WATER - WHAT ABOUT IT?

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ABSTRACT - Water purification techniques are briefly described, including filtering, distillation, softening, deionization and reverse osmosis. The units of measurement of water purity are explained and compared, and methods for achieving a desired water purity are listed. The water purification system in the textile conservation lab at the Minnesota Historical Society is described.

1. WATER PURIFICATION TECHNIQUES

Tap water contains many substances that could damage textiles, including particulate matter, dissolved metal ions such as the hardness ions calcium and magnesium, as well as iron and copper. Chlorine is added to municipal water to kill bacteria, and fluorine is added to many systems to prevent tooth decay.

Water purification techniques include filtering, distillation, softening, deionization, and reverse osmosis. Each technique removes some portion of the harmful substances listed above; no single technique removes all of them.

There are two kinds of filtering. Particulate filters are available in various pore sizes to remove particles of different diameters. Activated charcoal, or carbon, filters remove chlorine and organic compounds.

In distillation, water is boiled and the steam is condensed and collected. Ions, organics, microorganisms and particulates are removed by distillation, but only a small amount of mineral content is carried by the steam. This is usually in the range of 5 parts per million (ppm) or less.

Softening is a single-resin ion exchange technique. Water is passed through a resin or salt, which removes calcium and magnesium ions from water and exchanges them for sodium ions released from the resin. The number of ions in the water is actually higher after softening. Softening does not remove trivalent ions such as chlorine, particulates, organics, and the trivalent form of iron.

Deionization uses two resins to remove ions from water. Negatively charged cationic resins which have H+ ions on their surfaces adsorb anions from the water and replace them with the H+ ions. Similarly, anionic resins are positively charged, with OH- ions on their surfaces. Anions from water are adsorbed onto the surface of the resin, releasing the OH- ions. When a cationic resin is followed by an anionic, all ions are removed from the water, and the released H+ and OH- combine to form water. A mixed-bed deionizing system combines the cationic and anionic resins in a single tank, usually in proportions of 60:40.

In reverse osmosis, water is forced through a membrane that removes 85-95% of all ions in the water. Some ions are removed more efficiently than others, but some ions of all types remain in the water. Bacteria and particulates are effectively removed by reverse osmosis.

2. MEASUREMENT OF WATER PURITY

Conductivity is a measurement of the ability of water to carry an electric current. Minerals in the water increase conductivity; the more minerals, the higher the conductivity. Conductivity is measured in mhos[1]; deionized water has a very low conductivity which is measured in micromhos (one millionth of a mho).

Resistivity is a measurement of how much water resists the passage of an electric current. The more pure the water, the higher the resistance. Resistivity is measured in ohms; one megohm is one million ohms. Deionized water has a very high resistivity, measured in megohms.

The purity of deionized water is usually measured as resistivity, because of the magnitude of the measurement units involved. The margin for error is much smaller when you are working with millions of ohms as opposed to millionths of a mho. In theory, pure water has a resistance of 18 megohms at 25 degrees Centigrade.

The total dissolved solids, or ionic content, of water can also be measured and expressed as parts per million, 18 megohm water contains .028 ppm total dissolved solids, while 1 megohm water contains .5 ppm.

3. ACHIEVING A DESIRED WATER PURITY

There are several ways to achieve ultrapure water with a resistivity of 18 megohms, some more complicated or more practical than others. Use of reverse osmosis or distillation can be followed by a mixed-bed deionizing tank. Anionic and cationic deionizing resins in separate tanks will only achieve a resistivity of 500,000 ohms; they must also be followed by a mixed-bed tank to get 18 megohms. Mixed-bed tanks in a series of two or more tanks can be used to produce 18 megohm water, with carbon and particulate filters.

Some conservators prefer to have water of a lesser purity, about 1 to 4 megohms. This can also be achieved in several ways. The simplest way to do this is to use a single mixed-bed deionizing tank, combined with particulate and carbon filters. This will remove all of the cations and multivalent anions from the water, leaving only Na+ in quantities of about .5 ppm. Another way to do this would be to produce 18 megohm water through multiple mixed-bed tanks, and then add ions back into the water to get the desired purity. This allows one to remove all of the ions from the water, and to have control over which ions are added back in. In some systems, a solution of a chosen salt is added to the water flowing through the system by a metering pump controlled by a pulsemeter. In others, deionized water is passed through an additional resin tank which releases ions into the water.

4. THE WATER PURIFICATION SYSTEM IN THE TEXTILE CONSERVATION LABORATORY AT THE MINNESOTA HISTORICAL SOCIETY

When the Minnesota History Center was designed, a deionizing system was designed to serve both the textile and paper conservation laboratories. The feed water for this system was 50,000 ohm water produced for the building's humidification system. The water purification system as proposed consisted of a carbon prefilter, two mixed-bed deionizing tanks, and separate recirculating loops for hot and cold water, each with its own UV sterilizer.

A pulsemeter and metering pump were incorporated into the system to allow the purity of the water to be reduced. In practice, this part of the system is never used. The hot water component is also problematic. To prevent its rapid deterioration, the glass-lined hot water heater could not be left filled with deionized water and needed to be flushed and filled whenever hot water was required.

In the end, different requirements for the textile and paper labs led to the design of a second system for the textile lab. Because there were problems with low water pressure when the building's humidifiers were drawing from the system, the new system is fed from municipal tap water. Hot and cold tap water are blended to the desired temperature; a thermometer in the line displays the water temperature. The blended tap water passes through a carbon prefilter, and then a single mixed-bed deionizing tank. This is followed by a 5 micron particulate filter. The resins in the mixed-bed tank are degraded by water temperatures over 110 degrees Fahrenheit, which includes the water temperatures used in most treatments. A flowmeter records the number of gallons of water passing through the system, which facilitates calculation of percentages of solutions. There is no recirculation in this system; relatively short lengths of pipe prevent bacterial buildup, and the system is sanitized by annual flushing with hydrogen peroxide. This system produces water of 1-4 megohms resistivity, with the only ionic content being .5 ppm or less of Na+. The total cost for this system was the cost of the plumbing work required to connect to the tap water, plus the $600.00 per year tank rental from the vendor.

NOTES

1. The units of measurement mho and ohm are reciprocal; one mho is equal to 1/(ohm/cm). When conductivity is high, resistivity must be low, and vice versa.

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