Chapter Two

Measuring Stream Health

A Short History of Water Pollution

Native Americans who lived in North America before European colonists arrived lived in harmony with nature and strove to minimize their impact on the Earth. When the colonists arrived in America, they marveled at the abundance of clean water. However, they did not know that special laws would need to be created in the future just to ensure water stayed clean for their descendants.

As the population of settlers grew, trash, human and animal waste, and eroding soils from agriculture entered waterways. Early cities produced raw sewage, grease, dirt, organic matter from slaughterhouses and other pollutants. The Industrial Revolution brought more severe pollution problems to our nation's waters as factories became concentrated in burgeoning cities. Materials, such as iron, were produced in commercial quantities to build the machines needed for manufacturing and engines for transportation. Discharging pollutants into waterways became an easy way for factories to dispose of industrial waste water and byproducts.

The first water pollution legislation was the Rivers and Harbors Act of 1899, which prohibited dumping refuse or the construction of structures (dams, bridges, piers, etc.) in navigable waters without federal approval. However, the act made no provision for obtaining such approval nor did it designate responsibility for issuing permits to any particular government agency. In addition, there were no inspectors or fines to deal with illegal dumping activities. In short, there were no prescribed penalties for lawbreakers.

In 1927, President Calvin Coolidge asked members of the Izaak Walton League of America to conduct the nation's first water pollution survey. Members of the League adopted and cared for rivers, since there were no government agencies in place to ensure their protection.

Finally, the Water Pollution Control Act was passed in 1948. It was the first attempt by the federal government to exert some control over state and local handling of clean water issues. However, most of the control and management still rested with the states. In 1956, amendments to the Water Pollution Control Act were passed that provided for federal financial support for wastewater treatment plant construction (up to 55 percent of the total construction cost) and direct federal regulation of waste discharges through a process known as the enforcement conference. This only regulated discharges into interstate waters. By 1961 discharges into all navigable waters were covered. In 1965, the Water Quality Act established ambient water quality standards for interstate waterways and required states to file implementation plans.

The most important step in providing real protection for surface waters was the 1972 Clean Water Act, which required a much stronger and more active federal oversight role. The objective of the act is to "restore and maintain the chemical, physical and biological integrity of the nation's waters." The act also required that discharges of pollutants into the nation's waters be eliminated by 1985 and that pollutants discharged up until that point be regulated by the National Pollutant Discharge Elimination System (NPDES), which sets minimum standards for the amount and content of wastewater each type of industry may discharge to surface waters. The act also requires that all waters of the United States be "fishable and swimmable." In addition, the act created a permit program to regulate the discharge of dredged or fill material

The water chemistry of your stream is affected by the land use, soils, surrounding geology and precipitation in your watershed.

Chemical water quality usually is measured by a few basic parameters. If a river is to be used as a drinking water source, it is subject to stringent standards. In general, drinking water cannot have any volatile organics, radioactive materials, heavy metals or toxic chemicals. Volatile organics are organic chemicals that are unstable or combustible. Toxic substances are poisonous to aquatic and other life forms.

There are two general types of toxicity. Acute toxicity refers to a substance that causes death to a life form during a short exposure. Chronic toxicity causes harm over a prolonged and sustained exposure. Chronic toxicity may occur in small doses but can cause harm by having a cumulative effect on growth, respiration and reproduction of aquatic organisms. Identification of the type of toxic substance in a water sample may require expensive equipment such as a mass spectrometer. Testing should be done in a laboratory using Environmental Protection Agency-approved techniques that include stringent testing guidelines to monitor toxic substances, metals or radioactive elements.

The Safe Drinking Water Act of 1974 issued standards for community water systems and set standards for maximum allowable concentrations of bacteria, turbidity (muddiness) and chemical-radiological contaminants. The 1986 amendments to the act also required standards for specific contaminants to be set by EPA and established civil and criminal penalties for violations of the act.

The amount of a specific contaminant, chemical element or compound is expressed as a concentration — the specific weight of a contaminant in a specific volume of water. Milligrams per liter (mg/1) are roughly equivalent to parts per million (ppm). Another common reference is micrograms per liter (ug/l), which is roughly equivalent to parts per billion (ppb). "Ppm" means one part contaminant for every million parts of water. This measure serves as a ratio. A milligram is one-thousandth of a gram, and a microgram is one-thousandth of a milligram (one-millionth of a gram). Approximately 28 grams make an ounce, and a liter is equivalent to a quart. One quart is equal to 32 fluid ounces and 1 liter is equal to 33.8 fluid ounces.

Dissolved Oxygen

A basic parameter that indicates if a river is healthy is dissolved oxygen (DO), a measure of the concentration of oxygen dissolved in the water. DO is needed by aquatic organisms for respiration or processes such as decomposition. The DO content of water is influenced by several factors, including water temperature, salinity, atmospheric pressure (or altitude) and the amount of oxygen-demanding waste in the water. Bacteria living in the water use up available oxygen by breaking down organic wastes such as manure, leaf litter, woody debris or organic materials in wastewater. DO usually is expressed as milligrams per liter or mg/l.

Aquatic life have different requirements for oxygen. A tubifex worm that lives on streambottoms can go for a few days with no oxygen, but some fish, such as trout, need at least 6 mg/l of oxygen at all times to function normally. A healthy, warm-water stream may have oxygen levels of 11 mg/l or higher. Generally, once oxygen levels drop below 3 mg/l, the water is considered oxygen poor. Most fish are stressed at this level, and many species may be absent.

Biochemical Oxygen Demand

Another common measure of water quality is biochemical oxygen demand (BOD). BOD occurs when bacteria in the water use up available oxygen as they break down organic matter or nutrients in the nitrogen in the form of nitrate. Unpolluted waters generally have nitrate-nitrogen levels below 1 ppm. The drinking water standard for nitrates is 10 mg/l. This means waters with concentrations above 10 mg/l are considered unsafe for human consumption.

Total phosphorus levels higher than .03 ppm contribute to increased plant growth; levels above .1 ppm may stimulate plant growth above natural levels and contribute to oxygen-reduced conditions.

Temperature

Temperature is another commonly measured water quality indicator. The temperature of water directly affects its chemical concentrations and fish species. Water has a high heat capacity, which makes it resistant to changes in temperature. In the winter, water temperatures are often warmer than air temperatures. Temperature requirements vary among fish species. Trout need cooler water than carp, for example. Rapid changes in temperature (more than I to 2 degrees Celsius in 24 hours) can cause thermal stress to fish and other stream inhabitants.

Increased temperatures can decrease water's ability to hold dissolved oxygen and can impair feeding, growth and reproduction of fish and can kill them. Thermal pollution occurs when temperature increases exceed normal levels for the stream. Thermal pollution can be caused by upstream dams, removing streambank shade trees, heated discharges from industries or power plants, and inflow of storm water runoff from urban streets.

Turbidity

Turbidity (cloudiness) is another water quality indicator. Turbidity is caused by the number of suspended solids in the water. Although all natural streams and lakes have a certain amount of materials suspended in the water from decayed organic matter, sediment carried by the stream, minerals and other particulate matter, the concentration of these solids must not exceed the normal amount for the stream. Too many solids in the water can block light to underwater plants and clog fish gills, suffocating the fish. Fish spawning beds are buried as solids settle to the streambottom. Suspended solids are also a problem because they may contain nutrients, pesticides and toxins.

Total suspended solids (TSS) is a measure of the total amount of solids in a liter of water. Simple tests for turbidity in streams can be conducted in the field using portable turbidimeters or other devices (prices can be high). Secchi disks are colored disks used to measure turbidity in lakes or standing water.

Another measure of solids is total dissolved solids (TDS), which are materials left behind after a water sample is filtered and evaporated. Rather than measuring, drying and weighing a water sample in a laboratory, conductivity tests can be done to determine the amount of material dissolved in a sample of water. This is because materials dissolved in water conduct electricity. The amount of electricity conducted is the water's conductivity. Portable conductivity meters can be used to measure the approximate dissolved material in the water. Rainwater has about 10 ppm TDS.

Rivers may contain between 100 to 2,000 ppm of dissolved materials. This variability occurs because the amount of material dissolved and carried into a waterway is affected by factors such as local geology, acidity of rainfall, amount of nonpoint source runoff, etc.