ULTRAVIOLET DISINFECTION SYSTEM

WATER QUALITY TRAINING COURSE

The Nature Of Water

The need for safe, healthy water is critical to all human life. The search for ways to ensure a ready supply of high quality water has been the life's work of some of our brightest scientists, and the amount of technical knowledge they have generated can fill volumes of text. Such a vast amount of knowledge is beyond the scope of this manual. Our need for knowledge of water quality issues is more practical, more job and customer oriented. We have therefore, made a serious effort to limit this manual to 'purposeful information.' We recognize that your time is valuable and limited. So, our goal is to give you the technical information that will help you feel more comfortable when solving your customers water problems.

While you won't need to keep a copy of the periodic Table of the Elements at your side, and you wont need to know how to balance a chemical equation, understanding the contents of this manual will still require a good portion of your brain power and attention. You won't need to be a scientist to understand the material, but it will require more from you than a quick scan while having your morning coffee and doughnut. In exchange for your effort, you will gain the expertise necessary to hear the customer's problem: to determine the degree of the problem, or to see if any other problems also exist; and then to choose the correct R-Can product to solve the problem. . . to everyone's satisfaction.

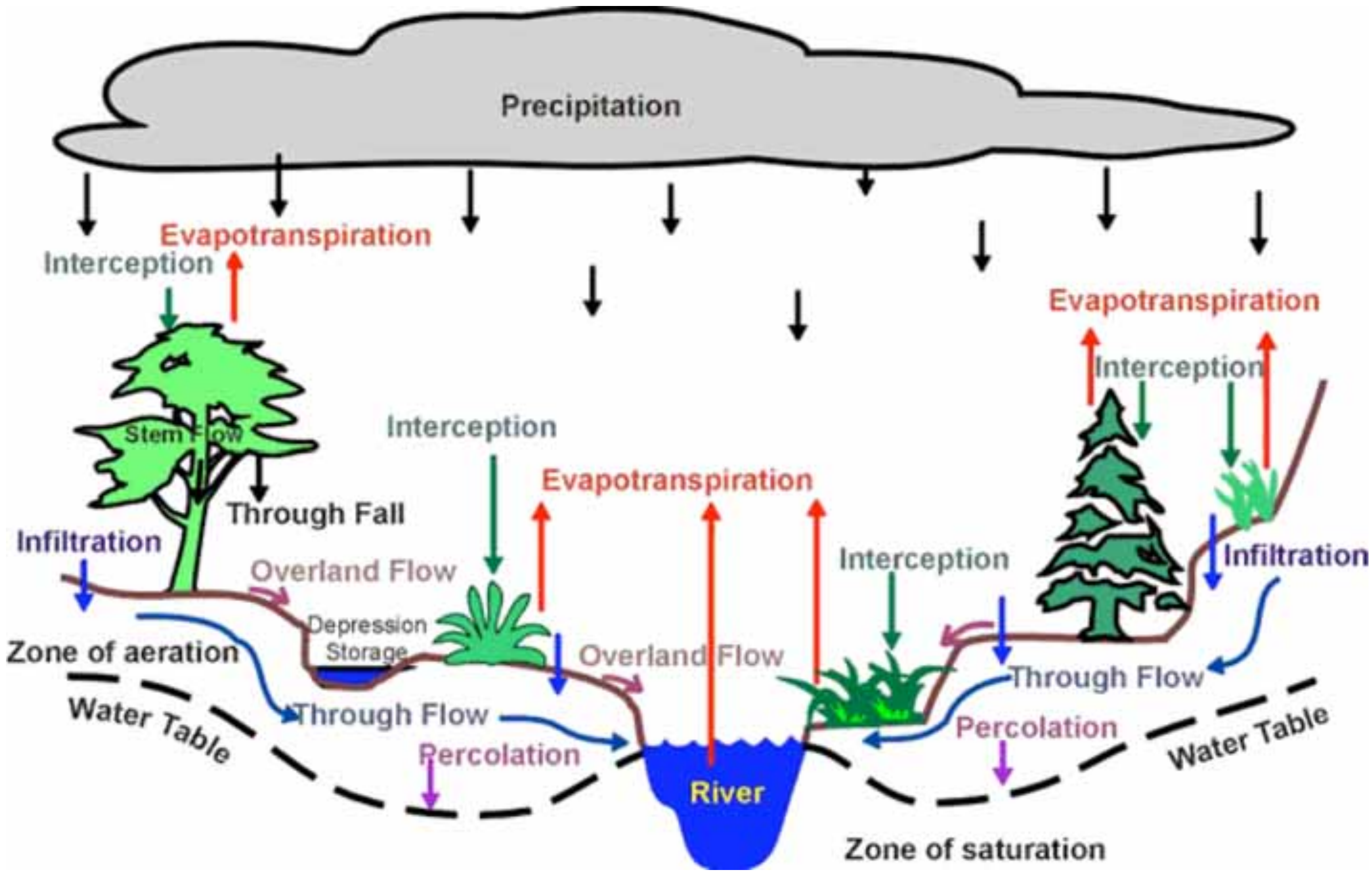
We need to consider the nature of water. The primary answer is water's ability to dissolve some portion of nearly everything with which it comes in contact. No matter if the material is natural or man-made, water seems to always dissolve, and hold in solution, some part of what it passes through or is contained in. In fact, water is referred to as the 'universal solvent.' If the substances that water dissolves were all good for us, and if they did not damage our plumbing systems and personal possessions, there would be no need to study this manual.

Unfortunately, the substances that water dissolves can be unhealthy or even toxic. These substances can also ruin expensive plumbing fixtures and clothing. In addition, they can be offensive to our senses of taste, smell and aesthetic appearance.

Water can also "carry along" with it particles of sediment, dirt and rust These are not dissolved in the water, but simply carried with the flowing water, or held suspended in standing water. Nevertheless they can do damage just the same.

A final troublesome characteristic of water is that water is a welcome home (or medium) for all types of bacteria and micro-organisms. When allowed to go unchecked, this condition can cause problems ranging from minor intestinal irritation to serious illness or death.

If we think back to our school days, most of us can remember studying the "hydrological cycle". You remember the process of how water vapor condenses in the atmosphere and falls to earth as precipitation. Once on the surface of the earth, most of the water evaporates back into the atmosphere, where it will again condense and fall back to earth as precipitation. About 30% of the precipitation, however, does not evaporate. Instead, it seeps into the ground or runs off into streams, rivers, or lakes. As the water seeps in to the ground or as it flows over the surface, it dissolves minerals and other substances contained in the ground. Under the surface, the water tends to collect in porous portions called 'aquifers.' These aquifers are the source of our well water.



POINTS TO KEEP IN MIND

- Water as found in nature, will always have some substances dissolved in it.
- It will always have the potential to have particles suspended in it.
- It will always have the potential to be a suitable home to disease causing organisms.

This is true of "fresh" mountain streams, well water, and even municipally treated water systems. To achieve "pure water", or anything close to that goal, water must be filtered or treated in some way.

As you now can begin to see, the problem for us to solve will depend upon what the water has had contact with. These conditions can vary greatly, not only from one region of the country to another, but also within the same general location. Water drawn from wells in the same area may not be exactly the same. The quality of water from a municipality owned treatment facility will depend upon the age and condition of the equipment. Even though the water may be classified as safe to drink, the aesthetic quality may be less than desirable.

Fortunately, our knowledge of the nature of water has increased steadily over the years. The most frequently occurring problems have been studied very closely. We now know the symptoms, the cause of the symptoms, and how to cure the problem itself. Sometimes the symptoms are easy to read and easy to cure. Other times, several problems exist in the water at the same time. Then it gets more complicated, and usually more costly to correct.

Let's examine these water problems as they will be reported to you by your customers ... the symptoms they see, taste, smell or fear. Along with the symptoms we will provide the cause of the condition, so you will be able to explain to our customer exactly what is going on with their water supply.

COMMON WATER PROBLEMS

HARDNESS
Calcium (Ca)
Magnesium (Mg)

The term hardness refers to the quantity of dissolved calcium and magnesium in water. These minerals, which come primarily from limestone type rock formations, are found to some degree in almost all natural waters. Calcium and magnesium cause problems for two principal reasons:

- When the water is warmed, they precipitate out of solution and form a hard, rock-like scale. This scale accelerates corrosion, restricts flow, and reduces heat transfer in water heaters and boilers.
- When they combine with soap, they react to form a curd, which interferes with cleaning, dries out skin, and leaves deposits on plumbing and clothes (bathtub ring; ring around the collar).

Hardness is measured in parts per million (or the equivalent mg/L) or in grains per gallon (gpg). Note: if the water analysis is given in ppm as $CaCO_3$ then 1 gpg = 17.1 ppm. A common aspirin tablet weighs 5 grains). There is no established limit for the acceptable level of hardness in water, but it is generally considered to become problematic at around 3 gpg.

Levels of hardness are referred to as follows:

Soft Water	0 - 1 grains per gallon (gpg)
Slightly Hard Water	1 - 3.5 grains per gallon (gpg)
Moderately Hard Water	3.5 - 7 grains per gallon (gpg)
Hard Water	7 - 10.5 grains per gallon (gpg)
Very Hard Water	over 10.5 grains per gallon (gpg)

Waters which naturally contain very little hardness can also be problematic because they may be corrosive in some applications (see acidity).

For some applications, sequestering agents (Siliphos) are good for hardness conditions under 15 gpg. The only practical method for hardness removal above 15 gpg in residential applications is through cation exchange process employed by water softeners (also called conditioners).

Acidity (pH)

Water which contains excess acidity tends to act aggressively towards plumbing and fixtures, causing corrosion and staining (i.e.-blue green stains on fixtures from copper pipes). Relative acidity/alkalinity is measured on the pH scale, ranging from 0- 1 4, where 7 is neutral, numbers lower than 7 are progressively more acidic, and numbers higher than seven are increasingly alkaline (basic). The pH value refers not to the quantity of acidity, but rather to the relative acidity/alkalinity of a particular sample.

Alkalinity acts as a buffer to deactivate the acidity, a process called neutralization. For example, limestone (calcium carbonate) is often applied to soil to offset the acidity which comes from acid rain and decaying organic material. The acceptable range for water is 6.5-8.5.

Acidity cannot be removed from water. However, it can be neutralized by raising the pH with alkalinity. This can be done by injecting a highly basic (alkaline) solution with a feed pump or by passing the water through a bed of processed limestone or similar material.

Iron (Fe)

The presence of Iron is a very common water quality problem, particularly in water from deep wells. Water containing even a significant quantity of iron may appear clear when drawn, but will rapidly turn red upon exposure to air. This process is called oxidation, and involves the conversion of ferrous (dissolved) iron, which is highly soluble, to ferric (precipitated) iron, which is largely insoluble. The ferric iron then causes red/brown staining on clothes, fixtures, etc.

Iron concentration is measured in ppm or mg/l (milligrams per liter, where 1 ppm = 1 mg/l). Staining usually becomes a problem at concentrations greater than 0.3 ppm. Removal is through ion exchange (water softener) or oxidation/filtration (APIR).

Manganese (Mn)

Manganese is a metal similar to iron which causes a grey/black stain. It can cause staining in concentrations as low as 0.05 ppm. Manganese is removed in a manner similar to iron, although oxidation is more difficult, requiring a pH of at least 8.5.

Hydrogen Sulphide (H_2S)

Hydrogen Sulphide is a gas which smells strongly like rotten eggs. It results from the decay of organic matter with organic sulphur and the presence of certain types of bacteria. Even very low concentrations are offensive as well as highly corrosive (silver tarnishes almost immediately upon contact with H_2S).

Because it is in a gaseous form, H_2S cannot be collected in a sample bottle for laboratory analysis. Therefore, its presence must be reported when a sample is submitted for a treatment recommendation. It can be removed by oxidation/filtration, aeration, or well sanitization.

Turbidity

Turbidity is a measure of suspended particles in water and can range from large particles which settle out of solution rapidly (such as sand), to extremely fine sediment which may stay suspended in solution even after standing for hours. Treatment depends upon size, which is measured in microns.

Tastes and Odours

Most tastes and odours are caused by the presence of organic matter and chlorine. The vast majority of these can be removed with activated carbon.

Organic Chemical Contaminants

The presence of toxic chemicals at various concentrations has been widely documented in many water supplies. Detection can be difficult as these contaminants often have no taste or odour. Treatment depends on type and concentration. These chemicals may be industrial solvents or agricultural pesticides and herbicides. One of the most common is Trihalomethane (THM) which is formed when chlorine in the water reacts with natural organic matter.

Total Dissolved Solids (TDS)

TDS is the sum of the mineral salts in water and if too high can result in objectionable taste, cloudy ice, interference with the flavor of foods and beverages and scale left behind in cookware. Generally speaking, the lower the TDS the more acceptable the drinking water. TDS of 1,000 ppm or more is unacceptable for drinking water. Reverse Osmosis (R0) process has proven itself as the most practical and cost effective method of correcting problems caused by high TDS.

Nitrates (NO_3)

Nitrates are inorganic chemicals dissolved in some water supplies as a result of feedlot and agricultural activities. Nitrate levels over 45 mg/L as actual NO_3 (or 10 mg/L as Nitrogen, N) can be a serious health risk to infants and children. Reverse Osmosis has proven itself as an effective method of reducing Nitrates to safe levels.

Heavy Metals
Lead (Pb)
Cadmium (Cd)
Mercury (Hg)
Arsenic (As)
Selenium (Se)
Chromium (Cr)

The so-called heavy metals are toxic elemental metals such as Lead, Cadmium, Mercury, and Arsenic that find their way into water supplies from natural and industrial sources as well as home plumbing. These metals, especially Lead, can seriously affect the mental and neurological development of infants and children. Reverse Osmosis (R0) is recognized as the most practical method of reducing Lead to insignificant levels in drinking water. Carbon Block technology that incorporates ceramic ion exchange media is also an effective method of reducing lead.

Radium 226/228 (Ra)

Radium occurs in ground water due to the radioactive decay of Uranium in geologic formation. There is a health risk if the Radium level exceeds 20 pecocuries per liter (pCi/L). Cation exchange water softeners using proper regeneration procedures are effective in reducing Radium for POE applications. Reverse Osmosis systems are effective for reducing Radium for POU applications.

MEASURING THE "INGREDIENTS" IN WATER

The world of water treatment has its own language that is used to express information. It's worth spending a little time learning this language so we will have an easier time understanding the extent of a particular water problem.

Dirt/Rust/Sediment/Turbidity

Particulate matter suspended in water is referred to as turbidity and is measured in Nephelometric Turbidity Units (NTU). A range of 0.5-1.0 NTU is the required limit for potable water. Higher levels of turbidity should be corrected with filtration.

Another measurement, the micron, is useful for measuring the size of particulate matter. A micron is one millionth of a meter or about 1/25,000 of an inch. Particles smaller than 30-40 microns cannot be seen with the naked eye and a 5 micron particle is about the size of a single grain of talcum powder.

Objectionable Colour

Objectionable colour in water is expressed in APHA units. Typically, colour levels above 25 APHA are noticeable. At levels of 50-60 APHA the water typically requires treatment.

Objectionable Odour

Objectionable odour from water is measured by the Threshold Odour Number (TON). The TON is the dilution factor required before an odour becomes minimally perceptible.

pH Scale

The pH Scale measures the relative acidity/alkalinity of a particular water sample. There are also several other contaminant measurement units with which you should be familiar. The first of these is pH, which measures the acidity or alkalinity of water due to dissolved substances.

pH scale
range 1 to 14

1+ most acidic
7 = neutral
14 = most alkaline

Water with a pH of below 6.5 or above 8.5 is generally unacceptable for drinking water.