Filtering Through the Claims of Varying Water Treatment Methods

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With all the attention in the news about problems with tap water, there is good reason for the boom in both bottled water sales and home water treatment systems. But does it really matter how the water is filtered? Is there really a difference between screens, strainers, cartridge filters, carbon filters, microfilters, ultrafilters, and reverse osmosis units? Well, quite simply, yes.

Water treatment methods are all designed with one goal: cleaner water. But there are varying degrees of "clean." For all practical purposes, there really is no such thing as "pure" water; the water we all drink contains much more than just H_2O. Fortunately, the human body either tolerates (or even craves) many of these extras—things like bicarbonates, calcium and other minerals that, in trace amounts, give water a "good" taste.

So before asking "*Which system?*" it may be more appropriate to ask "*What contaminants?*" The most important water contaminants to consider include:

- **suspended particles**, including sand, soil, silt, sediment and colloids,
- **dissolved inorganics**, including salts, minerals (especially those that contribute to hardness), nitrates, chlorides and metals such as arsenic, lead and iron,
- **dissolved organics**, including pesticides and natural byproducts from decaying vegetation, and
- **microorganisms**, including bacteria, *Giardia* cysts, *Cryptosporidium* and other parasites.

The type and quantity of these contaminants varies from water source to water source. Not only are regional water quality differences important, but determining whether the source is groundwater or surface water is critical. And with seasonal variations—increased silt levels in the spring from runoff, higher organics loading from leaves in fall—you can see that water quality is not a static thing.

Besides purifying water to meet health and safety standards, personal taste preferences can play a role, too. Additionally, children, the elderly and immunocompromised individuals may be more susceptible to even extremely low levels of certain contaminants (particularly microorganisms such as *Cryptosporidium*) and, thus, require a more stringent set of purification guidelines.

Fortunately, advances in water treatment technology enable us to stay ahead in the battle to ensure that we have clean water. In particular, advances in membrane manufacturing over the last few years have improved the technologies of microfiltration, ultrafiltration and reverse osmosis. More and more, these filtration methods are becoming viable options in the residential water treatment market. The big advantage that they provide over more conventional treatment technologies such as ion exchange (softening) is that they can remove particles, bacteria and parasites. In fact, many of the parasites that have created problems in municipal drinking water supplies around the country are so small that membrane filtration is one of the few effective ways of removing them. The following table will give you some sense of scale:

- ≥100 microns—grains of beach sand
- 1.0-100 microns—milled flour particles
- >1.0 micron—*Cryptosporidium*
- 30-200 microns—diameter of human hair
- 0.2-40 microns—bacteria
- 0.25–1.0 microns—circuit line on a computer chip
- 0.003–0.05 microns—viruses
- 0.002–0.03 microns--pyrogens

So let's take a look at some of the most popular methods of filtration that are commercially available today.

Pretreatment filters, screens and strainers (range: 0.1 to greater than 1000 microns). Based on separation by physical size, coarse filtration, screening and straining are common and inexpensive pretreatment steps that protect more advanced filtration equipment from fouling by particles and other large impurities. These pretreatment steps are particularly important when feed water comes directly from a well or from an old or problematic water distribution system where sediment, rust, scale and other debris may be a problem.

Screens and strainers are best for removing large particles (particles as small as 40 microns). Their advantage is that they can often be manually cleaned and reused. Cloth and fiber filters can remove particles down to about 15 microns. Disposable cartridge filters can remove contaminants down to about 0.1 micron. Additionally, carbon filters can be extremely valuable for treating feed water that contains organics, pesticides or chlorine-containing compounds.

Microfiltration (range: 0.05 to 10 microns). Microfiltration can use one of three filtration techniques: depth filtration, screening or surface (membrane) filtration. Membrane-based microfiltration is a low-pressure (typically 1 to 10 psi) process. Microfiltration separates suspended materials from water. Along with the water, some macromolecules (colloids) and all dissolved species pass through the filter.

To avoid some confusion, an extremely important clarification needs to be made in filter ratings. A nominal filter will remove *most* of the particles greater than the pore size rating of its membrane. Only an "absolute filter" removes *all* of the particles greater than the specified size. An important number to remember: a 0.1-micron absolute filter will retain all bacteria.

Ultrafiltration (range: 0.001 to 0.05 microns). Ultrafiltration is a pressure-driven (usually 10-150 psi) membrane-based process. Unlike conventional filtration, membrane filtration can use cross-flow technology in which the feed stream passes parallel to the filter media (membrane). Clean water passes through the membrane; contaminants are stopped by the membrane and continually swept away by the parallel flow of water past the membrane surface, thus reducing clogging and blinding on the membrane surface.

The ultrafiltration process functions as a molecular sieve, separating molecules by size in a selectively permeable membrane. Ultrafiltration membranes retain contaminants such as suspended solids, bacteria, colloidal silica and very large organic molecules, passing only water and low molecular weight species. Significantly, ultrafiltration removes bacteria, pyrogens and viruses such as *Cryptosporidium*.

Reverse osmosis (range: 0.0001 to 0.005 microns). Even though reverse osmosis and ultrafiltration are both membrane-based separation methods, reverse osmosis is distinctly different. While it is a cross-flow technique like ultrafiltration, it requires high pressures. By applying a pressure higher than osmotic pressure, reverse osmosis separates water from both the suspended *and* dissolved contaminants in it. The pressure forces water through the membrane, leaving the impurities behind.

Improvements in both equipment design and membrane fabrication have reduced the operating pressures necessary to achieve the desired separation to below 200 psi. Because of the nature of the process, clean water flow can be relatively slow. While not a critical concern for most residential needs, for higher volume applications, the membrane area must be boosted accordingly.

Significantly, reverse osmosis not only rejects particles and large molecules, but it also excludes much smaller dissolved salts and metal ions (ionic in nature) and low molecular weight species based on a charge phenomenon action. The semipermeable membrane actually works better on polyvalent ions (ions with more than one positive or negative charge, such as Ca^{++}, Mg^{++}, or SO_4^{--}) than it does on monovalent (single-charge) ions such as Na^{+} or Cl^{-}. Typically, reverse osmosis can remove greater than 99 percent of all polyvalent ions and greater than 95 percent of all monovalent ions.

Choosing the right filter begins with understanding which contaminants need to be removed from the water.

What's best?

Obviously, if there were one "best" choice, the selection process would be easy (and vendor literature would be pretty slim). But the myriad possibilities in feed water sources and quality, as well as personal preferences as to just what constitutes "good" water, makes choosing a treatment method a very personal choice.

Choosing the right filter begins with understanding which contaminants need to be removed from the water. Suspended particles, dissolved inorganics, dissolved organics, and microorganisms each present somewhat different removal challenges, so pick the method that best meets the actual needs of the particular application. •

About the Author:
U. S. Filter is the world's largest manufacturer of water and waste-water treatment equipment, systems and services for industrial, commercial, municipal, and residential customers. With corporate offices in Palm Desert, California, U.S. Filter serves customers through its worldwide network of more than 350 sales and service facilities.

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