Cloudiness is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of plankton present to fuel the fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight.

Suspended soil particles may carry nutrients, pesticides, and other pollutants throughout a stream system, and they can bury eggs and benthic critters when they settle. Turbid waters may also be low in dissolved oxygen. High turbidity may result from sediment bearing runoff, or nutrients inputs that cause plankton blooms (1991, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods) .