Water Education

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DIFFERENT WATER FILTRATION METHODS EXPLAINED

Water Purification Technologies

Whole House Water Filters

Shower & Bath Filters

Healthy Water Bottles

- Distillation
- Ion Exchange
- Carbon Adsorption
- Filtration
- Ultrafiltration
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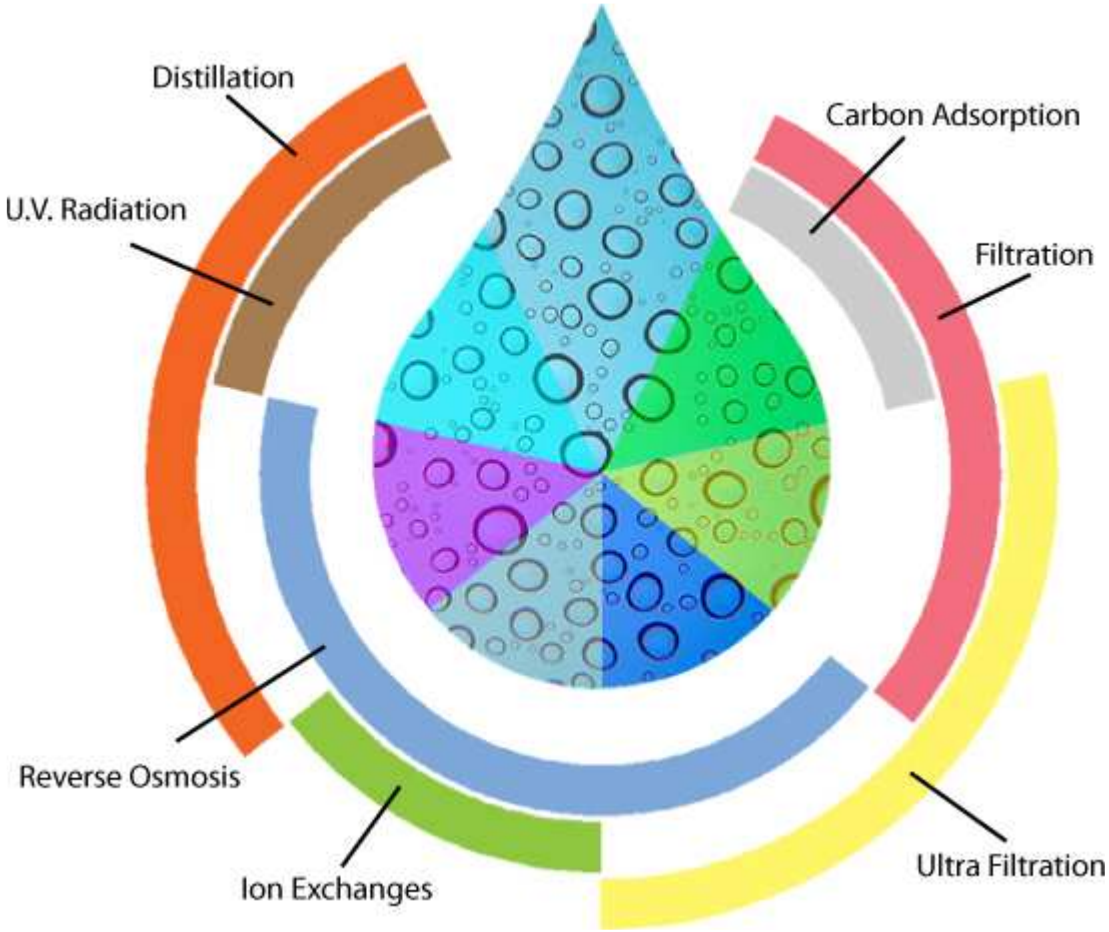


Did you know?
Reverse osmosis is the finest water filtration method known. This process will allow the removal of particles as small as ions from a solution. It is used to purify water and remove salts and other impurities in order to improve the color, taste or properties of the fluid. R.O. uses a membrane that is semi-permeable, allowing the fluid that is being purified to pass through it, while rejecting other ions and contaminants from passing. This technology uses a process known as crossflow to allow the r.o. membrane to continually clean itself. This is the reason of why an r.o. element can last many years before clogging or need replacement. This water purification process requires a driving force to push the fluid through the membrane, and the most common force is household water pressure or pressure from a booster pump. The higher the pressure, the larger the driving force and efficiency.

Distillation

Distillation is probably the oldest method of water purification. Water is first heated to boiling. The water vapor rises to a condenser where cooling water lowers the temperature so the vapor is condensed, collected and stored. Most contaminants remain behind in the liquid phase vessel. However, there can sometimes be what is called carry-overs in the water that is distilled. Organics **such as herbicides and pesticides,** with boiling points lower than 100 Â°C cannot be removed efficiently and can actually become concentrated in the product water. Another disadvantage is cost. Distillation requires large amounts of energy and water.

Distilled water can also be very acidic, having a low pH, thus should be contained in glass. Since there is not much left, distilled water is often called "hungry" water. It lacks oxygen and minerals and has a flat taste, which is why it is mostly used in industrial processes.

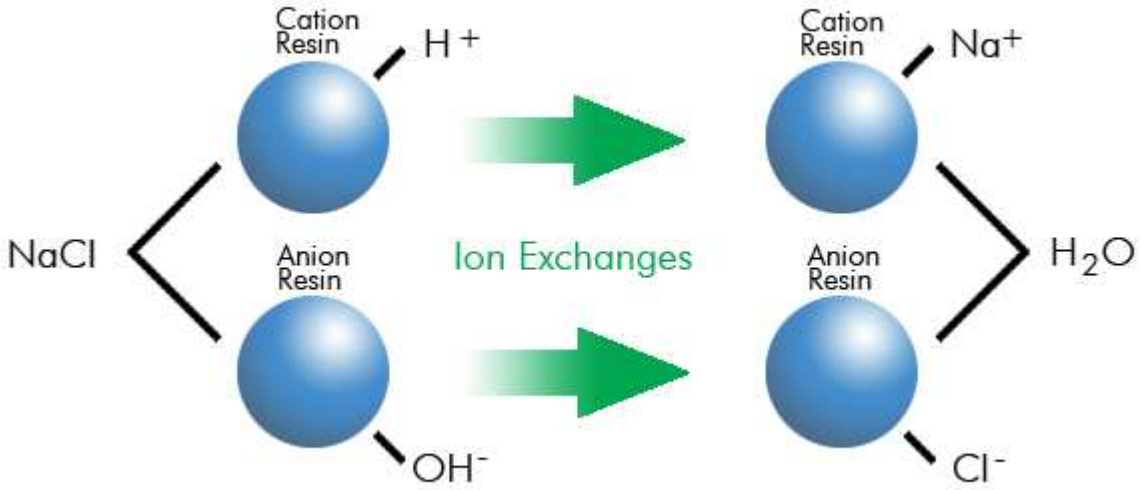
Table 1. Distillation

Advantages	Disadvantages
Removes a broad range of contaminants	Some contaminants can be carried into the condensate
Reusable	Requires careful maintenance to ensure purity
	Consumes large amounts of energy
	System usually takes a large space on counter

Ion Exchange

The ion exchange process percolates water through bead-like spherical resin materials (ion-exchange resins). Ions in the water are exchanged for other ions fixed to the beads. The two most common ion-exchange methods are softening and deionization.

Softening is used primarily as a pretreatment method to reduce water hardness prior to reverse osmosis (RO) processing. The softeners contain beads that exchange two sodium ions for every calcium or magnesium ion removed from the "softened" water.



Deionization (DI) beads exchange either hydrogen ions for cations or hydroxyl ions for anions. The cation exchange resins, made of styrene and divinylbenzene containing sulfonic acid groups, will exchange a hydrogen ion for any cations they encounter (e.g., Na+, Ca++, Al+++). Similarly, the anion exchange resins, made of styrene and containing quaternary ammonium groups, will exchange a hydroxyl ion for any anions (e.g., Cl-). The hydrogen ion from the cation exchanger unites with the hydroxyl ion of the anion exchanger to form pure water.

These resins may be packaged in separate bed exchangers with separate units for the cation and anion exchange beds. Or, they may be packed in mixed bed exchangers containing a mixture of both types of resins. In either case, the resin must be "regenerated" once it has exchanged all its hydrogen and/or hydroxyl ions for charged contaminants in the water. This regeneration reverses the purification process, replacing the contaminants bound to the DI resins with hydrogen and hydroxyl ions.

Deionization can be an important component of a total water purification system when used in combination with other methods discussed in this primer such as RO, filtration and carbon adsorption. DI systems effectively remove ions, but they do not effectively remove most organics or microorganisms. Microorganisms can attach to the resins, providing a culture media for rapid bacterial growth and subsequent pyrogen generation. The advantages and disadvantages of this technology are summarized below.

Table 3. Deionization

Advantages	Disadvantages
Removes dissolved inorganics effectively.	Does not effectively remove particles, pyrogens or bacteria.

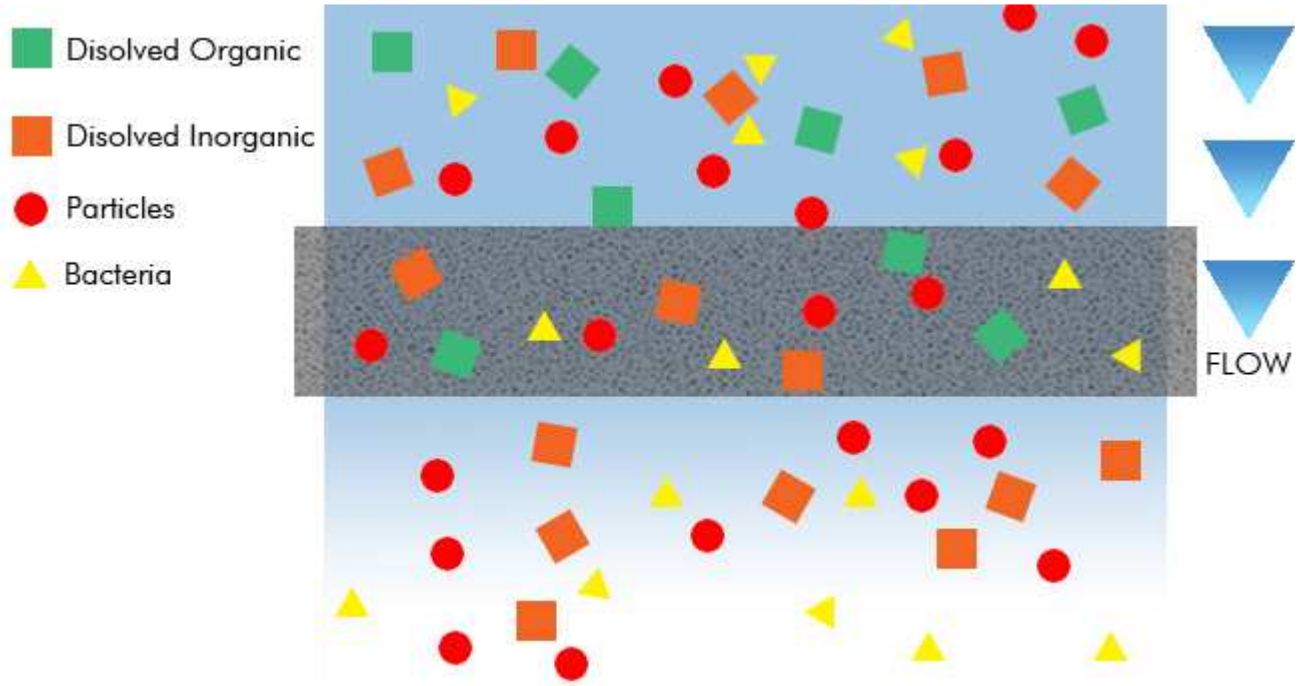
Regenerable (service deionization).	DI beds can generate resin particles and culture bacteria.
Relatively inexpensive initial capital investment.	High operating costs over long-term.

Carbon Adsorption

Carbon absorption is a widely used method of home water filter treatment because of its ability to improve water by removing disagreeable tastes and odors, including objectionable chlorine. Activated carbon effectively removes many chemicals and gases, and in some cases it can be effective against microorganisms. However, generally it will not affect total dissolved solids, hardness, or heavy metals. Only a few carbon filter systems have been certified for the removal of lead, asbestos, cysts, and coliform. There are two types of carbon filter systems, each with advantages and disadvantages: granular activated carbon, and solid block carbon. These two methods can also work along with a reverse osmosis system, which can be read about below.

Activated carbon is created from a variety of carbon-based materials in a high-temperature process that creates a matrix of millions of microscopic pores and crevices. One pound of activated carbon provides anywhere from 60 to 150 acres of surface area. The pores trap microscopic particles and large organic molecules, while the activated surface areas cling to, or adsorb, small organic molecules.

The ability of an activated carbon filter to remove certain microorganisms and certain organic chemicals, especially pesticides, THMs (the chlorine by-product), trichloroethylene (TCE), and PCBs, depends upon several factors, such as the type of carbon and the amount used, the design of the filter and the rate of water flow, how long the filter has been in use, and the types of impurities the filter has previously removed.



The carbon adsorption process is controlled by the diameter of the pores in the carbon filter and by the diffusion rate of organic molecules through the pores. The rate of adsorption is a function of the molecular weight and the molecular size of the organics. Certain granular carbons effectively remove chloramines. Carbon also removes free chlorine and protects other purification media in the system that may be sensitive to an oxidant such as chlorine.

Carbon is usually used in combination with other treatment processes. The placement of carbon in relation to other components is an important consideration in the design of a water purification system.

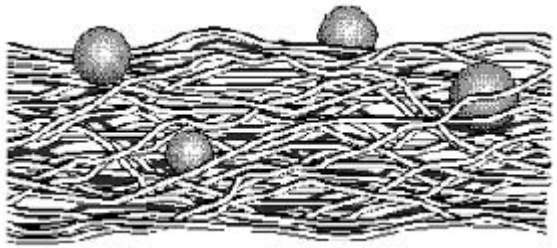
Table 3. Carbon Adsorption

Advantages	Disadvantages
Removes dissolved organics and chlorine effectively.	Can generate carbon fines.
Long life (high capacity).	

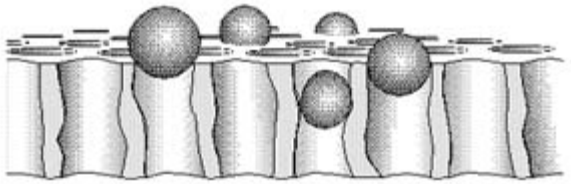
Microporous Basic Filtration

There are three types of microporous filtration: depth, screen and surface. Depth filters are matted fibers or materials compressed to form a matrix that retains particles by random adsorption or entrapment. Screen filters are

inherently uniform structures which, like a sieve, retain all particles larger than the precisely controlled pore size on their surface. Surface filters are made from multiple layers of media. When fluid passes through the filter, particles larger than the spaces within the filter matrix are retained, accumulating primarily on the surface of the filter.



The distinction between filters is important because the three serve very different functions. Depth filters are usually used as prefilters because they are an economical way to remove 98% of suspended solids and protect elements downstream from fouling or clogging.



Surface filters remove 99.99% of suspended solids and may be used as either prefilters or clarifying filters. Microporous membrane (screen) filters are placed at the last possible point in a system to remove the last remaining traces of resin fragments, carbon fines, colloidal particles and microorganisms.

Table 4. Microporous Membrane Filtration

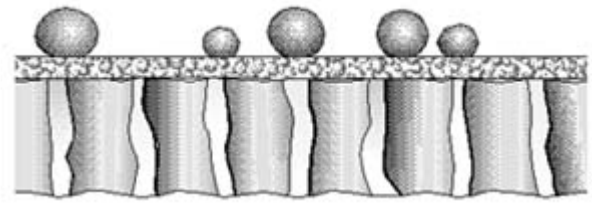
Advantages	Disadvantages
Absolute filters remove all particles and microorganisms greater than the pore size.	Will not remove dissolved inorganics, chemicals, pyrogens or all colloidals.
Requires minimal maintenance.	Potentially high expendable costs.
	Not regenerable.

Ultrafiltration

A microporous membrane filter removes particles according to pore size. By contrast, an ultrafiltration (UF)

membrane functions as a molecular sieve. It separates dissolved molecules on the basis of size by passing a solution through an infinitesimally fine filter.

The ultrafilter is a tough, thin, selectively permeable membrane that retains most macromolecules above a certain size including colloids, microorganisms and pyrogens. Smaller molecules, such as solvents and ionized contaminants, are allowed to pass into the filtrate. Thus, UF provides a retained fraction (retentate) that is rich in large molecules and a filtrate that contains few, if any, of these molecules.



Ultrafilters are available in several selective ranges. In all cases, the membranes will retain most, but not necessarily all, molecules above their rated size.

Table 5. Ultrafiltration

Advantages	Disadvantages
Effectively removes most particles, pyrogens, microorganisms, and colloids above their rated size.	Will not remove dissolved inorganics.
Produces highest quality water for least amount of energy.	
Regenerable.	

Reverse Osmosis

Reverse osmosis (RO) is the most economical method of removing 90% to 99% of all contaminants. The pore structure of RO membranes is much tighter than UF membranes. RO membranes are capable of rejecting practically all particles, bacteria and organics >300 daltons molecular weight (including pyrogens). In fact, reverse osmosis technology is used by most leading water bottling plants.

Natural osmosis occurs when solutions with two different concentrations are separated by a semi-permeable membrane. Osmotic pressure drives water through the membrane; the water dilutes the more concentrated solution; and the end result is an equilibrium.

In water purification systems, hydraulic pressure is applied to the concentrated solution to counteract the osmotic

pressure. Pure water is driven from the concentrated solution and collected downstream of the membrane.

Because RO membranes are very restrictive, they yield slow flow rates. Storage tanks are required to produce an adequate volume in a reasonable amount of time.

RO also involves an ionic exclusion process. Only solvent is allowed to pass through the semi-permeable RO membrane, while virtually all ions and dissolved molecules are retained (including salts and sugars). The semi-permeable membrane rejects salts (ions) by a charge phenomena action: the greater the charge, the greater the rejection. Therefore, the membrane rejects nearly all (>99%) strongly ionized polyvalent ions but only 95% of the weakly ionized monovalent ions like sodium.

Reverse osmosis is highly effective in removing several impurities from water such as total dissolved solids (TDS), turbidity, asbestos, lead and other toxic heavy metals, radium, and many dissolved organics. The process will also remove chlorinated pesticides and most heavier-weight VOCs. Reverse osmosis and activated carbon filtration are complementary processes. Combining them results in the most effective treatment against the broadest range of water impurities and contaminants.

RO is the most economical and efficient method for purifying tap water if the system is properly designed for the feed water conditions and the intended use of the product water. RO is also the optimum pretreatment for reagent-grade water polishing systems.

In addition, Reverse osmosis treatment is an insurance policy against nuclear radiation such as radioactive plutonium or strontium in the drinking water. If one lives near a nuclear power plant, this is a key way to ensure the household is drinking the best water for their health.

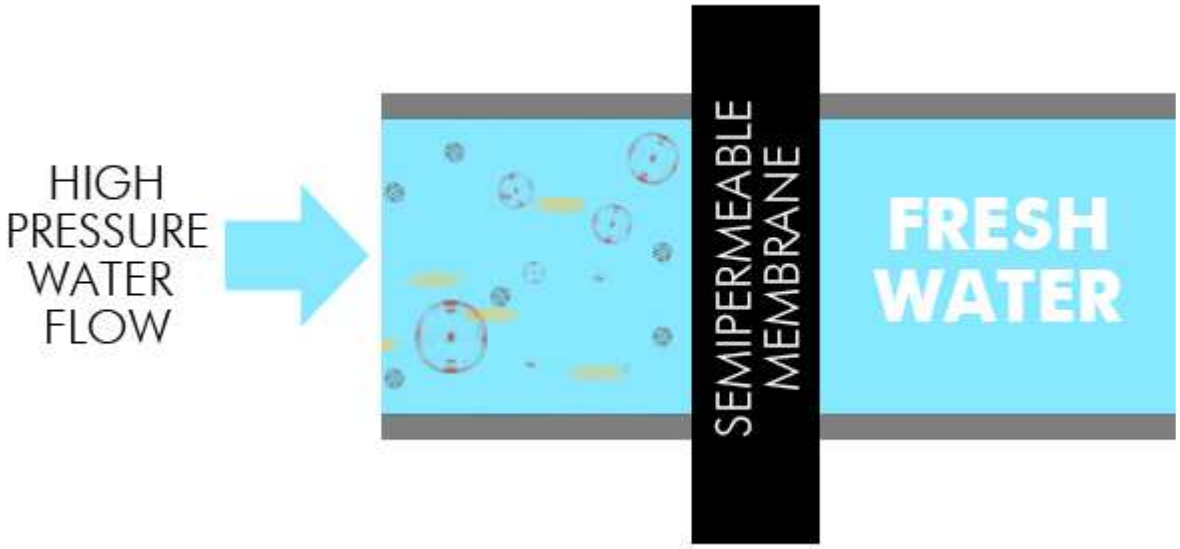
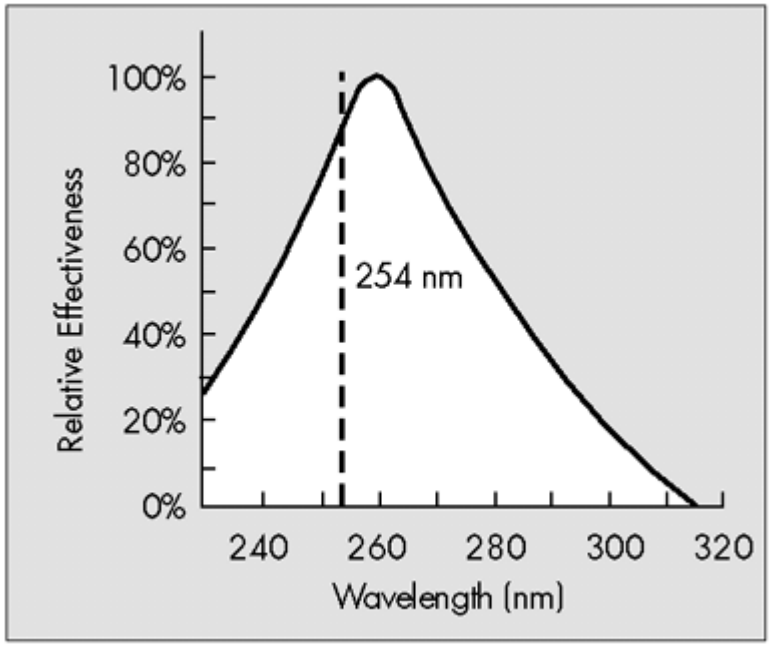


Table 6. Reverse Osmosis

Advantages	Disadvantages
Effectively removes all types of contaminants to some extent (particles, pyrogens, microorganisms, colloids and dissolved inorganics).	Flow rates are usually limited to a certain gallons/day rating.
Requires minimal maintenance.	

Ultraviolet (UV) Radiation

Ultraviolet radiation has widely been used as a germicidal treatment for water. Mercury low pressure lamps generating 254 nm UV light are an effective means of sanitizing water. The adsorption of UV light by the DNA and proteins in the microbial cell results in the inactivation of the microorganism.

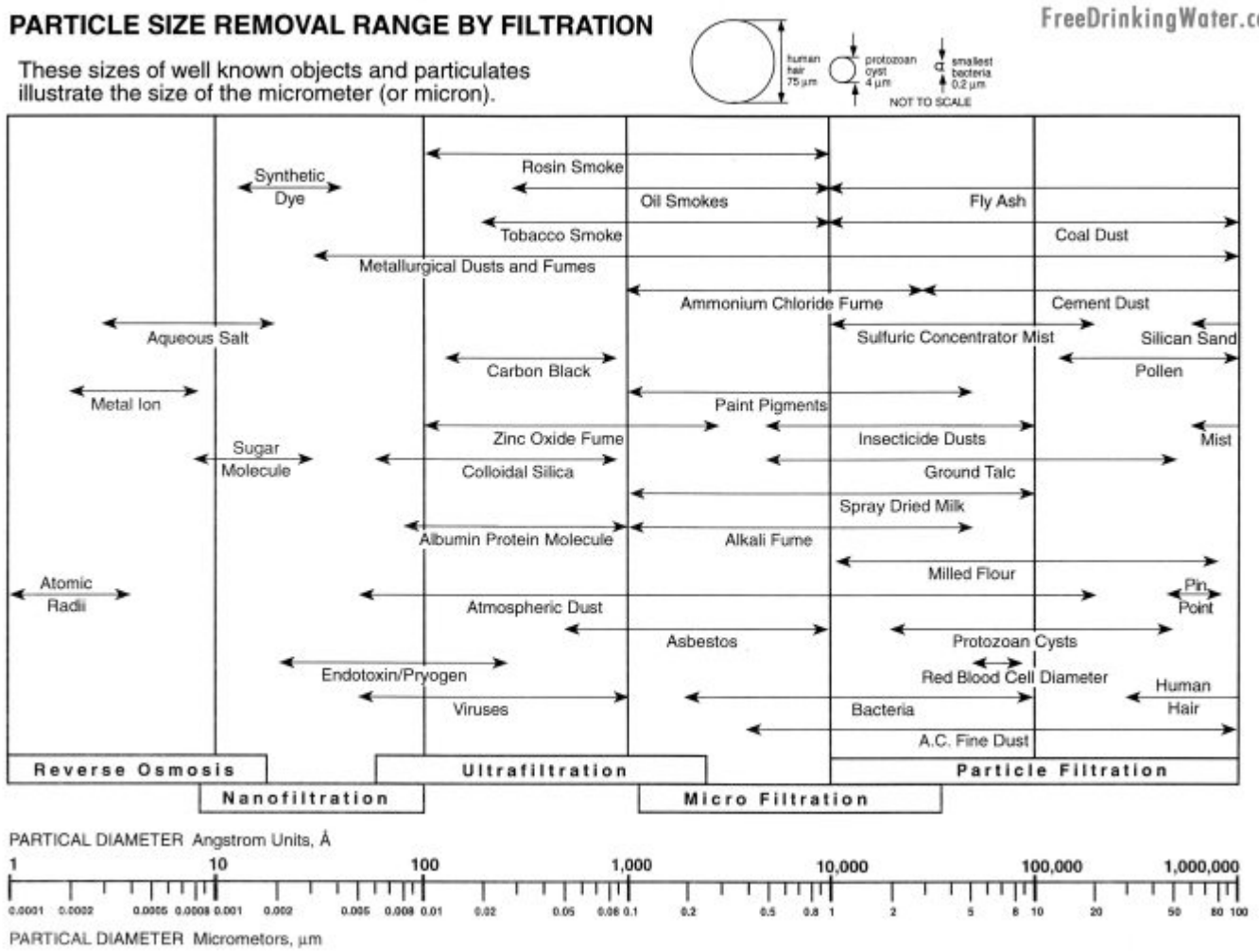


Recent advances in UV lamp technology have resulted in the production of special lamps which generate both 185 nm and 254 nm UV light. This combination of wavelengths is necessary for the photooxidation of organic compounds. With these special lamps, Total Organic Carbon (TOC) levels in high purity water can be reduced to 5 ppb.

Table 8. Ultraviolet Radiation

Advantages	Disadvantages
Effective sanitizing treatment.	Decreases resistivity.
Oxidation of organic compounds (185 nm and 254 nm) to < 5 ppb TOC	Will not remove particles, colloids, or ions

Pulling It All Together

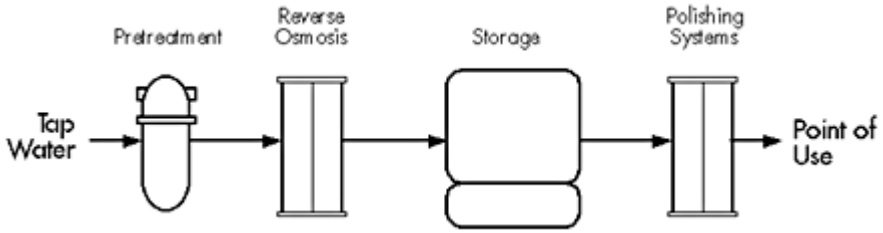


Water Purification Systems

Because each purification technology removes a specific type of contaminant, none can be relied upon to remove all contaminants to the levels required for critical applications. A well-designed water purification system uses a combination of purification technologies to achieve final water quality.

Each of the purification technologies must be used in an appropriate sequence to optimize their particular removal capabilities. The schematic below shows a central laboratory water purification system designed to produce water for critical applications.

The first step is pretreatment equipment specifically designed to remove contaminants in the feed water. Pretreatment removes contaminants that may affect purification equipment located downstream, especially reverse osmosis (RO) systems. Examples of pretreatment are: carbon filters (or tanks) for chlorine removal, particulate filters for sediment/silt/particulate removal, and softening agents to remove minerals that cause "hard" water.



The next purification step is RO. RO removes 90 to 99% of all the contaminants found in water. It is the heart of any well designed water purification system because it effectively removes a broad range of contaminants.

However, the tight porosity of the RO membrane limits its flow rate. Therefore, a storage container is used to collect water from the system and distribute it to other points-of-use such as polishing systems.

Polishing systems purify pretreated water, such as RO water, by removing trace levels of any residual contaminants. Polishing elevates the quality of pretreated water to "Type I" or "ultrapure" water.

A polishing system is designed to remove residual traces of impurities from water already pretreated by some other means (such as reverse osmosis or deionization). Treating raw tap water using such a system would quickly exhaust its capacity and affect final quality.

A typical polishing system may consist of activated carbon, mixed-bed deionization, organic scavenging mixtures and 0.22 Âµm final filtration. Systems can also be enhanced with ultrafiltration, ultraviolet oxidation or other features for use in specific applications.

This combination of purification technologies, combined with proper pretreatment, will produce water that is virtually free of ionic, organic and microbial contamination.

Healthy and Convenient! Our Featured Reverse Osmosis Drinking Water System

More Topics on Water Quality & Treatment:

- General water treatment
- Water quality defined
- Hydrologic cycle of water
- Meteoric water and cycle
- Environmental factors of water
- Age of ground water
- Temperature of ground water
- Water quality of surface water
- Cistern water quality
- Summary of water quality and the environment
- Hard water explained
- Hard water problems
- Softened water energy savings
- Hard water analysis
- Hard water and soap curd
- Ion exchange principles
- More on water softening
- Home water softener basics
- Water deionization
- Lime soda ash water treatment
- Water softener alternatives
- 3 Types of basic water
- TDS-Total dissolved solids
- Reverse osmosis treatment
- Alkalinity of water
- Reverse osmosis and pH
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- Chloride and sulfate
- Fluoride in drinking water
- Hydrogen sulfide in water
- Nitrate/ nitrogen in water
- Oxygen in drinking water
- Silica in drinking water
- Sodium/methane/ phenol
- Disease-causing organisms
- Micro-organism in water1
- Micro-organism in water2
- Viruses in drinking water
- Bacteria in drinking water
- Water disinfect methods1
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- Water disinfect-chlorine
- Dechlorinating filters Q&A
- Palatability of water
- Turbidity of drinking water
- Mechanical filtration
- Multi-media (depth filters)
- Color of drinking water

- Self maintenance guideline for private well owners
- Water pressure matters
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- Public water systems users
- The guardian-Safe Drinking Water Act
- The correct disinfection practice
- Facts on home water treatment
- Experiment1-water cycle purify our drinking water
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- Experiment3-waster filtration
- Experiment4-build an aquifer
- Experiment5-pollution control by using carbon
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- Lead in your drinking water?
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- Read the bottled water label
- Common bottled water treatment II
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- Earth water distribution
- A natural setting for fishs
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- Common contaminants in the water system
- Microbes & water quality
- The origination of modern water filtration
- Define Spring water & the safety
- Water quality issues in Europe
- Seawater drinkable?

- How do water treatment plants work
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- Enough water for the future?
- Water & agriculture..big connection
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- Negotiation of Water Rights
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- Water treatment techniques in the 70's & 80's
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- To filter or purify water
- The physical parameters of good water quality
- The chemical parameters of good water quality
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- The "hidden" dangers of water
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- Coliform bacteria affect water quality
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- Stone Fly & May Flies show the water quality
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- Corrosion on the common household used metals
- How to choose the right plumber to install water softener
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Nuclear atom-Protons, Neutrons, & Electrons
Basic atom in Flourine, Magnesium, & Chlorine
The Isotopes of Hydrogen
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Ionic reaction in natural
Remove Ionic impurities from water
Chemical term explained-Valence

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An effective treatment for medium concentrations of Iron
Sequestration-Polyphosphate treatment explained
Chemical solution feeders explained
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Solution for pressure drop II- water softener

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Concern about GAC filtration systems that trap nitrate
Legality for a salt-based water softener
Methods of regenerate manganese greensand filter media
From chlorine to chlormaines
Humidifers operate better using filtered & purified water

Consumer confidence report to the public
Water contaminants -Cyanobacteria
Reverse osmosis can filter out Cryptosporidiosis microbes
Taste of water - TDS level
Private well water supplies - risk for Radon
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Biofouling in a water pump/filter/plumbing system
Reasons for testing total coliforms & fecal coliforms
Drinking water reservoirs-manganese problems due to temperature stratification
Ozone treatment remove iron or manganese from water
Bacterial colonies-Biofilms
Public water treatment cost-Petroleum

Chloramines disinfection - Nitrite problem
Bottled water regulation - Mercury
The strangest compound known to man
The new detection of low levels of enteric viruses
The use of bio-sensors to detect Crypotosporidium-parvum bacteria
Produce higher quality well-water
Controlling taste & odor - Arizona
Methylmercury is a concern in aquatic environments
Time to backwash your acid neutralizing filter
Protecting pubic water systems from terrorist threats
Ultrafiltration(UF) & membrane filter technology
Restore oxidizing power of greensand water filters-potassium permanganate
Public health & bioterrorism act
Synthetic chemical vs. nature chemical-toxic level

Blue-green algae in surface water & distribution networks
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Blue-green algae & cyanobacteria
The Effectiveness of Membrane filtration systems
The major elements of a consumer confidence report
Membrane technology
Viruses/bacteria/protozoan-the hardest to kill in drinking water
Genetic mutations of microbes
Private well water test-Nitrate
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Differentiate water filter system, descaler, conditioner, water softener
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Does water have unique thermal properties?
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Can water and oil be mixed to form a solution?
Can we produce electricity from tides and waves?
Can wetting agents improve the efficiency of irrigation water
How much water was used to produce the food item?
Do polyelectrolyte type chemical form

Can the oceans serve as a great power source for the earth?
Will salt dissolved in water increase or lower pH?
How do you calculate power needs for pumping water?
How does capillarity affect soil water holding capacity?
How does natural purification of liquid water work on earth?
How important are ocean phytoplankton organisms to total global photosynthesis?
How is energy generated in a hydroelectric power plant?
Sodium hexametaphosphate used as a dispersing & deflocculating agent
How is water a powerful source of energy?

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The distance from septic tanks & fieldlines for private wells
Constructed a well-reduce the likelihood of contamination from a septic system
What is the cause of odor that resembles chloroform in my private well?
Should I worry about water pollution from antifreeze leaks onto my driveway?
Water pollution from solvents down

evaporated from the earth's hydrologic cycle
How much water returns to the earth's land surface as precipitation
Electric current-Seperate pure water into acidic/alkaline components
Improve water quality for certain uses with some contaminants
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How does natural purification of liquid water work on earth?
How do algae blooms cause severe oxygen depletion in water?
Is drinking water that meets drinking water standards suitable for kidney dialysis machines to remove wastes from a person?
What does water purity really mean?
What do we mean by an "unhealthy aquatic ecosystem?"

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Does our neighboring planet of Mars have water?
Dose water dousing really work?
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An indicator of chemical pollution with specific conductance of water
Can algae have beneficial effects on water supplies?
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What are brine wells?
What are silicates & why are they in water?
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How salty is sea water in comparison to fresh water?
Is sea water the saltiest water found on earth?
What are the key factors that influence water quality?
What does the definition of critical period mean for water purity standard?
What are the key factors that influence water quality?
The activity/action/practice that reduce natural water purification

the household drain
What can I do to prevent water pollution?
The recommended setback distance for a new private well from an operating or unplugged abandoned well
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Radiator coolant water from automobiles that contain ethylene glycol antifreeze may kill animals
Drinking water standards vs. kidney dialysis standards
Is it common to find pure water in nature?
Is water pollution & water contamination the same thing?
What do we mean by water quality?
Silica/Silicates concentration in fresh surface/ground water supplies on earth

We are proud to be the authoritative website for information on water quality solutions, water purification and treatment. We provide heavy duty, professional water filtering products to remove contaminants caused by industrial and agricultural water pollution and contamination to provide safe and pure drinking water. Many of our top quality home reverse osmosis drinking water systems, whole house water filters, salt-free water softeners, and electronic water softeners/conditioners are currently on sale.

= Products of Superior Performance and Dependability