HOW WATER QUALITY INDICATORS WORK

Following are summaries of water quality indicators from several sources collated by the International Water Institute. They provide information about how the specific water quality indicators describe river health and factors affecting them. Other sources: http://ga.water.usgs.gov/edu/characteristics.html, and http://bcn.boulder.co.us/basin/data/NUTRIENTS/info/

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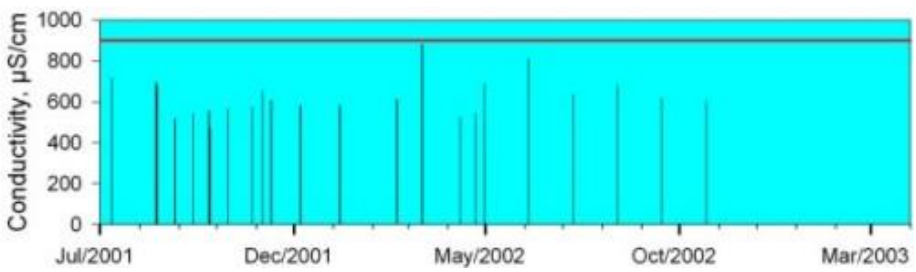
Following from FM RIVER at: http://www.undeerc.org/watman/FMRiver/PPTV/factsheets.asp

Electrical Conductivity

The Red River contains 1/70th the dissolved minerals found in seawater.

The electrical conductivity of water is directly related to the concentration of dissolved solids in the water. Ions from the dissolved solids in water influence the ability of that water to conduct an electrical current, which can be measured using a conductivity meter. When correlated with laboratory TDS measurements, electrical conductivity can provide an accurate estimate of the TDS concentration. Conductivity measurements for the Red River correlate very closely to the TDS determinations. Water in the Red River is usually below the 900 microsiemens/cm (red line on graph) set for drinking water by EPA's National Secondary Water Standards even before entering the local water treatment plants.

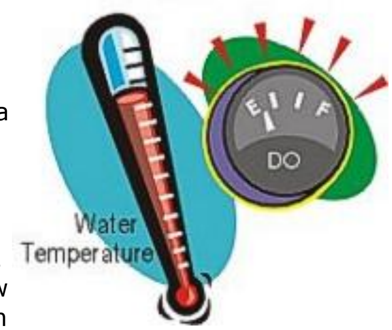


Graph of electrical conductivity (µS/cm) for the Red River in the FM metro area for the period July 2001 to April 2003 in relation to the EPA guideline (900 µS/cm; red line) for drinking water.

Dissolved Oxygen

Dissolved oxygen (DO) refers to the amount of oxygen (O_2) dissolved in water. Because fish and other aquatic organisms cannot survive without oxygen, DO is one of the most important water quality parameters. DO is usually expressed as a concentration of oxygen in a volume of water (milligrams of oxygen per liter of water, or mg/L).

In nature, oxygen from the atmosphere can be mixed into (diffused into) a body of water. The mixing is easiest where water is rough (for example, where water is tumbling over rocks or where there are waves). Oxygen is also introduced into water by green aquatic plants and algae during photosynthesis.

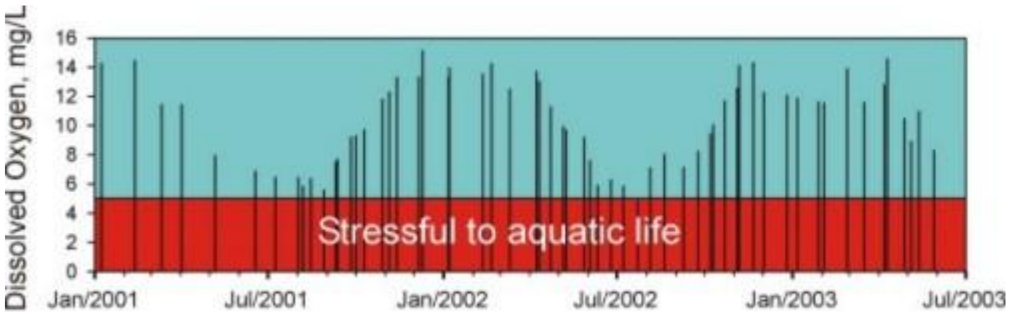


Cold water holds more oxygen than warm water. For example, pure water at 4°C (40F) can hold about 13.2 mg/L DO at 100% saturation, while pure water at 25°C (77F) can hold only 8.4 mg/L at 100% saturation. Water with a high concentration of dissolved minerals cannot hold as much DO as pure water.

Dissolved Oxygen in the Red River

Aquatic life is put under stress when the DO concentration falls below 5 mg/L (red band on graph); if the DO concentration falls under 2 mg/L for just a few hours, large fish kills can result. Good fishing waters have a DO concentration around 9 mg/L.

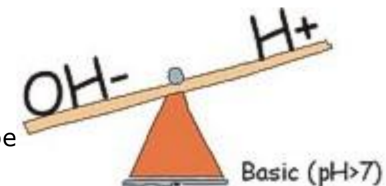
As shown on the graph, DO concentrations in the Red River vary from highs of 15 mg/L in the winter (water temperature from 0.2° to 10°C) to summer lows of 7 mg/L (water temperature from 20° to 26°C). Human activity can also affect DO levels in the Red. Summer increases in the amount of nutrients (phosphorus, nitrogen [N] as ammonia, nitrite, and nitrate) from lawn and farm fertilizers in runoff, runoff from feedlots, storm water, and other discharges. This can result in the increased growth of plants and algae. Bacteria take up oxygen and reduce DO as they decompose this excess organic matter.



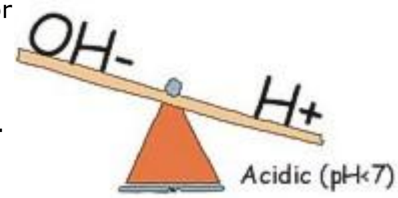
Graph of dissolved oxygen for the Red River in the Fargo-Moorhead metro area (January 2001 to July 2003) in relation to the level of DO (less than 5 mg/L; red band) stressful to aquatic life.

pH

pH describes the acidity or alkalinity of water and represents the balance between hydrogen ions (H^+) and hydroxide ions (OH^-) in water.



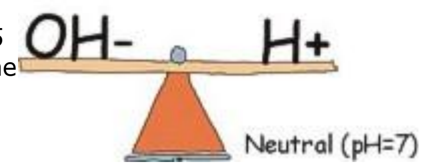
The value for pH is expressed on a scale ranging from 0 to 14. Solutions with more H^+ than OH^- ions have a pH value lower than 7 and are said to be acidic. Solutions with pH values higher than 7 have more OH^- than H^+ ions and are said to be basic, or alkaline. If the pH value is 7, the solution is said to be neutral (an equal number of H^+ and OH^- ions) and is neither acidic nor alkaline.



It is important to note that the pH scale is logarithmic. This means that each step on the scale represents a tenfold change in the H^+ concentration. For example, water with a pH of 5 has ten times the number of H^+ ions than water with a pH of 6 and is ten times more acidic.

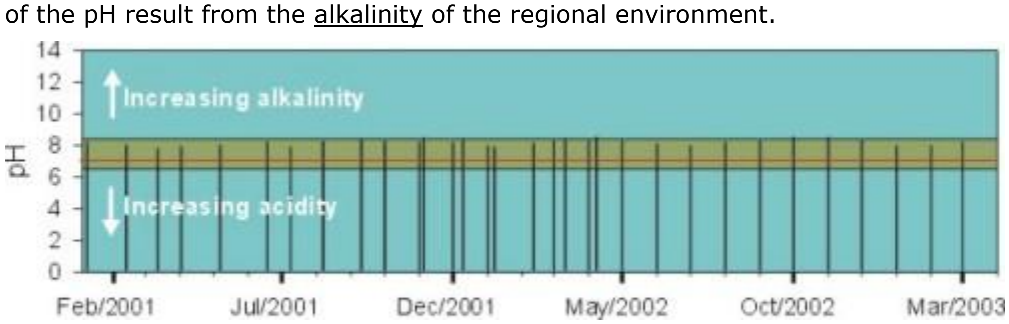
pH and Water

Water with a pH of less than 4.8 or greater than 9.2 can be harmful to aquatic life. Most freshwater fish prefer water with a pH range between 6.5 and 8.4 (colored band on the graph). The pH is also a useful indicator of the chemical balance in water. A high or low pH will adversely affect the availability of certain chemicals or nutrients in the water for use by plants.



pH in the Red River

As seen in the graph below, the pH in the Red River at Fargo-Moorhead (FM) is relatively constant year-round. The average pH of the Red River is around 8, or slightly basic. The slightly basic pH and the stability of the pH result from the alkalinity of the regional environment.



Graph of pH (relative acidity/alkalinity) for the Red River in the FM metro area for the period January 2001 to April 2003 in relation to neutral pH (red line) and the optimal pH conditions for fish (green band).

Turbidity

secchi disk

High turbidity means you cannot see the disk very far below the surface of the water

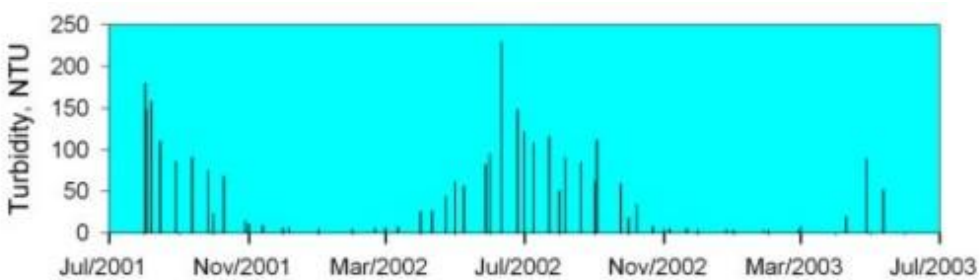
Turbidity, like transparency, is a measure of water clarity (how far light can travel through water). The more particles suspended in a sample of water, the more difficult it is for light to travel through it and the higher the water's turbidity, or murkiness. Although the suspended particles that reduce clarity can include organic particles (microbes, algae and plant particles, and animal detritus) as well as inorganic particles (silt and clay particles), turbidity in the Red River is usually a measure of the inorganic particles that account for most of the total suspended solids (TSS).

Measuring Turbidity

Turbidity is measured by an instrument called a nephelometer and is reported in nephelometric units (NTUs). The nephelometer, also called a turbidimeter, has a photocell similar to the ones used in cameras to indicate when the "flash" is needed. The water sample is placed in a column in the instrument, and the photocell reads the intensity of a beam of light showing through the water column. The cloudier or more turbid the water, the lower the intensity of the light that reaches the photocell and the higher the NTUs. High TSS or the presence of dark-colored humic acids from the decay of vegetation, common in the water of peat bogs, would result in a high turbidity reading.

Turbidity in the Red River

Turbidity varies seasonally for the Red River. In the winter, when the soil is frozen and precipitation is stored in the snowpack, runoff and erosion are very low, resulting in low turbidity (less than 10 NTUs). During the summer, the soil and plant particles entering the river from runoff and bank erosion result in high turbidity (above 60 NTUs), with the highest levels in July and August (over 100 NTUs). The local water treatment plants bring the turbidity level down to meet the U.S. Environmental Protection Agency National Primary Drinking Water Standards (turbidity in local municipal water is usually less than 1 NTU).



Graph of turbidity (NTU) for the Red River in the Fargo-Moorhead area (July 2001 to April 2003)

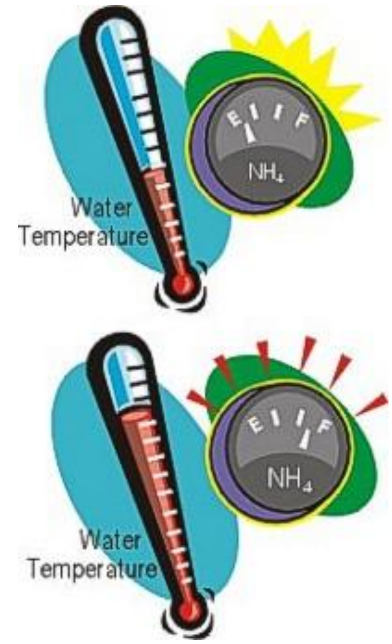
Water Temperature

Water temperature is important because it affects the rates of biological processes and chemical processes. Temperature is measured in degrees Fahrenheit (180° between the freezing and boiling point of water) or degrees Celsius (100° between the freezing and boiling point of water).

The optimal health of aquatic organisms from microbes to fish depends on temperature. If temperatures are outside the optimal range for a prolonged period, organisms are stressed and can die. For fish, the reproductive stage (including spawning and embryo development) is the most temperature-sensitive period. Macroinvertibrates (for example, insects, crayfish, worms, clams, and snails) will move about in the stream bed to find their optimal temperature.

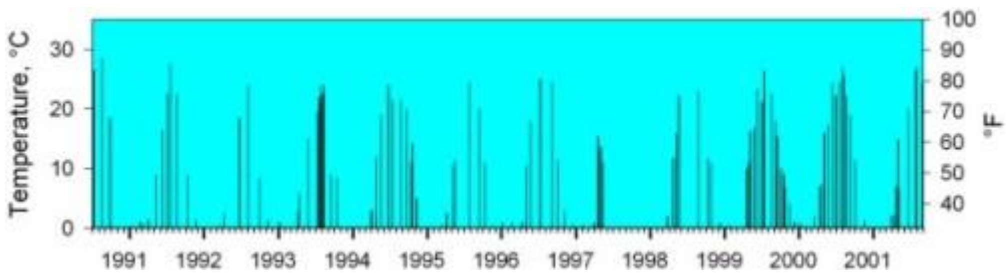
The temperature of the water also affects the volume of dissolved oxygen (DO) it can hold (water's ability to contain dissolved oxygen decreases as water temperature rises),the form of ammonia (harmful or harmless to aquatic life), the rate of photosynthesis by aquatic plants, metabolic rates of aquatic organisms, and the sensitivity of organisms to pollution.

Water temperature is affected by the seasons and can also be affected by weather, removal of shading stream bank vegetation, building dams on rivers, discharging cooling water, discharging storm water, and groundwater influx.



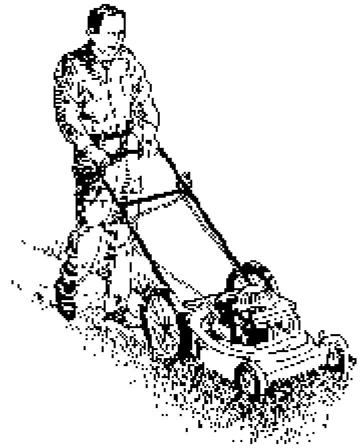
As water temperature increases, the level of ammonia occuring in the water as a gas increases.

Water Temperature in the Red River
As shown on the graph, the water temperature in the Red River varies seasonally from just above freezing (0°C or 32°F) in the winter to over 25°C (over 77°F) in the summer. Among other things, this seasonal change in river water temperature causes seasonal changes in the level of dissolved oxygen and in the level of ammonia gas in the river.



Graph of water temperature (°C) for the Red River in the FM metro area for the period July 1990 to July 2001.

Phosphorus

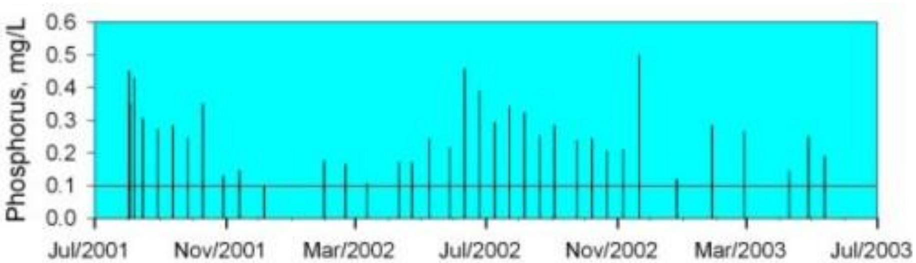


Phosphorus (P), like nitrogen (N, found in ammonia, nitrite, nitrate), is an important nutrient for plants and algae. Because phosphorus is in short supply in most fresh waters, even a modest increase in phosphorus can cause excessive growth of plants and algae that deplete dissolved oxygen (DO) as they decompose. Excessive growth can also reduce the transparency of the water. Much of the excess phosphorus available to plants in the environment comes from farm and lawn fertilizers, runoff containing soil-bound phosphate, yard waste, runoff from animal feedlots, storm water, and certain industrial wastewaters.

Phosphorus in the Red River

The limits for phosphorus in water set by the North Dakota Department of Health (NDDH) and the Minnesota Pollution Control Agency (MPCA) are designed to prevent the excessive growth of aquatic plants and algae. NDDH has established an interim guideline limit for phosphorus at 0.1 mg/L. MPCA does not have a specific numeric limit for phosphorus but addresses the issue as part of a comprehensive strategy for phosphorus control.

Phosphorus can come from yard waste, fertilizers, animal feedlots, and wastewater.



Graph of phosphorus (mg/L) for the Red River in the FM metro area for the period July 2001 to December 2003 in relation to the NDDH standard of 0.1 mg/L (red line) for surface waters intended to prevent excessive plant growth.

Trends

A graph illustrating phosphorus levels in the Red River in the Fargo-Moorhead (FM) area is shown above. These levels are above the 0.1-mg/L interim guideline limit (red line) set by NDDH to protect the river environment. You can help reduce the phosphorus level in the Red River by properly applying fertilizer to lawns and gardens and properly disposing of yard waste.

Nitrate (NO_3) and Nitrite (NO_2)

Nitrite and nitrate are sources of nitrogen (N), an important nutrient for plants and algae. As ammonia (NH_3) is broken down by bacterial action, nitrite is formed and is then converted to the more stable, much less toxic nitrate through a process called "nitrification."

Nitrate and Nitrite in Water

Nitrogen is a component of fertilizers and organic material.

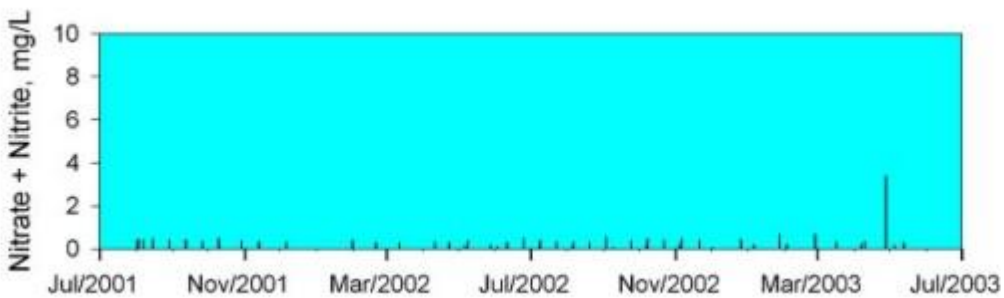
The typically low natural levels of nitrate in surface water can be supplemented with nitrate from human sources. Nitrate from the fertilizer not taken up by crops in fields and grass in lawns can enter water bodies in runoff. Nitrate can also enter water bodies from wastewater discharge or runoff from feedlots. Once in the water, nitrates can stimulate excessive plant and algae growth. Decomposition of the plant and algal material by bacteria can deplete dissolved oxygen (DO), adversely impacting fish and other aquatic animals.

As early as 1940, it was recognized that consuming waters with high nitrate levels contributed to methemoglobinemia ("blue baby" syndrome). This condition, usually in infants, impairs the ability of blood to carry oxygen. The U.S.

Environmental Protection Agency (EPA) National Primary Drinking Water Standards require that nitrate nitrogen not exceed 10 mg/L in public water supplies. Nitrite, much more toxic than nitrate, is regulated at a level not to exceed 1.0 mg/L in public water supplies.

Nitrate and Nitrite in the Red River
Nitrate is regulated to protect human health as well as aquatic environments. The Minnesota Pollution Control Agency (MPCA) uses the EPA limits of 10 and 1.0 mg/L for nitrate and nitrite nitrogen, respectively, in drinking water supplies. The North Dakota Department of Health (NDDH), on the other hand, has established what it intends as an interim guideline limit of 1.0 mg/L nitrate nitrogen. NDDH is reserving the right to review this standard after additional study and to set specific limitations for constituents that cause excessive plant growth in surface water. NDDH states that in no case shall the standard for nitrate nitrogen ever exceed 10 mg/L for any waters used as a municipal or domestic drinking water supply.

Trends
The graph below shows measured nitrate + nitrite concentrations expressed as nitrogen in the local stretch of the Red River from July 2001 through June 2002. Even with higher levels in the summer, attributed in part to runoff from fields and urban green spaces, the nitrate-nitrite concentrations in the river water were below the federal regulatory limits set for human consumption even before entering the local water treatment plant.



Graph of nitrate + nitrite concentrations (mg/L) expressed as nitrogen for the Red River in the Fargo-Moorhead metro area (July 2001 through June 2002).

Fecal Bacteria

The Fargo and Moorhead wastewater treatment plants ensure that the levels of pathogens entering the Red River from discharges of treated wastewater are kept at a safe level.

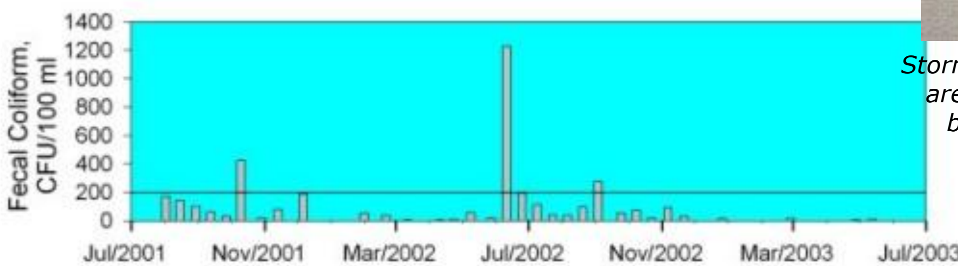
Members of two bacteria groups, coliforms and fecal streptococci, are used to test for contamination from sewage. These bacteria are called "fecal" indicators because they live in the intestinal track of humans and animals and are found in human and animal feces. The fecal indicators themselves are not harmful, but because they live in the same portion of the digestive system where disease-causing microorganisms occur, the presence of these fecal bacteria in a water sample indicates that water might contain microorganisms harmful to human health. Very high levels of fecal bacteria can give water a cloudy appearance, cause unpleasant odors, and increase oxygen demand (see BOD and Dissolved Oxygen). Disinfectants added at the local water treatment plants kill microbes in drinking water. Sources of fecal bacteria in surface waters include outflow from wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff.

Measuring Fecal Bacteria
Fecal bacteria levels in water are determined by incubating a water sample for 24 hours and then counting the number of bacterial colonies that grew during that time. The unit for reporting fecal bacteria is "colony-forming units" per 100 milliliters of water (CFU/100 mL). CFUs/100 mL is used interchangeably with "organisms per 100 mL."

Fecal Bacteria in the Red River

The regulatory standard for fecal bacteria in the water varies by state, and several fecal bacteria indicators can be used. In this region, we use fecal coliform. The regulatory limit in North Dakota is 200 organisms/100 mL of water, which applies only during the recreational season, May 1 to September 30. The regulatory limit in Minnesota is also 200 organisms/100 mL of water.The intent of the regulations is to protect people who use the river for recreation. The level of fecal bacteria and other parameters in treated sewage that is discharged to the Red is checked frequently. The monthly average for treated wastewater from the Fargo and Moorhead Wastewater Treatment Plants is usually less than 100 CFU/100 mL and in most winter months is less than 10 CFU/100 mL. Specific reaches of the Red River, including the Fargo-Moorhead (FM) metropolitan area, and some of its tributaries contain elevated levels of fecal coliform bacteria. State regulatory agencies are developing a water quality management plan as part of TMDL activity, to address and remedy these impairments. The target date for implementing this plan is 2004.

Storm water from urban and rural areas can be a source of fecal bacteria for the Red River.



Graph of fecal bacteria levels (CFU/100 mL) for the Red River in the FM metro area for the period July 2001 to July 2003 in relation to the regulatory limit for surface water of 200 CFU/100 mL (red line) intended to protect human health.

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The following is excerpted from Mark Mitchell and William Stapp's, "Field Manual for Water Quality Monitoring," (second edition) Dexter, MI: Thomson-Shore Printers: 1986.

ALKALINITY: [*120-170 mg/L*]

The alkalinity of a water is a measure of its capacity to neutralize acids. Although many materials may contribute to the alkalinity of water, most of the alkalinity in natural water is caused by the presence of hydroxides, carbonates, and bicarbonates. Carbonates and bicarbonates are common to most waters because carbonate materials are abundant in nature, whereas the presence of hydroxides is usually due to water treatment or contamination. Because these substances act as buffers to resist change in pH, alkalinity can also be viewed as a measure of a water's buffering capacity. Alkalinity impacts and is impacted by chemical and biological systems of natural waters.

CHEMICAL OXYGEN DEMAND (COD): [*20-60 mg/L*]

Chemical Oxygen Demand (COD) is a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. It represents potential "consumption" of oxygen within the receiving water.

CONDUCTIVITY: [*20-60 μS/CM*]

Conductivity measures the electrical conductance in the water. This is an indication of the quantity of dissolved inorganic acids, bases and salts in the water.

DISSOLVED OXYGEN (DO): [5 mg/L]
Dissolved oxygen is an essential element for the maintenance of healthy lakes and rivers. Most aquatic plants and animals need a certain amount of oxygen dissolved in water for survival. Some aquatic organisms such as pike and trout require medium to high levels of dissolved oxygen to live. Waters of consistently high dissolved oxygen are usually considered healthy and stable aquatic ecosystems capable of supporting many different kinds of aquatic organisms. The atmosphere, algae, and vascular aquatic plants are the sources of dissolved oxygen in lakes and rivers; the accumulation of organic wastes depletes dissolved oxygen.

FECAL COLIFORM: [230 colonies/100 ml]
Fecal coliform bacteria are derived from the feces of humans and other warm-blooded animals. These organisms enter rivers through direct discharge from mammals and birds; from agricultural and storm runoff containing mammal and bird wastes; and from sewage discharge. Even though fecal coliform bacteria are not pathogenic, they occur along with pathogenic organisms; therefore, their presence suggests the occurrence of disease-causing organisms. When fecal coliform counts are greater than 200-colonies/100 ml of water sample there is a greater chance that the disease-causing organisms are present. It is advised that water contact be avoided at this coliform level. Possible diseases and illnesses carried by such waters are typhoid fever, hepatitis, gastroenteritis, dysentery, swimmers itch, and ear infections.

NITRATES (NO_2-NO_3, NH_3): [.2 mg/L, .29 mg/L]
Nitrate and nitrite are inorganic forms of nitrogen in the aquatic environment. Nitrate along with ammonia (NH_3) are the forms of nitrogen used by plants. Nitrates and nitrites are formed through oxidation of ammonia by nitrifying bacteria, a process known as nitrification. In turn they are converted to other nitrogen forms by denitrification and plant uptake. Nitrogen, in its various forms is usually more abundant than phosphorous in the aquatic environment; therefore, nitrogen rarely limits plant growth as does phosphorous. Aquatic plants are not usually as sensitive to increases in ammonia and nitrate levels. Sources of nitrates are the atmosphere, inadequately treated wastewater from sewage treatment plants, agricultural runoff, storm drains, and poorly functioning septic systems.

pH: [8.3]
The pH value of water, on a scale of 0 to 14, measures the concentration of hydrogen ions. Pure distilled water is considered neutral, with a pH reading of 7. Water is basic if the pH is greater than 7; water with pH of less than 7 is considered acid. For every one unit change in pH there is approximately a ten-fold change in how acid or basic the sample is. Most valuable species, such as brook trout, are sensitive to changes in pH; immature stages of aquatic insects and immature fish are extremely sensitive to low pH values. Very acidic lakes and streams cause leaching of heavy metals into the water.

TEMPERATURE: [19.9]
Many of the physical, biological, and chemical characteristics of surface water are dependent on temperature. Temperature affects the solubility of oxygen in water; the rate of photosynthesis by algae and larger aquatic plants; the metabolic rates of aquatic organisms and the sensitivity of organisms to toxic wastes, parasites and diseases.

TOTAL PHOSPHOROUS (TP) [.322 mg/L]
Total phosphorous includes organic phosphorous and inorganic phosphate. Organic phosphorous is a part of living plants and animals. It is attached to particulate organic matter composed of once-living plants and animals. Inorganic phosphates comprise the ions bonded to soil particles and phosphates

present in laundry detergents. Phosphorous is an essential element for life; it is a plant nutrient needed for growth and a fundamental element in metabolic reactions of plants and animals. In northern Minnesota, phosphorous functions as a "growth-limiting" factor because it is usually present in very low concentrations. This scarcity of phosphorous is attributed to its relationship with organic matter and soil particles. Any unattached or "free" phosphorous, in the form of inorganic phosphates, is rapidly taken up by algae and larger aquatic plants. Because algae only require small amounts of phosphorous to live, excess phosphorous causes extensive algal growth called algal blooms. Algal blooms color the water a pea soup green and are a classic symptom of cultural eutrophication. Sources of phosphorous are human wastes, industrial wastes, and human disturbance of the land and its vegetation.

TURBIDITY: [23 NTU]

Turbidity is the relative clarity of the water. It is the result of suspended solids in the water that reduce the transmission of light. Suspended solids are varied, ranging from clay, silt, and plankton to industrial wastes and sewage. When turbidity is high, water loses its ability to support a diversity of aquatic organisms. Oxygen levels decrease in turbid waters as they become warmer as the result of heat absorption from the sunlight by the suspended particles and with decreased light penetration resulting in decreased photosynthesis. Suspended solids can clog fish gills, reduce growth rates and disease resistance, and prevent egg and larval development. Settled particles can accumulate and smother fish eggs and aquatic insects on the river bottom, suffocate newly-hatched insect larvae and make river bottom microhabitats unsuitable for mayfly nymphs, stonefly nymphs, caddisfly larvae, and other aquatic insects.

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The following information is from an NDSU Extension Service Report, *Interpreting Your Water Test Report*, November 1987.

Alkalinity: Alkalinity is a measure of the capacity of water to neutralize acids. The predominant chemical system present in natural waters is one where carbonates, bicarbonates and hydroxides are present. The bicarbonate ion is usually prevalent. However, the ratio of these ions is a function of pH, mineral composition, temperature and ionic strength. A water may have a low alkalinity rating but a relatively high pH or vice versa, so alkalinity alone is not of major importance as a measure of water quality. Alkalinity is not considered detrimental to humans but is generally associated with high pH values, hardness and excess dissolved solids. High alkalinity waters may also have a distinctly flat, unpleasant taste.

Calcium and Magnesium: Calcium and Magnesium are important contributors to water hardness. When water is heated they break down and precipitate out of solution, forming scale. Maximum limits have not been established for these parameters. Magnesium concentrations greater than 125 mg/L may have a laxative effect on some people.

Chloride: High concentrations of chloride ions may result in an objectionable salty taste to water and the corrosion of plumbing in the hot water system. High chloride waters may also produce a laxative effect. An upper limit of 250 mg/L has been set for the chloride ions, although at this limit few people will notice the taste. Higher concentrations do not appear to cause adverse health effects. An increase in the normal chloride content of your water may indicate possible pollution from human sewage, animal manure or industrial wastes.

Conductivity: Conductivity is the measure of the conductance of the water to an electric current. Conductivity is commonly reported as umhos/cm (micromhos per centimeter). This is an easy measurement to make and relates closely to the total dissolved solids content of the water. The total dissolved solids is approximately 70 percent of the conductivity in umhos/cm.

Fluoride: At concentrations greater than 1.0 mg/L, fluoride will reduce the incidence of dental cavities. At concentrations greater than 1.5 mg/L, fluorosis (mottling) of teeth may occur. Most municipal water supplies have added fluoride to reach the optimal level of 1.2 mg/L to reduce cavities. Some water supplies in North Dakota contain naturally occurring fluoride in amounts high enough to cause mottling of the teeth.

Iron and Manganese: Iron in concentrations greater than 0.3 mg/L and manganese in concentrations greater than 0.05 mg/L may cause brown and black stains on laundry, plumbing fixtures and sinks. A metallic taste may also be present and it may affect the taste of beverages made from the water. High concentrations of iron and manganese do not appear to present a health hazard.

Nitrate: Nitrate levels should not be higher than 10 mg/L if reported as nitrogen (N). High nitrate may cause methemoglobinemia (infant cyanosis or "blue baby disease") in infants who drink water or formula made from water containing nitrate levels higher than recommended. Adults can drink water with considerably higher concentrations than infants without adverse affects. Livestock water can contain up to 100 mg/L of nitrate as nitrogen, but young monogastric animals such as hogs may be affected at nitrate levels considerably less than 100 mg/L.

pH: pH is a measure of the hydrogen ion concentration of the water. The pH of water indicates whether the water is acid or alkaline. The measurement of pH ranges from 1 to 14 with a pH of 7 indicating a neutral solution, neither acid nor alkaline. Numbers lower than 7 indicate acidity; numbers higher than 7 indicate alkalinity. Drinking water with a pH of between 6.5 and 8.5 is generally considered satisfactory. Acid waters tend to be corrosive to plumbing and faucets, particularly if the pH is below 6. Alkaline waters are less corrosive. Waters with a pH of above 8.5 may tend to have a bitter or soda like taste. The pH of water may have an effect on the treatment of water and also should be considered if the water is used for field application of pesticides. Water with a pH of 7.0 to 8.5 will require more chlorine for the destruction of pathogens than will water that is slightly acidic.

Potassium: Potassium concentrations in water are generally very small. Although excessive intakes may have a laxative effect, public health authorities have not established a maximum limit.

Sodium: Sodium is a very active metal which does not occur in nature in a free state. It is always combined with other substances. In the human body sodium helps maintain water balance. Human intake of sodium is mainly influenced by the consumption of sodium as sodium chloride or table salt. The contribution of drinking water is normally small compared to other sources. The treatment for certain heart conditions, circulatory or kidney diseases or cirrhosis of the liver may include sodium restriction. Diets for these persons should be designed with the sodium content of their drinking water taken into account. The National Academy of Sciences has suggested a standard for public water allowing no more than 100 mg/L of sodium. This would insure that the water supply adds no more than 10 percent of the average person's total sodium intake. The American Health Association has recommended a more conservative standard of 20 mg/L to protect heart and kidney patients.

High concentrations of sodium will reduce the suitability of water for irrigation or house plant watering use. High sodium water will alter the soil chemistry and absorption properties, eventually sealing the soil surface.

Softening water by ion exchange or lime-soda ash processes will increase the sodium content. Softening by ion exchange will increase the sodium content by approximately 8 mg/L for each grain per gallon of hardness removed.

Sulfate: Water containing high levels of sulfates, particularly magnesium sulfate (Epsom salts) and sodium sulfate (Glauber's salt) may have a laxative effect on persons unaccustomed to the water. These effects vary with the person and appear to last only until one becomes accustomed to using the water. High sulfate content also affects the taste of water and will form a hard scale in boilers and heat exchangers. For these reasons the upper recommended limit for sulfates is 250 mg/L.

Total Dissolved Solids: High concentrations of total dissolved solids (TDS) may cause adverse taste effects. Highly mineralized water may also deteriorate domestic plumbing and appliances. It is recommended that waters containing more than 500 mg/L of dissolved solids not be used if other less mineralized supplies are available. This does not mean water containing more than 500 mg/L TDS is unusable. Exclusive of most treated public water supplies, the Missouri River, a few fresh lakes and scattered wells, very few water supplies in North Dakota contain less than 500 mg/L concentration of total dissolved solids. Many households in the state use drinking water supplies with concentrations of 2000 mg/L and greater.

Total Hardness: Hardness is the property which makes water form an insoluble curd with soap and is primarily due to the presence of Calcium and Magnesium. Waters which are very hard have no known adverse health effects and may be more palatable than soft waters. Hard water is primarily of concern because it requires more soap for effective cleaning, forms scum and curd, causes yellowing of fabrics, toughens vegetables cooked in the water and forms scale in boilers, water heaters, pipes and cooking utensils.

The hardness of good quality water should not exceed 270 mg/L (15.5 grains per gallon) measured as calcium carbonate. Water softer than 30-50 mg/L may be corrosive to piping depending on pH, alkalinity and dissolved oxygen.

Turbidity: Turbidity is a measure of light transmission and indicates the presence of suspended material such as clay, silt, finely divided organic material, plankton and other inorganic material. Turbidities in excess of 5 are usually objectionable for aesthetic reasons. If turbidity is high, be aware of possible bacterial contamination.

Following from MPCA website: http://www.pca.state.mn.us/gloss/index.cfm

Turbidity provides an estimate of the muddiness or cloudiness of water caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.

In streams, a major cause of elevated turbidity are disturbed and eroding soils carried by storm run-off to streams. Once in the stream system, elevated turbidity reduces the depth of photosynthesis and the feeding ability of aquatic organisms. When soils settle out in downstream reaches with slower flow, bed substrate becomes embedded, removing essential habitat for aquatic insects and other organisms. Measured in Nephelometric Turbidity Units (NTU) or Formazin Turbidity Units (FTU).

Dissolved Oxygen (DO)

The concentration of molecular oxygen (O2) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. The DO level represents one of the most important measurements of water quality and is a critical indicator of a water body's ability to support healthy ecosystems. Levels above 5 mg/L are considered optimal, and most fish cannot survive for prolonged periods at levels below 3 mg/L.

Microbial communities in water use oxygen to breakdown organic materials, such as manure, sewage and decomposing algae. Low levels of dissolved oxygen can be a sign that too much organic material is in a water body.

Most dissolved oxygen gets into the water from physical contact with the atmosphere. Waves or riffles that increase air exposure mixes oxygen in the water. Plants and algae also add oxygen to water through photosynthesis.

Conductivity

The ability of a substance to conduct or transmit heat, electricity, or sound. Relating to water quality, it is a measure of dissolved minerals and/or ions in the water. Typically measured in micromhos per centimeter (µmhos/cm).

If baseline levels of conductivity are established for an area, this measurement can be used to detect possible pollution discharges that have a high ionic strength. This would include manure directly from livestock in streams, land application, or releases from storage basins.

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