Modern Water Management –Basic Track treatment & pretreatment

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- Filters & Units
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  - Cartridge filters
  - Activated carbon filters
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- Jar test
- Drinking water Treatment

Water Contaminants

- **Solids**

Other than gases, all contaminants of water contribute to the solid's content. Natural waters carry a lot of dissolved solids and non-dissolved solids. The non-dissolved solids are nonpolar substances and relatively large particles of materials, such as silt, that

will not dissolve, solids in water can be classified With regard to size,

- Suspended solids
- Settleable solids
- Colloidal solids
- Dissolved solids

Total solids

are those solids, both suspended and dissolved, that remain behind when the water is removed by evaporation. Solids are also characterized as being volatile or nonvolatile. Colloidal solids are extremely fine suspended solids less than 1 micron in diameter that can still make the water cloudy; they are so small they will not settle even if allowed to sit quietly for days or weeks.

- Note: Though not technically accurate from a chemical point of view because some finely suspended material can actually pass through the filter, suspended solids are defined as those that can be filtered out in the suspended solids laboratory test. The material that passes through the filter is defined as dissolved solids.

• Turbidity

Turbidity is a condition in water caused by the presence of suspended matter, resulting in the scattering and absorption of light rays, turbidity is a measure of the light-transmitting properties of water. Natural water that is very clear (low turbidity) allows one to see images at considerable depths. High-turbidity water appears cloudy.

Even water with low turbidity, however, can still contain dissolved solids. Dissolved solids do not cause light to be scattered or absorbed; thus, the water looks clear.

High turbidity causes problems in water treatment because the components that cause high turbidity can cause taste and odor problems and will reduce the effectiveness of disinfection.

- ## Color

color is considered an aesthetic quality of water and has no direct health impact. Many of the

colors associated with water are not “true” colors but are the result of colloidal suspension. This apparent color can be attributed to dissolved tannin extracted from decaying plant material. The true color is the result of dissolved chemicals, most often organics that cannot be seen.

- ## Dissolved Oxygen

gases such as oxygen, carbon dioxide, hydrogen sulfide, and nitrogen dissolve in water. Gases dissolved in water are important. Carbon dioxide, for example, is important because of the role it plays in pH and alkalinity. Carbon dioxide is released into the water by microorganisms and consumed by aquatic plants Dissolved oxygen (DO) it is an indicator of water quality. Just as solutions can become saturated with solute, this is also the case with water and oxygen.

The amount of oxygen that can be dissolved at saturation depends on the temperature of the water. In the case of oxygen, however, the effect is just the opposite of other solutes. The higher the temperature, the lower the saturation level; the lower the temperature, the higher the saturation level.

- **Metals**

most metals are not harmful, but a few metals can cause taste and odor problems in drinking water. Some metals may be toxic to humans, animals, and microorganisms. Most metals enter water as part of compounds that ionize to release the metal as positive ions.

- **Organic Matter**

Organic compounds include fats, dyes, soaps, rubber products, plastics, wood, fuels, cotton, proteins, and carbohydrates. Organic compounds in water are usually large, nonpolar molecules that do not dissolve well in water. They often provide large amounts of energy to animals and microorganisms.

- ## Inorganic Matter

Inorganic matter or inorganic compounds are carbon-free not derived from living matter and easily dissolved in water. Inorganic matter is of mineral origin and includes acids, bases, salts, etc. Several inorganic components are important in establishing and controlling water quality.

- ## Acids

An acid is a substance that produces hydrogen ions (H^+) when dissolved in water. Lemon juice, vinegar, and sour milk are acidic or contain acid. The common acids used in treating water are hydrochloric acid (HCl), sulfuric acid (H_2SO_4), nitric acid (HNO_3), and carbonic acid (H_2CO_3).

- ## Bases

A base is a substance that produces hydroxide ions (OH^-) when dissolved in water. Bitter things, such as lye or common soap, contain bases. The bases used in waterworks operations are calcium hydroxide, $Ca(OH)_2$; sodium hydroxide, NaOH; and potassium hydroxide, KOH. Note that the hydroxyl group (OH) is found in all bases. In addition, note that bases contain metallic substances, such as sodium (Na), calcium (Ca), magnesium (Mg), and potassium (K). These bases contain the elements that produce the alkalinity in water.

- **Salts**

When acids and bases chemically interact, they neutralize each other.

The compounds (other than water) that form from the neutralization of acids and bases are salts.

- **pH**

pH is a measure of the hydrogen ion (H+) concentration, the pH of water is important to the chemical reactions that take place within the water, and pH values that are too high or low can inhibit the growth of microorganisms.

Natural water varies in pH depending on its source. Pure water has a neutral pH, with an equal number of H+ and OH–.

pH adjustment is used to optimize coagulation, softening, and disinfection reactions, as well as for corrosion control. To control water coagulation and corrosion, it is necessary for the waterworks operator to test for the hydrogen ion concentration of the water to get the pH. In coagulation tests, as more alum (acid) is added, the pH value is lowered. If more lime (alkali, or base) is added, the pH value is raised. This relationship is important, and if a good floc is formed the pH should then be determined and maintained at that pH value until there is a change in the new water.

- **Alkalinity**

Alkalinity is defined as the capacity of water to accept protons (positively charged particles);

alkalinity is a measure of the capacity of the water to absorb hydrogen ions without a significant

pH change (i.e., to neutralize acids). Bicarbonates, carbonates, and hydrogen cause alkalinity compounds in a raw or treated water supply. Bicarbonates are the major components, because of the action of carbon dioxide on the basic materials of soil; borates, silicates, and phosphates may be minor components.

The alkalinity of raw water may also contain salts formed from organic acids, such as humic acid. Alkalinity in water acts as a buffer that tends to stabilize and prevent fluctuations in pH. It is usually beneficial to have significant alkalinity in water because it would tend to prevent quick changes in pH. Quick changes in pH interfere with the effectiveness of the common water treatment processes. Low alkalinity also contributes to the corrosive tendencies of water. When alkalinity is below 80 mg/L, it is considered to be low.

- **Hardness**

It represents the total concentration of calcium and magnesium ions, reported as calcium carbonate. Hardness causes soaps and detergents to be less effective and contributes to scaling formation in pipes and boilers. Hardness is not considered a health hazard; however, water that contains hardness must often be softened by lime precipitation or ion exchange. Low hardness contributes to the corrosive tendencies of water. Hardness and alkalinity often occur together because some compounds can contribute both alkalinity and hardness ions.

HORIZON
ACADEMY
INDUSTRIAL TRAINING ACADEMY

Water Measurement:

- PH
- Total Dissolved Solid (T.D.S)
- Conductivity
- Turbidity

PH measurement device

TDS measurement device

Conductivity measurement device

Turbidity measurement device

Conductivity ,TDS and Temperature measurement device

Testes

Determine the total hardness

- Hardness in water is due to the presence of dissolved salts of calcium and magnesium.
- Hardness of water is determined by titrating with a standard solution of ethylene diamine tetra acetic acid (EDTA) which is a complexing agent
- Two type of hardness is present in water first is temporary hardness and second is permanent hardness. Temporary hardness is due to the presence of bicarbonates of calcium and magnesium ions. It can be easily removed by boiling. Permanent hardness is due to the presence of chlorides and sulphates of calcium and magnesium ions. This type of hardness cannot be removed by boiling.

Reagent

1. EDTA 0.02N
2. Erio–T indicator
3. Ammonia buffer

Procedure:

1. The burette is filled with standard EDTA solution to the zero level.
2. Take 50ml sample water in flask.
3. Add 1ml Ammonia buffer.
4. Add 5 to 6 drop of Erio– T indicator. The solution turns into wine red colour.
5. Note the initial reading.
6. Titrate the content against EDTA solution. At the end point colour change from wine red to blue colour.
7. Note the final reading and record it. Repeat the process till we get concordant value.
8. Take 50ml sample in another flask and boiled it. (Add distilled water to get final volume of water.

Calculation

- Total hardness of water mg/L ($CaCO_3$ Scale) = ml of EDTA used (unboiled) $*10^3$ /ml of sample
- Permanent hardness of water mg/L ($CaCO_3$ Scale) = ml of EDTA used (boiled) $*10^3$ /ml of sample
- Temporary hardness of water mg/L ($CaCO_3$ Scale) = Total hardness of water - Permanent hardness of water

- Total hardness as $CaCO_3$ In ppm$=\frac{\mathrm{V1}*N*50*1000}{V}$=ppm

When :

- V1=volume of end point , N=normality of EDTA=molarity *valence =.02*4
- V=volume of sample,
- 50 is equivalent weight of $CaCO_3$ $=\frac{\mathrm{molecular}\ weight}{total\ no\ of\ positivve\ charge\ on\ cation\ ca{+}{+}} = \frac{40+12+(16*3)}{2}$

Determine the Alkalinity

- The alkalinity of the water is a measure of its capacity to neutralize acids.

Reagents:

H_2SO_4 solution 0.01 N

Phenolpthalein indicator

Methyl Orang indicator OR Bromocrosol green

Procedure:

1. Fill the burette to H_2SO_4 0.01 N solution.

2. Take a 50 ml water sample in flask. Add few drop of Phenolphthalein indicator.

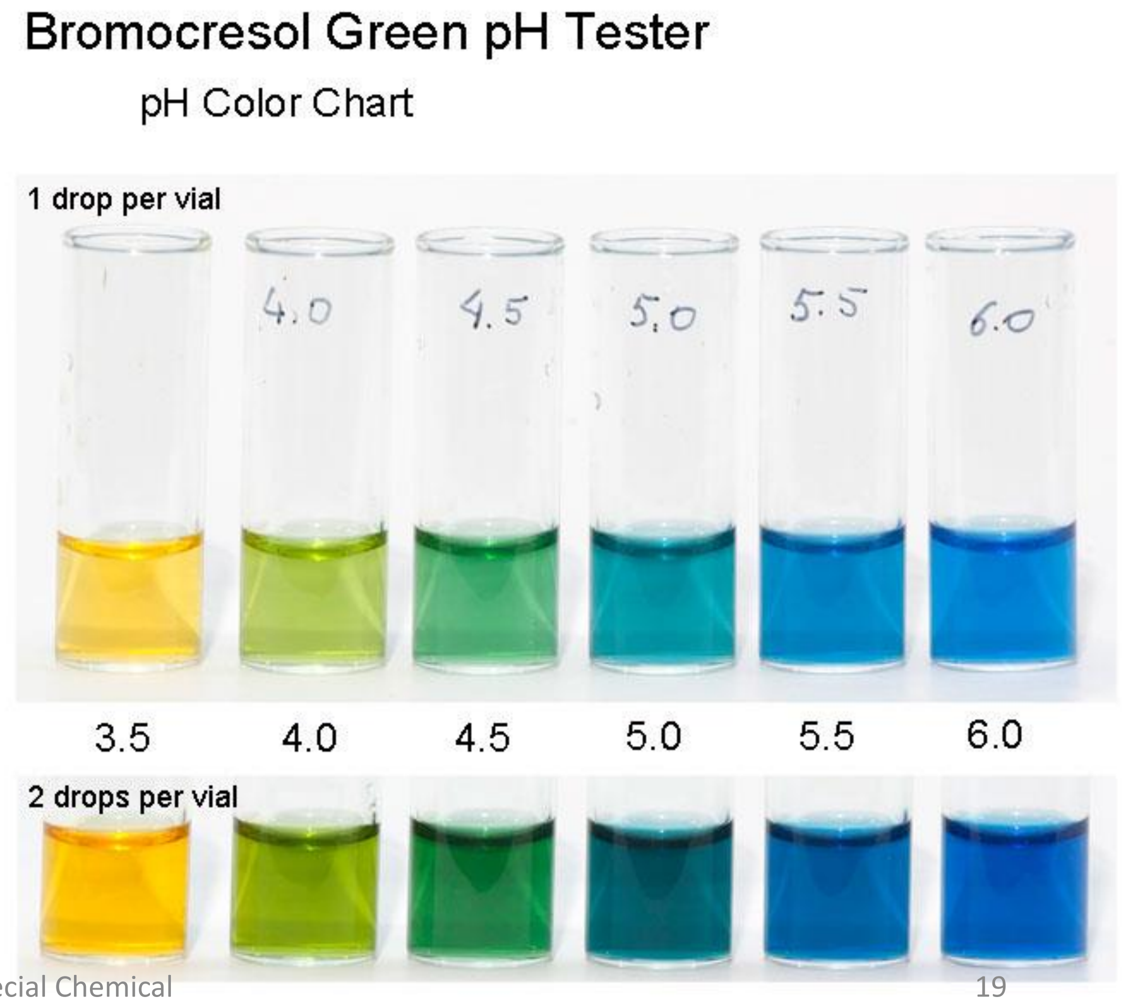
3. Titrate against H_2SO_4 till the pink colour disappear.

4. Note the end point reading and get volume of used H_2SO_4 in ml

5. Add 1-3 drop of Bromocrosol green in same sample flask.

6. Titrate it, till the appearance of green colour.

7. Note down the final reading and find the volume of used H_2SO_4 .



Calculation

$$\text{M-P-Alkalinity} = \frac{(N*V)H2SO4*50000}{Vml}$$

Alkalinity Relationships

Condition	Hydroxide	Carbonate	Bicarbonate
P=0	None	None	M
P=M	M	None	None
P=1/2M	None	M	None
P<1/2M	None	2P	M-2P
P>1/2M	2P-M	2(M-P)	None

Filters & Units

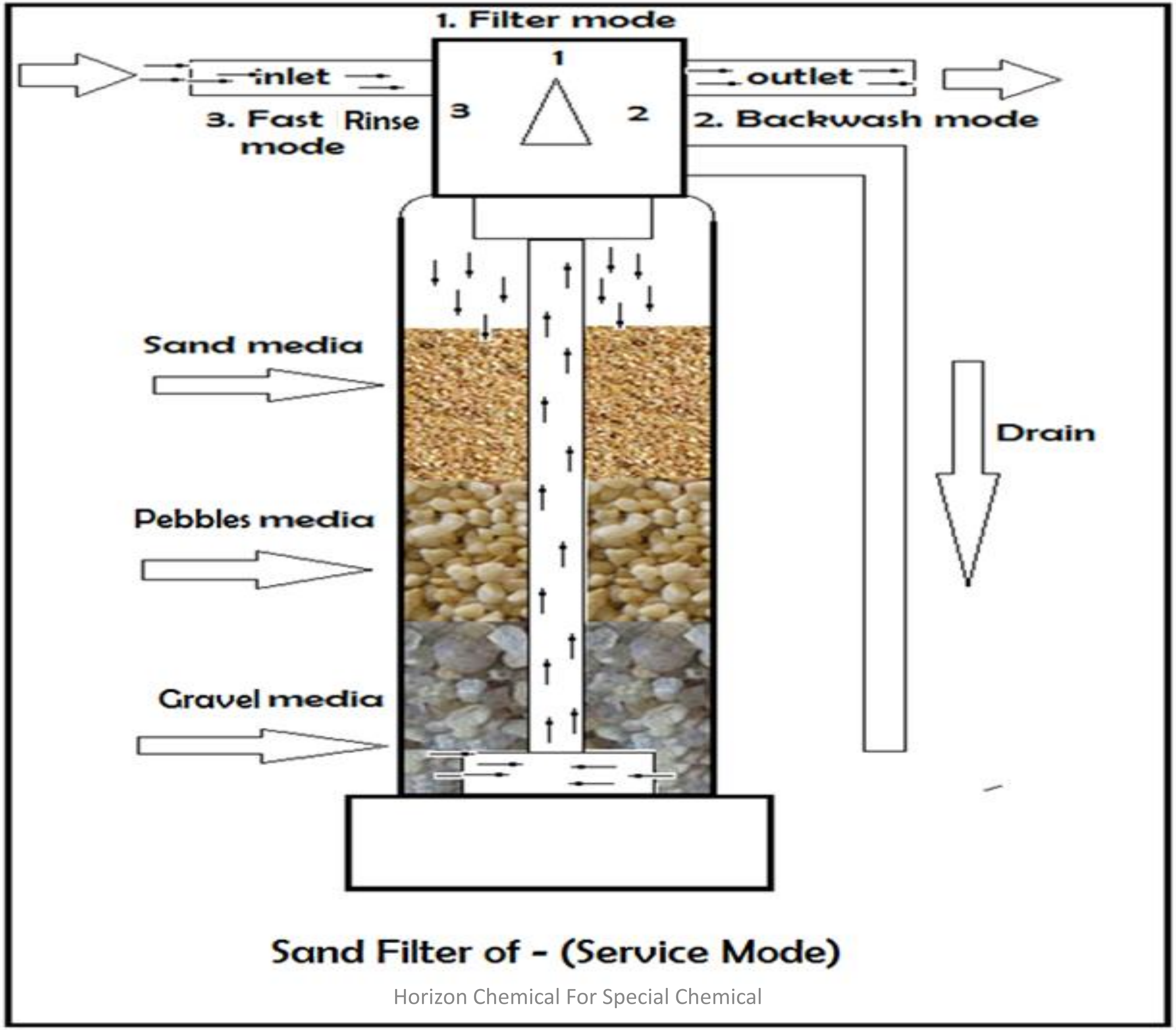
1. Sand filters
2. Cartridge filters
3. Activated carbon filters
4. Multi-media filters
5. Softener Unit
6. Demineralization unit
7. R.O Unit

1. Sand filters

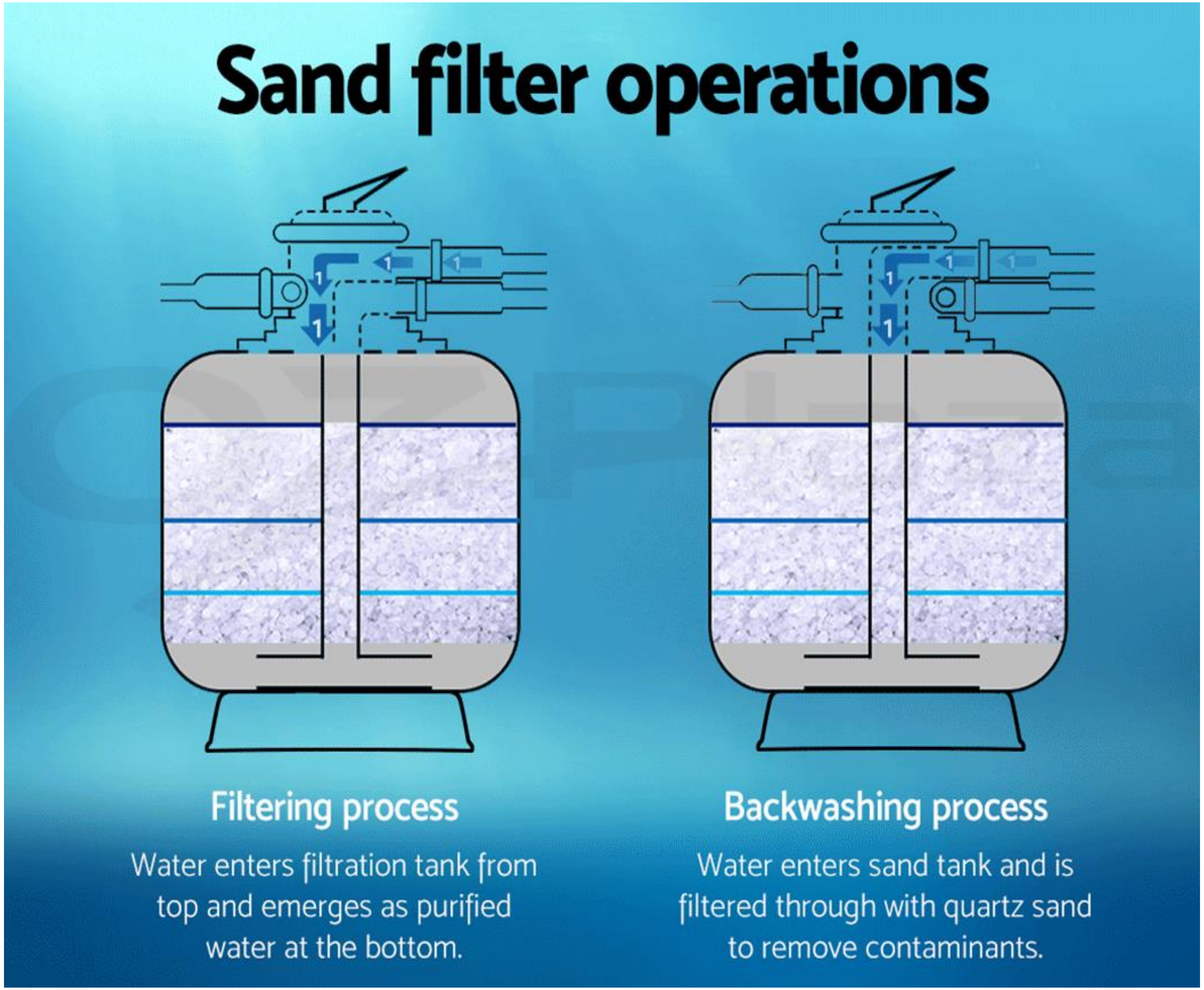
- A sand filter makes use of sand to filter water. The water to be purified slowly sinks through the sand leaving the dirt particles behind in the fine pores of the sand.
- The back wash of the sand filter is needed to keep it is efficiency

Note

- sand filter does not filter dissolved salts like iron from the water. A sand filter can only filter Salts that do not dissolve in water.
- We use green sand to get rid of iron


1. Filter mode
1
inlet
outlet
3
2
3. Fast Rinse mode
2. Backwash mode
Sand media
Pebbles media
Gravel media
Drain
Sand Filter of - (Service Mode)

Sand filters



2. Cartridge Filter

- Filter Cartridge is considered the heart of the filter;
- it is inserted inside the housing and used to
- Remove the contaminant/particles from the water.

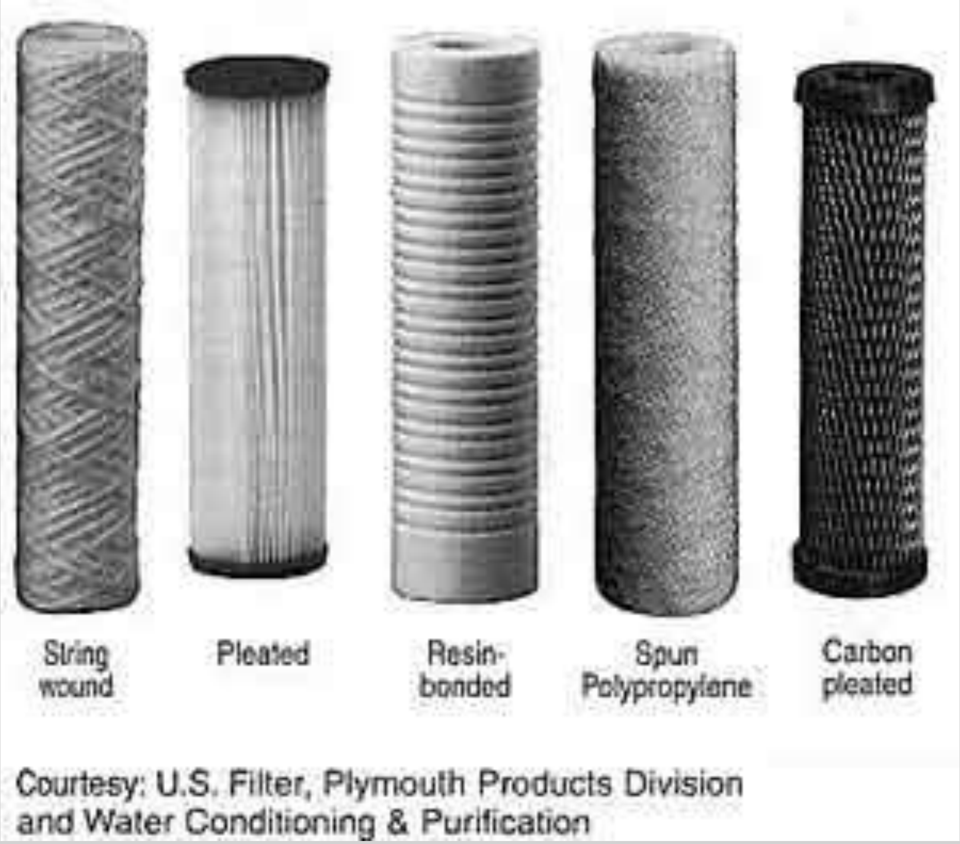
- it changes once a month

Types Of Filter Cartridge

- Polypropylene Spun filter cartridge
- Polypropylene wound filter cartridge
- Polypropylene Pleated filter cartridge
- PTFE polytetrafluorethylene

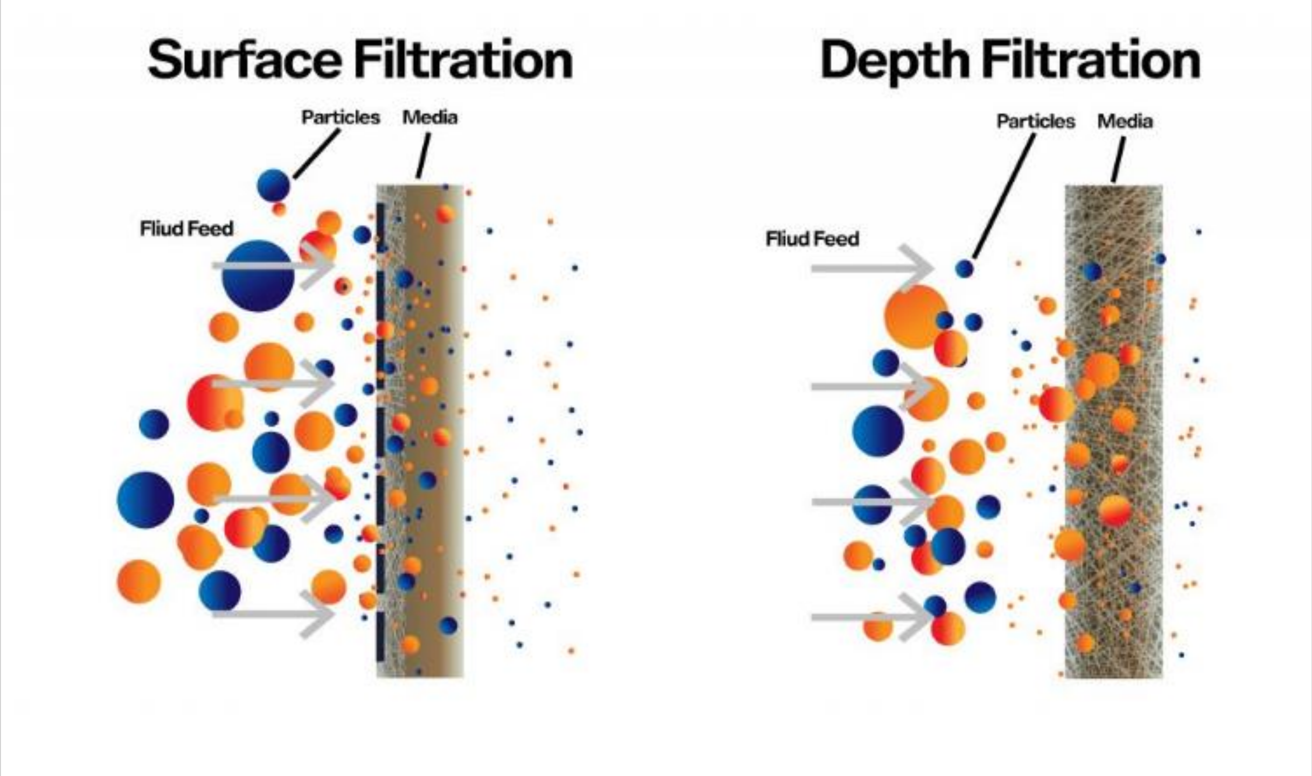
pleated filter cartridge

- Resin bonded filter cartridge
- Stainless steel filter cartridge



What Are The Two Categories Of Cartridge Filter?

a) surface filters
b) depth filters.

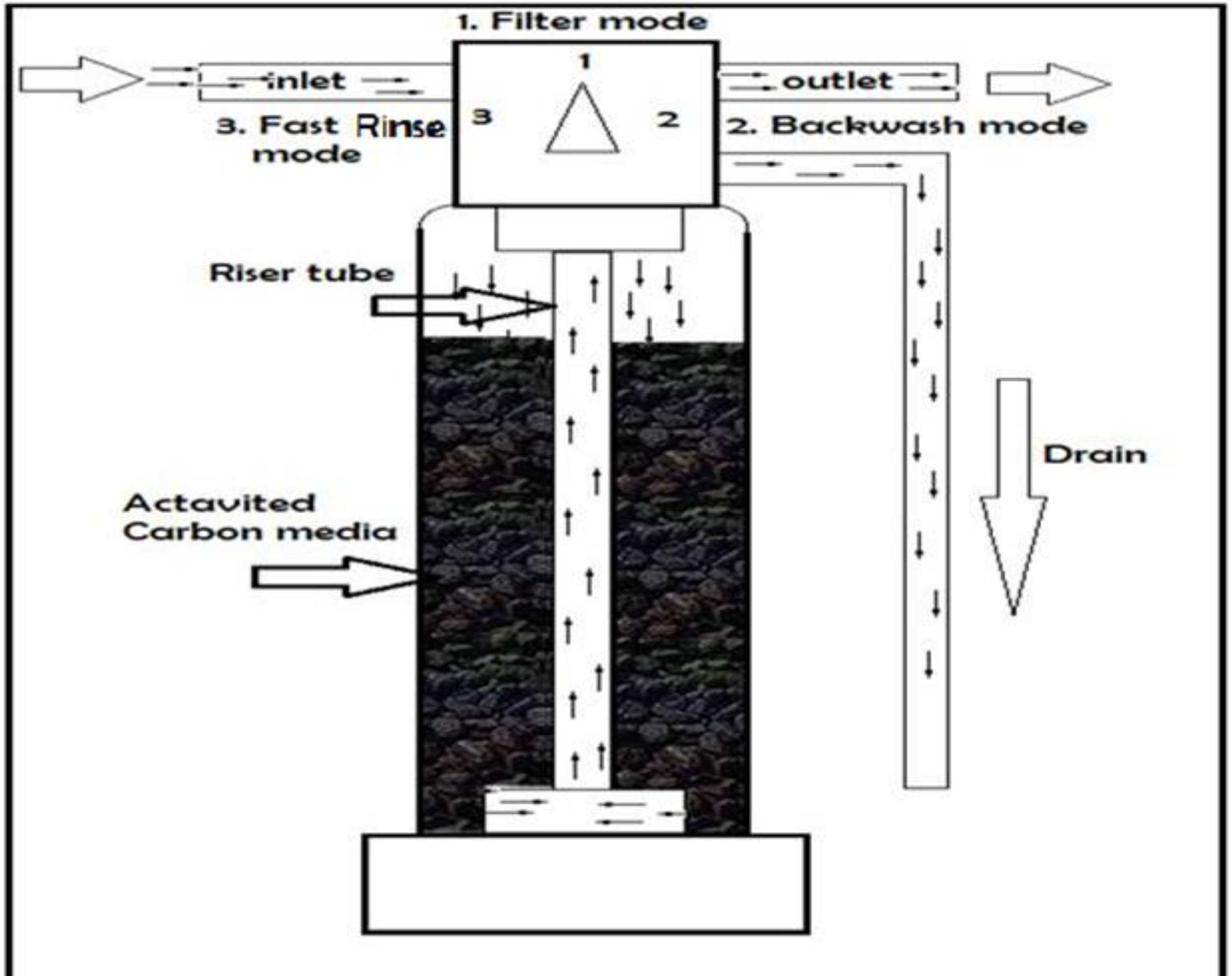


3. Activated carbon filter

- carbon filters remove contaminants through adsorption. adsorption means that contaminants are attracted to the surface of the activated carbon and held to it, much the same way a magnet attracts and holds iron filings.

- carbon filters also act as a catalyst to change the chemical composition of some contaminants. activated carbon is ideal for removing chlorine, organic chemicals such as pesticides, solvents and industrial cleaners.

Activated carbon filters



Carbon Filter - (Service Mode)

4. Multi-media filters

Purpose of a Multi-Media Filter

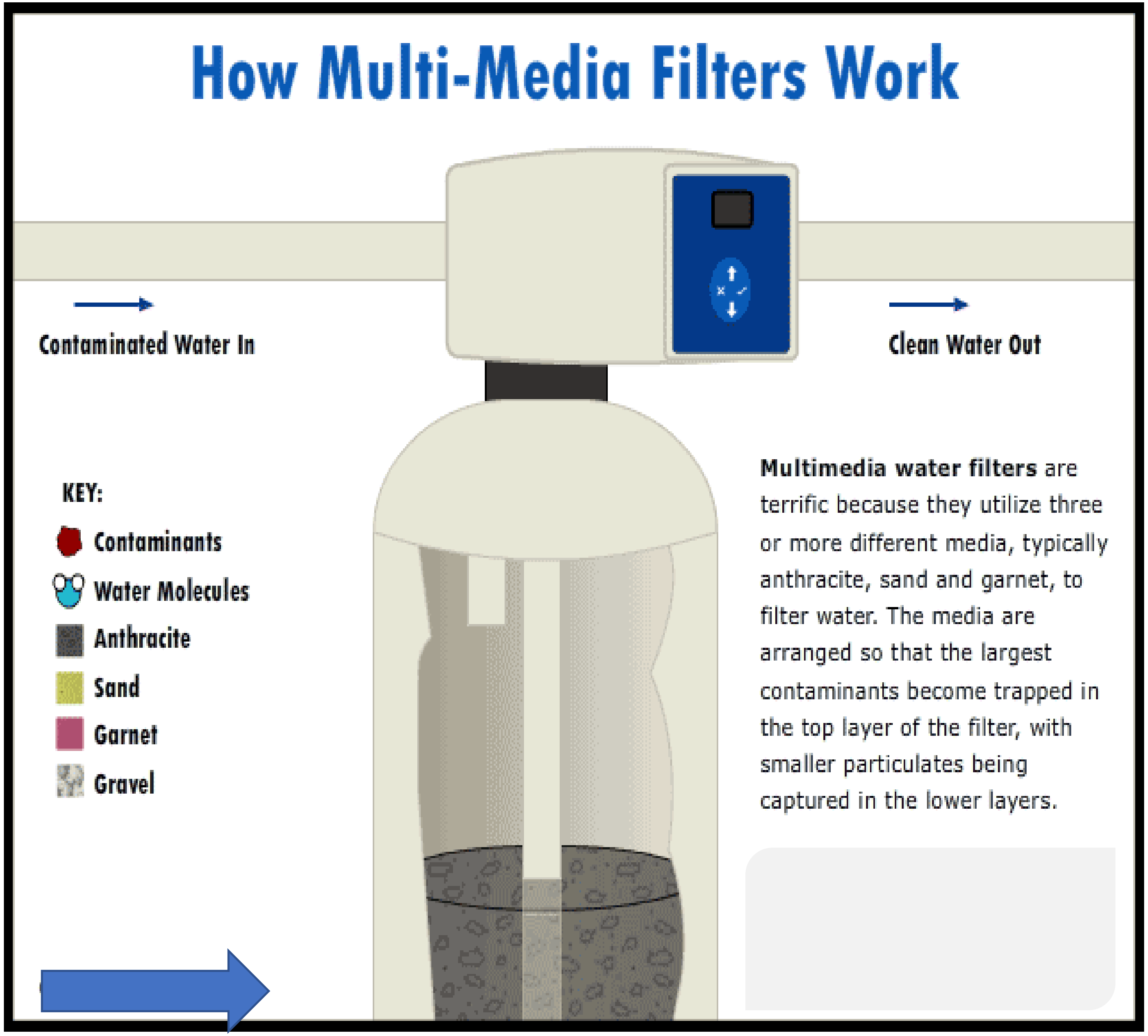
a Multi- Media Filter is used to reduce the level of suspended solids in incoming feed water, suspended Solids consist of small particles such as silt, clay, grit, organic matter !algae and other micro-organisms Incoming feed water that is high in suspended solids can cause a high pressure drop and reduce the effectiveness of downstream filtration equipment such as reverse osmosis membranes and ion exchange beds.

When is a Multi-Media Filter required?

a multi-media filter is suggested when the Silt Density Index (SDI) value is greater than 3 or when the turbidity is greater than 0.2 NTU.

we will discuss “Silt Density Index (SDI) ”in RO unit.

Multi-media filters



Microfiltration And Ultrafiltration Systems

- **What does microfiltration remove?**

MF membranes are available in pore sizes ranging from 0.1 to 10 µm.

MF porosity is the highest in the membrane filtration family, with the result that MF membranes allow water, ions, dissolved organic material, small colloids, and viruses to pass through, while retaining larger contaminants such as:

- Algae
- Bacteria
- Pathogenic protozoa
- Sediment, including sand, clay, and complex metals/particles

- **What does ultrafiltration remove?**

UF membranes are available in pore sizes ranging from 0.1 to 0.001 µm. Owing to the smaller pore size of its membranes, UF removes a more comprehensive range of contaminants than MF does, while leaving behind ions and organic compounds of low molecular weight. UF is suited for removal of very fine particles, including:

- Endotoxins
- Plastics
- Proteins
- Silica
- Silt
- Smog
- Viruses

- **How does MF/UF work?**

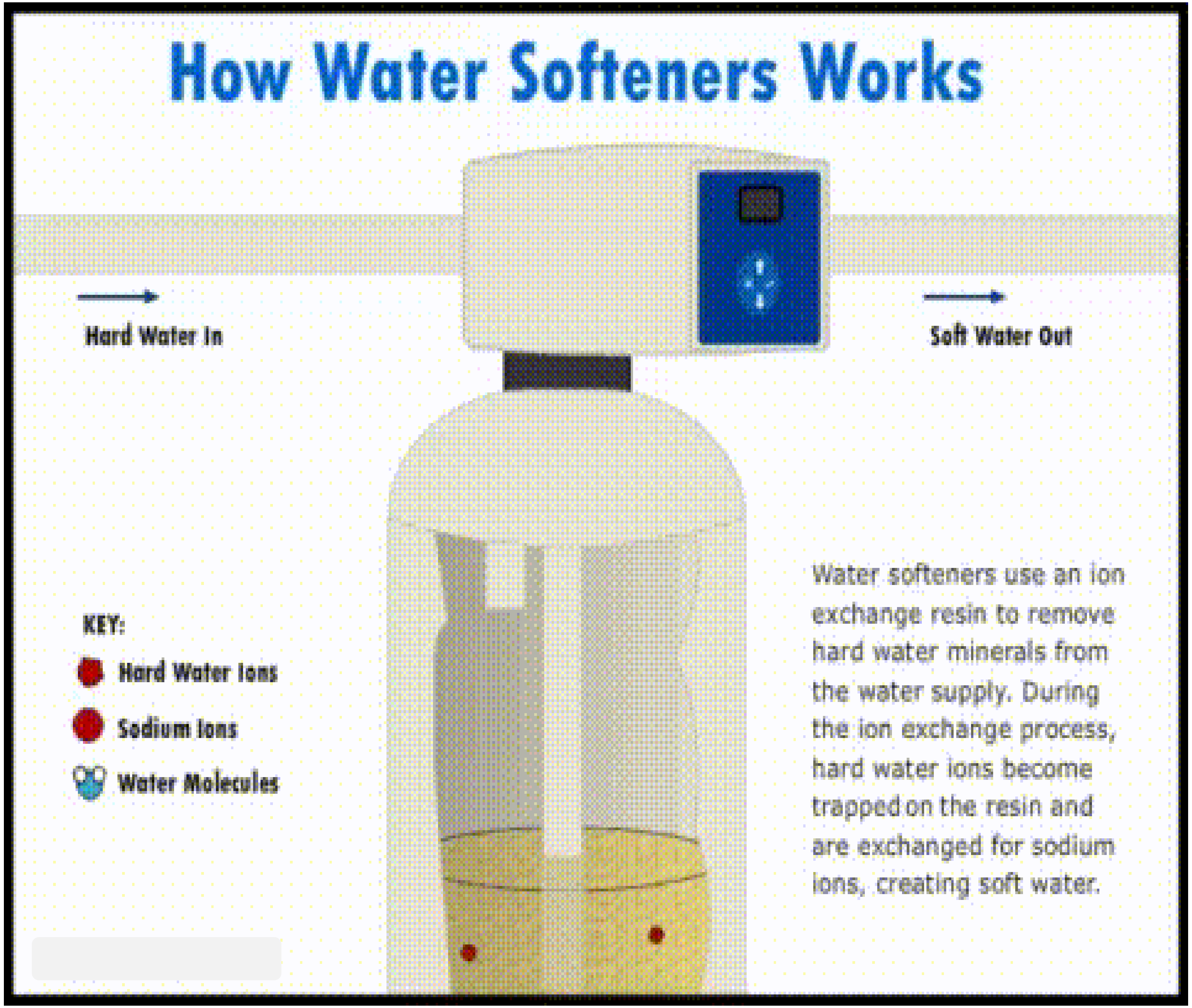
MF and UF physically separate solids from liquid streams based on the principle of size-exclusion. As a feed stream is passed through the MF/UF membrane, any solids that are too large to pass through the membrane's pores are retained, while any liquid or small particles are permitted to flow through. In either MF or UF, the portion of the feed stream that has passed through the filter membrane is referred to as the filtrate or permeate, while the remainder is known as the retentate.

5. Softener unit

- A water softener is a filtration system that removes hardness-causing calcium and magnesium minerals from your water through a process called ion exchange.

- a water softener removes calcium and magnesium from water through a process called ion exchange. when the hard water enters into the mineral tank, it flows through a bed of spherical resin beads. These plastic beads, usually made from polystyrene, are charged with a sodium ion. The resin beads are anions, meaning they have a negative charge. The calcium and magnesium minerals have a positive charge, making them cations. Since opposite charges attract, the negative charge of the minerals is attracted to the positive charge of the resin beads. As the hard water passes through the resin, the beads grab ahold of the mineral ions and remove them from the water. When the bead seizes the mineral ion, the sodium ion is released. The column of resin strips all the hardness out of the water as it passes through the mineral tank, and softened water flows out.

Softener unit

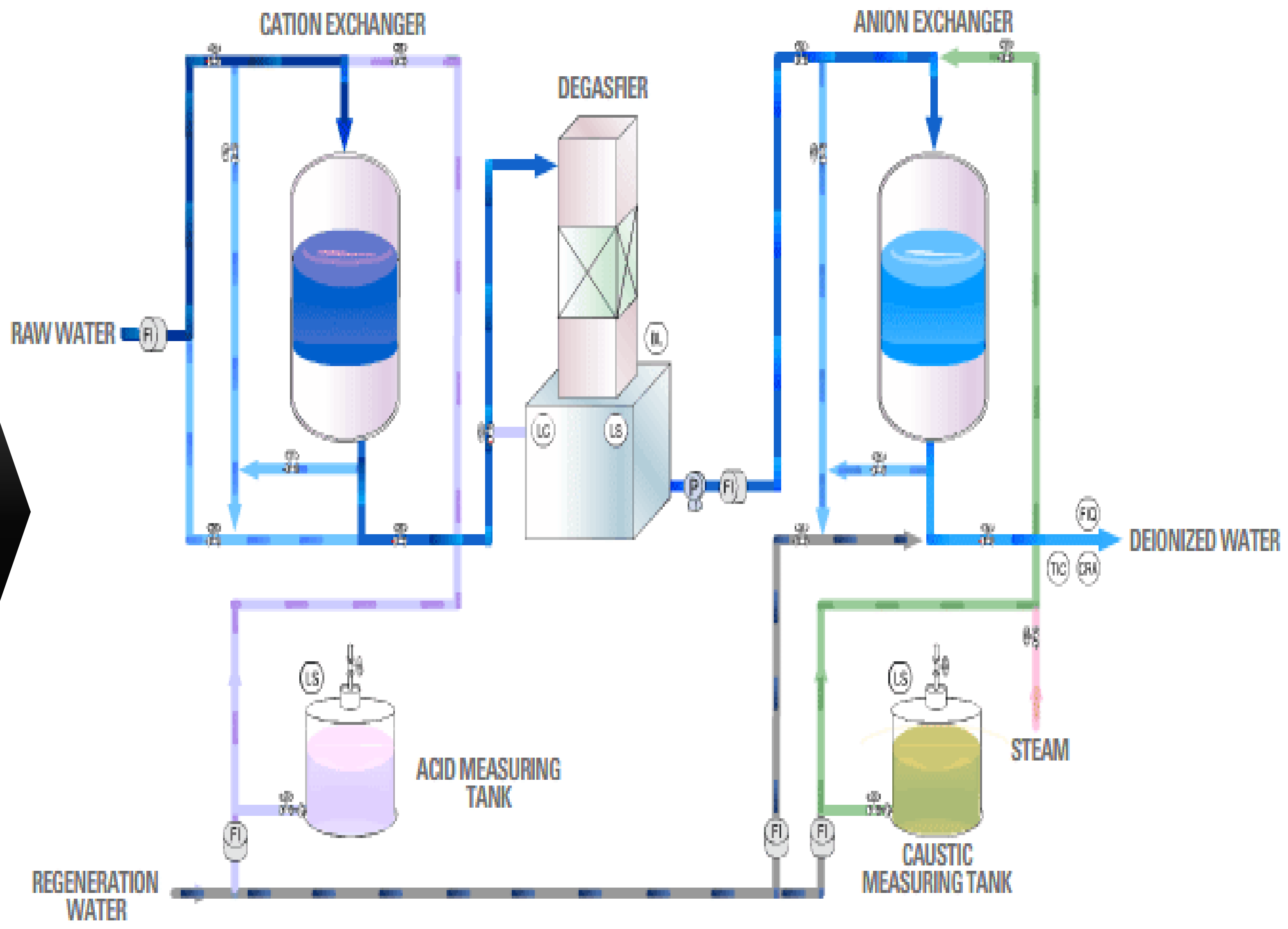


6. Demineralization unit

Demineralization is the process of removing mineral salts from water by using the ion exchange process. demineralized water is water completely free (or almost) of dissolved minerals.

demineralized water also known as deionized water, mineral ions such as cations of sodium, calcium, iron, copper, etc and anions such as chloride, sulphate, nitrate, etc are common ions present in water. deionization is a physical process which uses specially-manufactured ion exchange resins which provides ion exchange site for the replacement of the mineral salts in water with water forming H+ and OH- ions. because the majority of water impurities are dissolved salts, deionization produces a high purity water that is generally similar to distilled water.

Demineralization unit



Jar test

- Jar testing is a pilot-scale test of the treatment chemicals used in a particular water plant , It simulates the coagulation/flocculation process in a water treatment plant and helps operators determine if they are using the right amount of treatment chemicals.

- Frequency of Jar Testing Jar testing should be done seasonally (temperature), monthly, weekly, daily, or whenever a chemical is being changed, or new pumps, rapid mix motors, new floc motors, or new chemical feeders are installed. There is no set requirement for how often jar testing should be conducted, but the more it's done the better the plant will operate.

Jar Testing Procedures

The following jar test procedure uses alum (aluminum sulfate) a chemical for coagulation/flocculation in water treatment, and a typical six-gang jar tester. the results of this procedure can help optimize the performance of the plant.

• first, using a 1,000 milliliter (ml) graduated cylinder, add 1,000 ml of raw water to each of the jar test beakers. record the temperature, PH, turbidity, and alkalinity of the raw water before beginning.

• next, prepare a stock solution by dissolving 10.0 grams of alum into 1,000 ml distilled water. each 1.0 ml of this stock solution will equal 10 mg\l (ppm) when added to 1,000 ml of water to be tested.

• using the prepared stock solution of alum, dose each beaker with increased amounts of the solution. see the table

Table 1

Jar #	mL Alum Stock Added	mg\L Alum Dosage
1	1.0	10.0
2	1.5	15.0
3	2.0	20.0
4	2.5	25.0
5	3.0	30.0
6	3.5	35.0

- After dosing each beaker, turn on the stirrers. this part of the procedure should reflect the actual conditions of the plant as much as possible. meaning, if the plant has a static mixer following chemical addition, followed by 30 minutes in a flocculator, then 1.5 hours of settling time before the filters, then the test also should have these steps. the jar test would be performed as follows: operate the stirrers at a high rpm for 1 minute to simulate the static mixer. then reduce the speed of the

- stirrers to match the conditions in the flocculator and allow them to operate for 30 minutes. observe the floc formation periodically during the 30 minutes. at the end of the 30 minutes turn off the stirrers and allow settling. most of the settling will be complete after one hour.

- Now, look at the beakers and determine which one has the best results (if any). if no results were noticeable, then increase the dosage using the table above for the next six jars. an underfeeding will cause the sample in the beaker to look cloudy with little or no floc and no settling or very little. an overfeeding will cause a dense fluffy floc to form and will not settle well, meaning it stays in suspension and floats. the beaker that looks like it has the appropriate dosage of alum (coagulant) will have floc that has settled to the bottom, and the water above it will be relatively clear (remember this is before the filtering process of the water treatment plant). the best way to determine which sample is the clearest would be to check the turbidity of each beaker and record this information. use a pipette to draw a portion from the top of each beaker one at a time not stirring or disturbing the sample. if none of the beakers appear to have good results, then the procedure needs to be run again using different dosages until the correct dosage is found.

Drinking water Treatment

Water treatment steps

- **Coagulation**

Coagulation is often the first step in water treatment. During coagulation, chemicals with a positive charge are added to the water. The positive charge neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals to form slightly larger particles. Common chemicals used in this step include specific types of salts, aluminum, or iron.

- **Flocculation**

Flocculation follows the coagulation step. Flocculation is the gentle mixing of the water to form larger, heavier particles called flocs. Often, water treatment plants will add additional chemicals during this step to help the flocs form.

- **Sedimentation**

Sedimentation is one of the steps water treatment plants use to separate out solids from the water. During sedimentation, flocs settle to the bottom of the water because they are heavier than water.

- **Filtration**

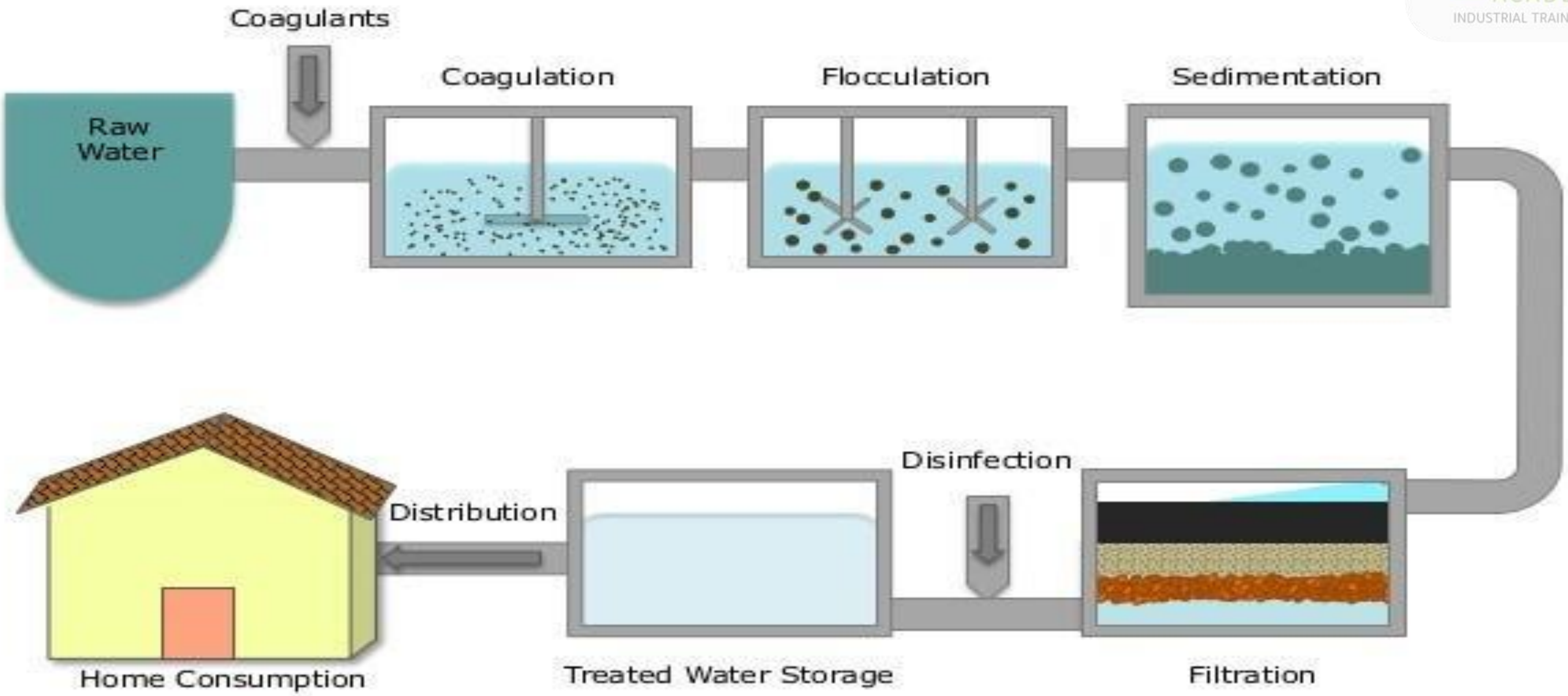
Once the flocs have settled to the bottom of the water, the clear water on top is filtered to separate additional solids from the water. During filtration, the clear water passes through filters that have different pore sizes and are made of different materials (such as sand, gravel, and charcoal). These filters remove dissolved particles and germs, such as dust, chemicals, parasites, bacteria, and viruses. Activated carbon filters also remove any bad odors.

- Water treatment plants can use a process called ultrafiltration in addition to or instead of traditional filtration. During ultrafiltration, the water goes through a filter membrane with very small pores. This filter only lets through water and other small molecules (such as salts and tiny, charged molecules).
- Reverse osmosis external icon is another filtration method that removes additional particles from water. Water treatment plants often use reverse osmosis when treating recycled water external icon (also called reused water) or salt water for drinking.

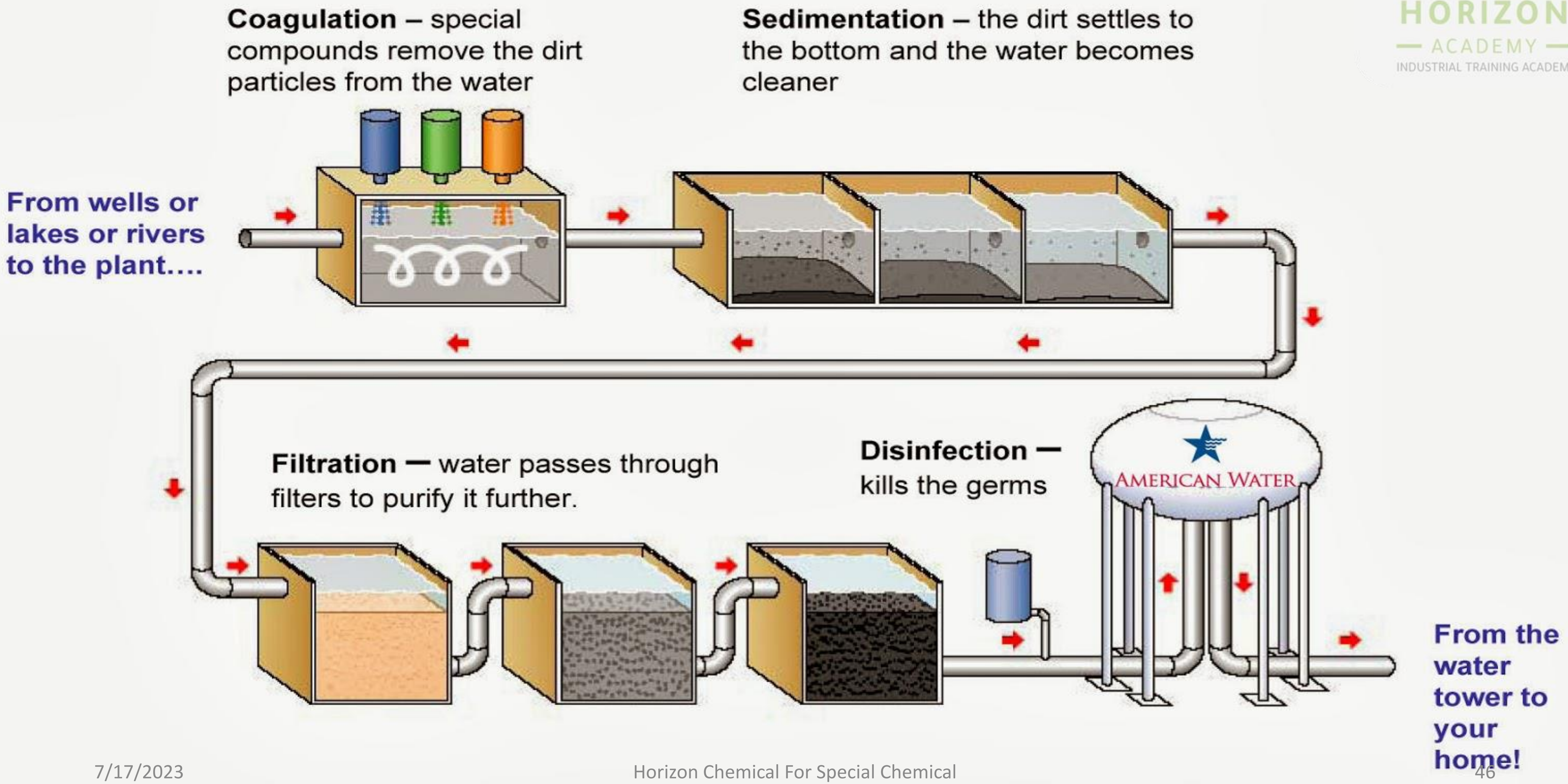
- **Disinfection**

After the water has been filtered, water treatment plants may add one or more chemical disinfectants (such as chlorine, chloramine, or chlorine dioxide) to kill any remaining parasites, bacteria, or viruses. To help keep water safe as it travels to homes and businesses, water treatment plants will make sure the water has low levels of chemical disinfectant when it leaves the treatment plant. This remaining disinfectant kills germs living in the pipes between the water treatment plant and your tap.

Water Treatment Process



How a Water Treatment Plant Works



Thank you