MODULE 4: FILTRATION

INSPECTION CERTIFICATE ASSOCIATES

Filtration

- Prior to the design of a proper filtration system, the water should be tested to ensure the proper equipment and methods are used. The filtration system can also improve the quality of the smell and taste of the water for a more pleasant consumption.

Filtration vs Treatment

- Filtration is the act of passing water through a membrane where as treatment is using outside elements to act on the chemicals or organisms in the water.
- For the purposes of the course, we will be calling both filtration.

Locations of Filtration

Point of Entry

- This is a filtration system that is set up at the service entrance of the home. It is designed to both improve the water quality and to prevent problems with the plumbing system inside the home.

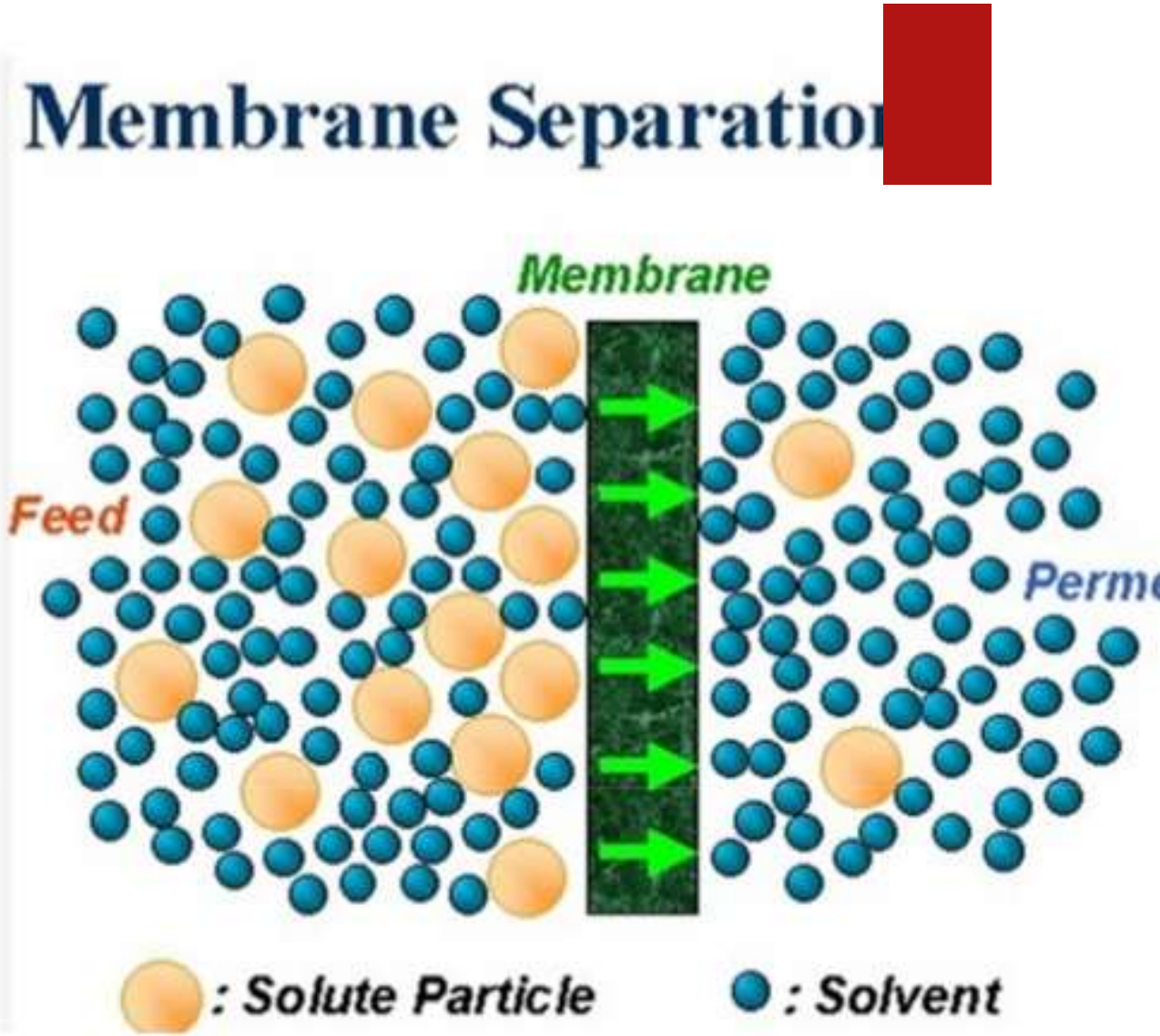
Point of Use

- This is a system that is set up prior to a fixture i.e. under the kitchen sink.

Combination

- It is not uncommon for filtration systems to be setup prior to entry into the home and at the point of use to increase taste and possibly even potability

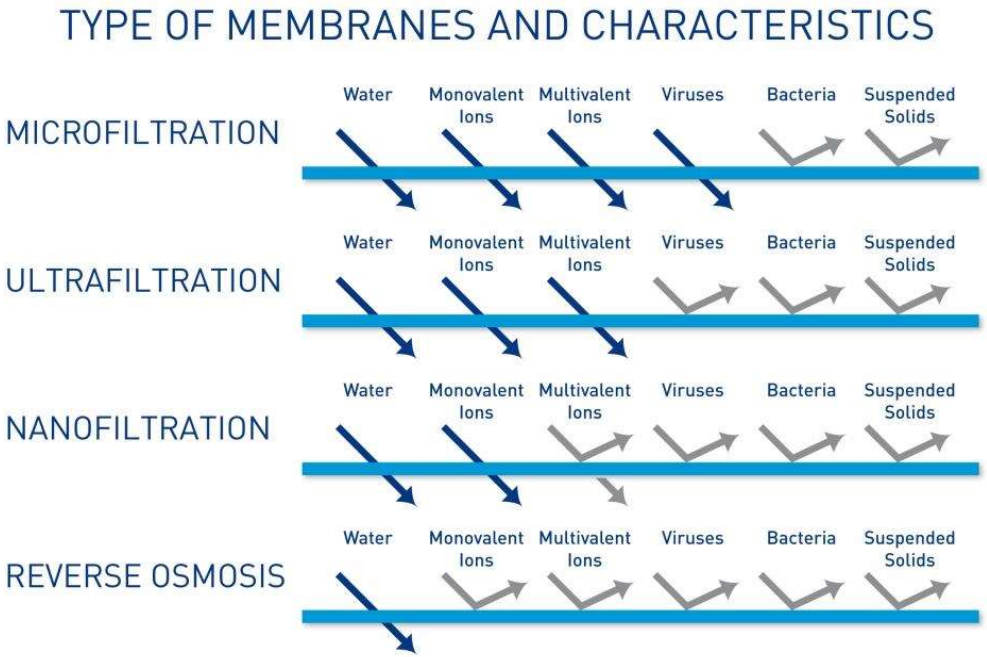
Process of Filtration

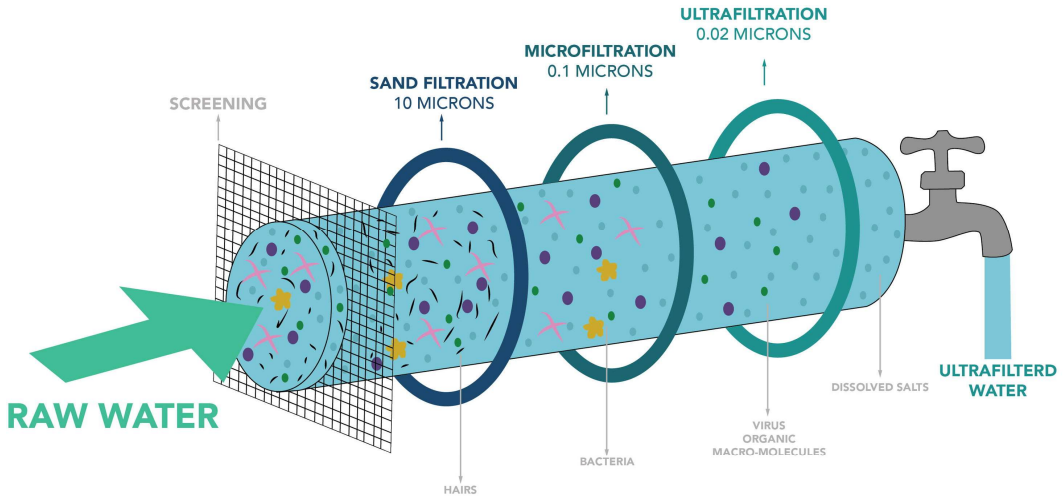


Filtration

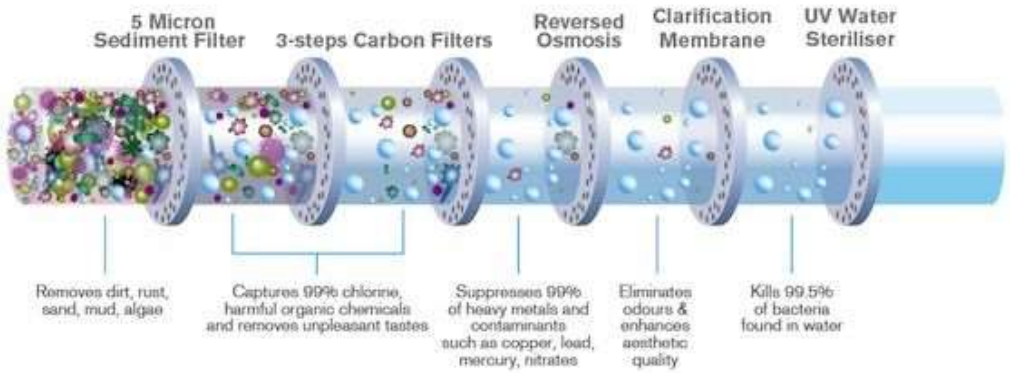
- Filtration is a physical process that occurs when liquids, gases, dissolved or suspended matter adhere to the surface of, or in the pores of, an absorbent medium.
- Filtration of contaminants depends highly on the amount of contaminant, size of the contaminant particle, and the charge of the contaminant particle. Depending on the household's water needs, pretreatment before filtration may include the addition of coagulants and powdered activated carbon, adjustments in pH or chlorine concentration levels, and other pretreatment processes in order to protect the filter's membrane surface.

Types of Membranes





Graduated Filtration Process



Common Setup

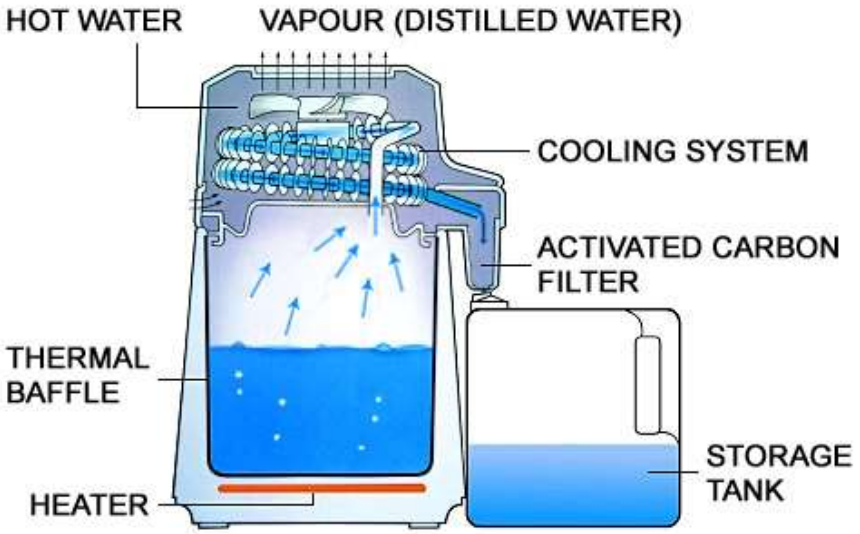
Types of Membranes

- Wound String
- Layered
- Pleated
- Resin Bonded
- Spun Polypropylene
- Carbon Pleated
- Ceramic

Distillation

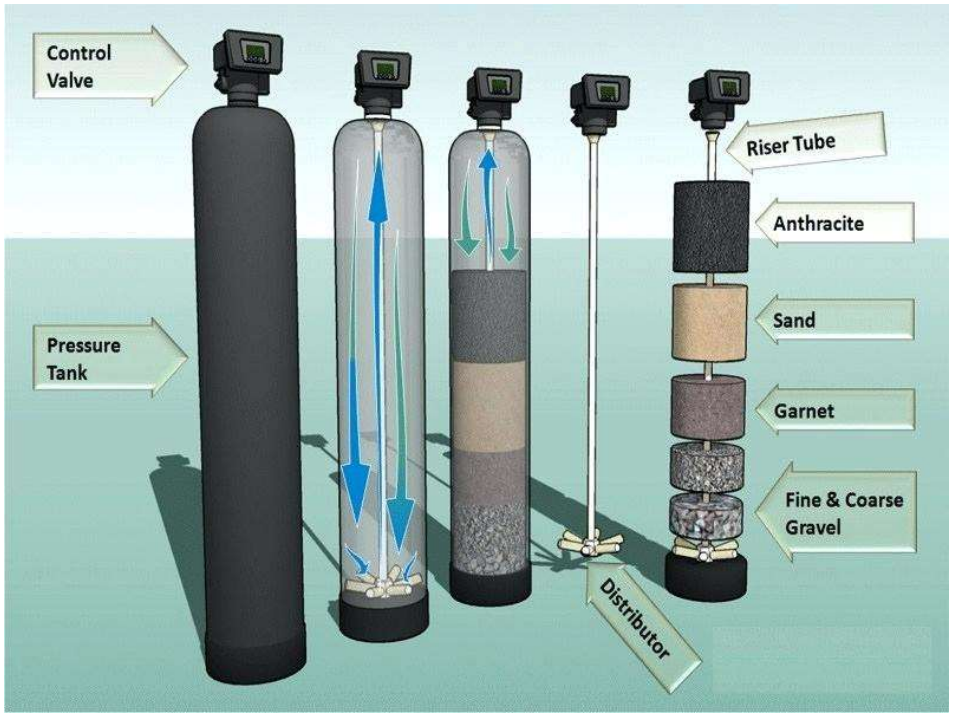
Often, these systems are only used for POU, they:

- Use a process of heating water to the boiling point and then collecting the water vapor as it condenses, leaving many of the
- Have a very high effectiveness in removing protozoa (for example, Cryptosporidium, Giardia);
- Have a very high effectiveness in removing bacteria (for example, Campylobacter, Salmonella, Shigella, E. coli);
- Have a very high effectiveness in removing viruses (for example, Enteric, Hepatitis A, Norovirus, Rotavirus);
- Will remove common chemical contaminants, including arsenic, barium, cadmium, chromium, lead, nitrate, sodium, sulfate, and many organic chemicals.



Activated Carbon

- Activated carbon filters are comprised of charcoal. To activate the charcoal, the surface area gets increased. The two types are granular and powdered. The surface area and the oxygen within the filter increases its capability. Backflushing the filter will increase lifespan.



Activated Carbon Filter
(includes mixed media that remove heavy metals)

Absorbs organic contaminants that cause taste and odor problems.

Some designs remove chlorination byproducts

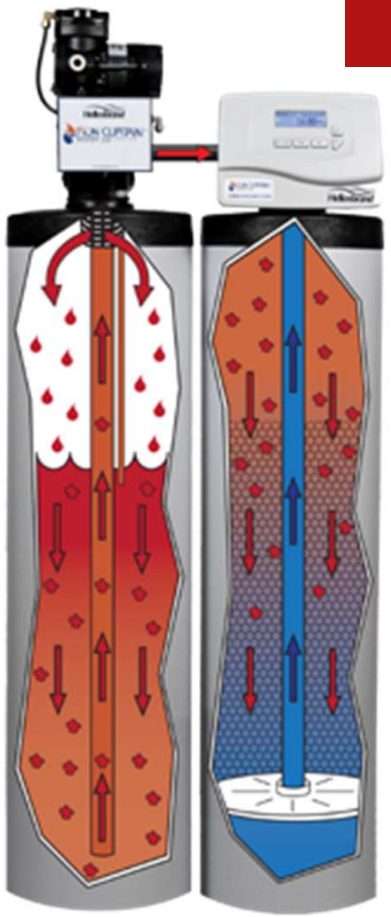
Some types remove cleaning solvents and pesticides

Activated Carbon Filter Limitations

- Is efficient in removing metals such as lead and copper
- Does not remove nitrates, bacteria, or dissolved minerals

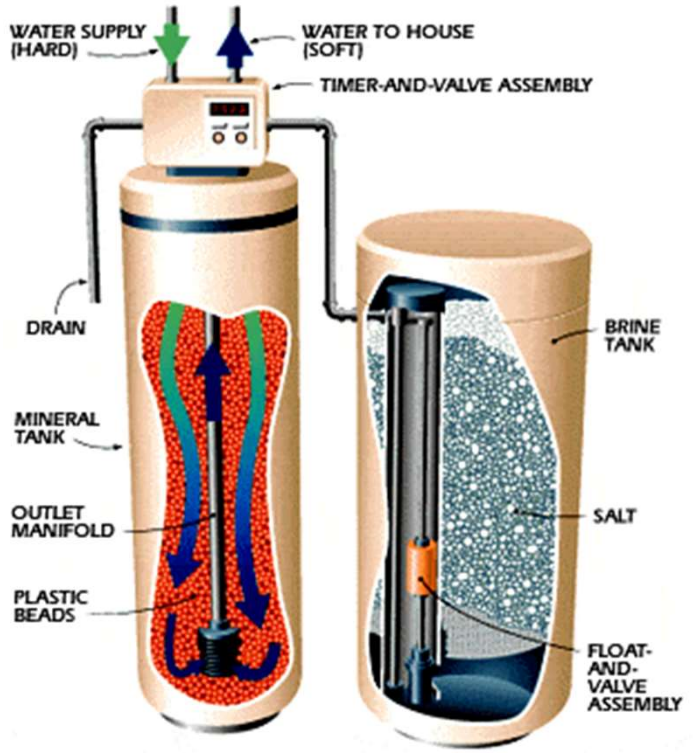
Iron Filtration

- For higher amounts of clear-water iron, about 7 to 15 mg/L, it is recommended to use specialized iron filters. They are widely used for their versatility of oxidizing filter media, for example greensand, Birm and Pro-OX.
- Iron filters are similar in appearance to conventional water softeners. The important distinction, though, is that as soon as water passes through their filter media, any soluble ferrous oxidizes into the ferric state. Thereby it becomes insoluble and gets trapped.

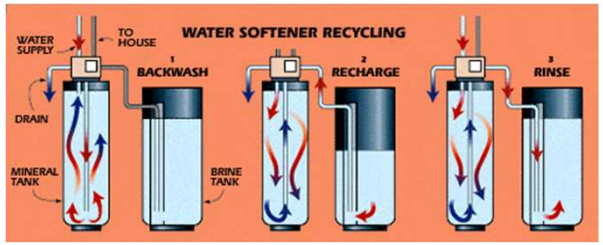


Water Softeners
Ion Exchange Unit (with activated alumina)

- A water softer uses salt to extract elements such as calcium and manganese. These elements give the water a hard feeling and can lead to mineralization on everything from dishes to the inside of plumbing.



Water Softener



- Calcium and manganese in water both carry positive charges. This means that these minerals will cling to the beads as the hard water passes through the mineral tank. Sodium ions also have positive charges, albeit not as strong as the charge on the calcium and manganese. When a very strong brine solution is flushed through a tank that has beads already saturated with calcium and manganese, the sheer volume of the sodium ions is enough to drive the calcium and manganese ions off the beads. Water softeners have a separate brine tank that uses common salt to create this brine solution.

Water Softeners and Iron

- Does a water softener remove iron? Yes, ferrous can be removed in an ion exchange process with the help of a softener. It's a commonly used method which delivers good results for concentrations of up to 3 (5) mg/L.
- This isn't the best method as it will overload the bead media and require more frequent regeneration cycles and premature failure of the unit.
- This method can only be used for ferrous type iron.

Water Softeners

- In normal operation, hard water moves into the mineral tank and the calcium and manganese ions move to the beads, replacing sodium ions. The sodium ions go into the water. Once the beads are saturated with calcium and manganese, the unit enters a 3-phase regenerating cycle. First, the backwash phase reverses water flow to flush dirt out of the tank. In the recharge phase, the concentrated sodium-rich salt solution is carried from the brine tank through the mineral tank. The sodium collects on the beads, replacing the calcium and manganese, which go down the drain. Once this phase is over, the mineral tank is flushed of excess brine and the brine tank is refilled.

WHAT IS DISINFECTION?

- A. Contaminated drinking water may contain harmful bacteria, viruses or other microorganisms that can make you sick. Disinfection is one way to kill or inactivate microorganisms to make water safe for drinking. It can also get rid of the kinds of bacteria that can cause unpleasant tastes and odors.

Treatments Using Oxidizers

There are several treatment systems that utilize the use of oxidizers in removing elements such as iron and manganese while at the same time disinfecting the water. They are all implemented similarly as the oxidizers need a contact time based on their concentration and strength as an oxidizer. They are:

- Chlorination
- Peroxide
- Ozone

Chlorine Treatment

- Chlorine readily combines with chemicals dissolved in water, microorganisms, small animals, plant material, tastes, odors, and colors. These components "use up" chlorine and comprise the **chlorine demand** of the treatment system. It is important to add sufficient chlorine to the water to meet the chlorine demand and provide residual disinfection.

  The chlorine that does not combine with other components in the water is **free** (residual) chlorine, and the **breakpoint** is the point at which free chlorine is available for continuous disinfection. An ideal system supplies free chlorine at a concentration of 0.3-0.5 mg/l. Simple test kits, most commonly the DPD colorimetric test kit (so called because diethyl phenylene diamine produces the color reaction), are available for testing breakpoint and chlorine residual in private systems.

Chlorine Treatment- Contact Time

- A long interaction between chlorine and the microorganisms results in an effective disinfection process. The contact time varies with chlorine concentration, the type of pathogens present, pH, and temperature of the water. The calculation procedure is given below.

  Contact time must increase under conditions of low water temperature or high pH (alkalinity). Complete mixing of chlorine and water is necessary, and often a holding tank is needed to achieve appropriate contact time. In a private well system, the minimum-size holding tank is determined by multiplying the capacity of the pump by 10. For example, a 5-gallons-per-minute (GPM) pump requires a 50-gallon holding tank. Pressure tanks are not recommended for this purpose since they usually have a combined inlet/outlet and all the water does not pass through the tank.

Peroxide Treatment

Advantages of hydrogen peroxide over chlorine:

- Works faster than chlorine, so often no contact tank is required
- Unlike chlorine will not leave a chemical residual in the water
- Peroxide works over a wider pH range

Like chlorine, hydrogen peroxide is a strong oxidizer and can quickly eliminate the odors. Unlike chlorine however, hydrogen peroxide leaves behind no trace of chemical by-products. When hydrogen peroxide is injected into water, a large amount of dissolved oxygen is released and a strong oxidizing effect takes place. Odors are eliminated, microorganisms are destroyed, and tannins can be oxidized.

Peroxide Treatment

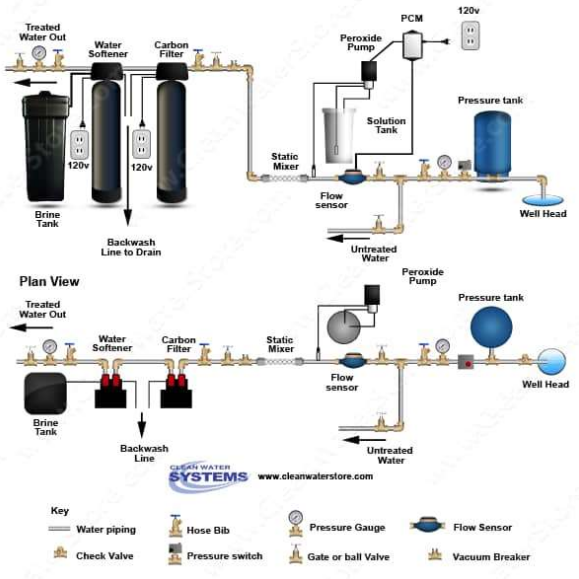
- Hydrogen peroxide converts hydrogen sulfide gas, and iron present to a solid particle which is then removed by a back-washing self-cleaning carbon filtration system. For many applications no retention tank is needed, and any residual hydrogen peroxide will be effectively removed by the carbon filter.

Peroxide Contact Tank

- If the rotten-egg odors are extremely excessive, a contact tank is recommended, which allows a few minutes of time for the peroxide to contact with the water, to make sure the water is properly treated.

Typical Setup

- Flow Sensor Systems Allow Peroxide Systems to Be Installed After Well
- In some cases, its not practical to install the peroxide injection point near the well, or perhaps you are on a shared community well, and you prefer to have the system right where the water enters the home. In this case, a flow-based system can be used. This type of system uses a flow meter to control the peroxide injection pump. As soon as there is flow, the peroxide pump injects a small amount of hydrogen peroxide based on how fast the water is flowing through the pipe. Proportionally fed hydrogen peroxide products offer owners a convenient way to inject hydrogen peroxide as the water enters the household plumbing system and are very easy to set up and maintain.

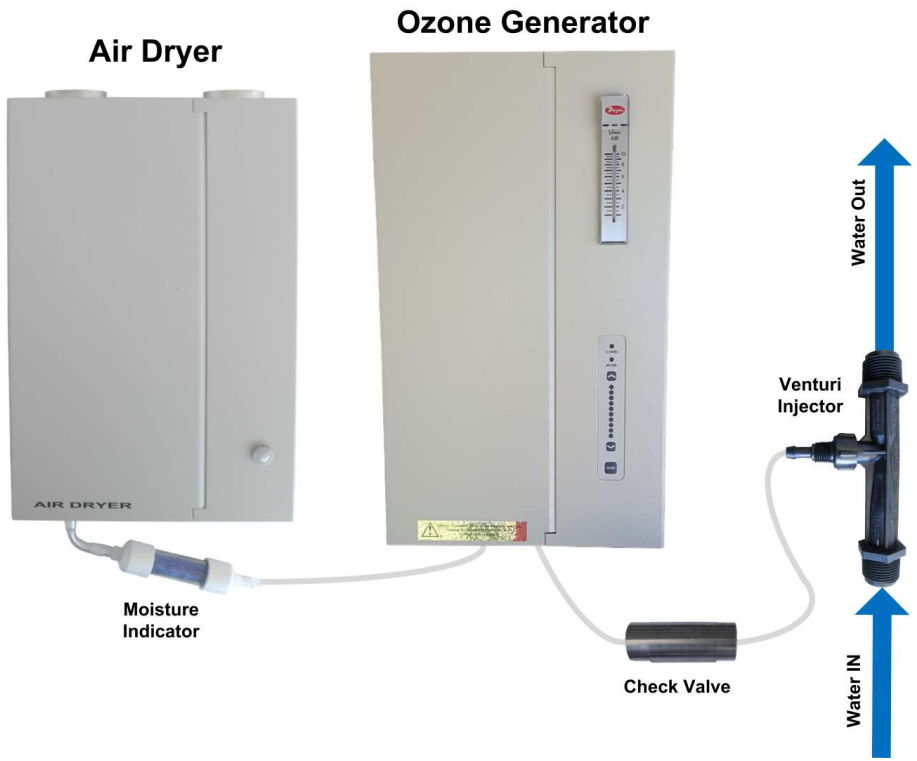


Ozone Treatment

- Ozone injection/oxidation. Ozone is triatomic oxygen (O3) that has very high oxidizing power. It is a gas produced from air and high voltage electricity. The injection of the ozone into the water produces tiny ozone bubbles, which saturate every drop of water. At this point oxidation of iron, Sulphur and manganese is immediate.

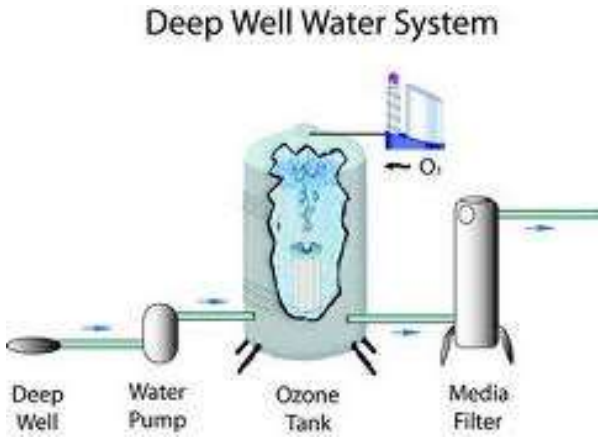
Ozone

- The elimination (off gassing or venting) of the ozone and other gases/odors such as sulfur is known as aeration. This occurs by an ozone stripping action. As water flows down the off gas tank, ozonated water rises and strips any gas in the incoming water. There are two types of venting devices on the market. Electric self-cleaning types and float types that only release gas. The float types tend to require more maintenance than the electric type.



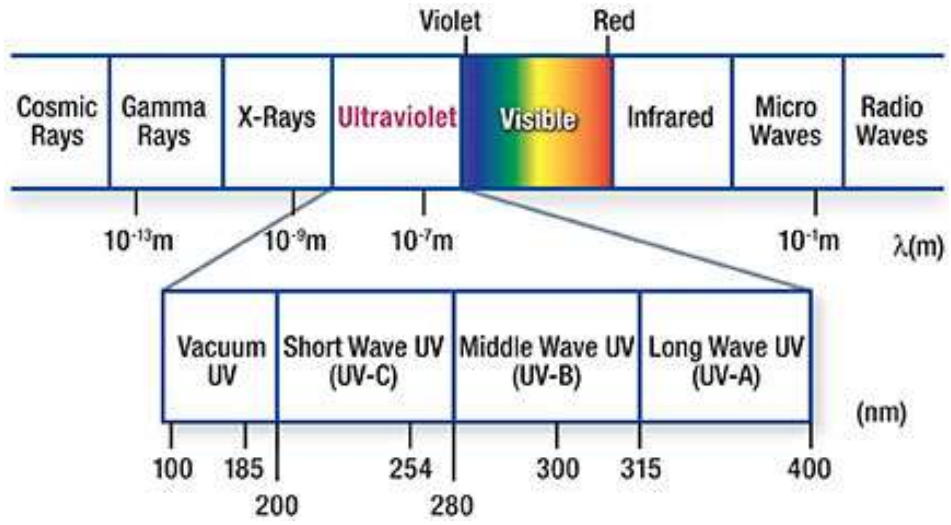
Ozone Treatment

- The final step for removing the oxidized material is filtration. There are several media on the market. The idea is to use a medium that has low water waste (backwash), high service flow and high removal capacity and requires no chemicals during regeneration. Mechanical filtration is all that is necessary, and Birm, Greensand, and Centaur typically are not necessary.



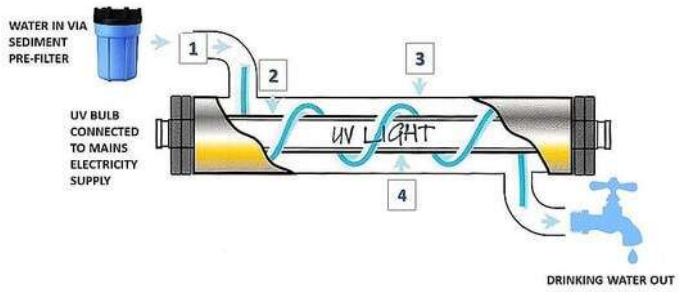
Ultra Violet Light

- UV radiation has three wavelength zones: UV-A, UV-B, and UV-C, and it is this last region, the shortwave UV-C, that has germicidal properties for disinfection.



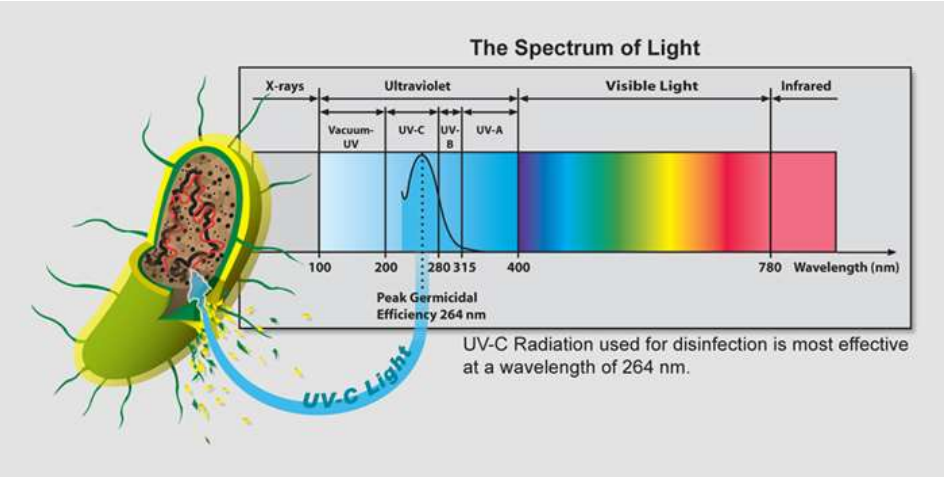
UV Treatment

- A low-pressure mercury arc lamp resembling a fluorescent lamp produces the UV light in the range of 254 manometers (nm). A nm is one billionth of a meter (10^-9 meter). These lamps contain elemental mercury and an inert gas, such as argon, in a UV-transmitting tube, usually quartz. Traditionally, most mercury arc UV lamps have been the so-called "low pressure" type, because they operate at relatively low partial pressure of mercury, low overall vapor pressure (about 2 mbar), low external temperature (50-100oC) and low power. These lamps emit nearly monochromatic UV radiation at a wavelength of 254 nm, which is in the optimum range for UV energy absorption by nucleic acids (about 240-280 nm).



UV Radiation

- UV radiation affects microorganisms by altering the DNA in the cells and impeding reproduction. UV treatment does not remove organisms from the water, it merely inactivates them. The effectiveness of this process is related to exposure time and lamp intensity as well as general water quality parameters.



UV Disinfection

- Used alone, UV radiation does not improve the taste, odor, or clarity of water. UV light is a very effective disinfectant, although the disinfection can only occur inside the unit. There is no residual disinfection in the water to inactivate bacteria that may survive or may be introduced after the water passes by the light source. The percentage of microorganisms destroyed depends on the intensity of the UV light, the contact time, raw water quality, and proper maintenance of the equipment. If material builds up on the glass sleeve or the particle load is high, the light intensity and the effectiveness of treatment are reduced. At sufficiently high doses, all waterborne enteric pathogens are inactivated by UV radiation.