Available Online through
www.ijpbs.com (or) www.ijpbsonline.com
IJPBS |Volume 4| Issue 2|APR-JUN|2014|07-18
Review Article
Pharmaceutical Sciences

WATER TREATMENT PROCESS IN PHARMA INDUSTRY - A REVIEW

B. Venkateswara Reddy[1]*, P. Sandeep[1], P. Ujwala[1], K. Navaneetha[1] & K.Venkata Ramana Reddy[2]

[1]Department of Pharmaceutics, St.Paul's college of Pharmacy, Turkayamjal(V), Hayathnagar (M), Rangareddy Dist-501510, Andhra Pradesh.
[2]Sree Datta collage of pharmacy,Sheriguda(v),R.R.Dist
*Corresponding Author Email: basu.pharmacist@gmail.com

ABSTRACT

The presence of organic micro pollutants (OMPs), pharmaceuticals and personal care products (PPCPs) in potable water is of great environmental and pu blic health concern. Organic micro pollutants are included in the priority list of contaminants in United States EPA and European frame work directives.This paper presents a review on importance of water treatment and methods of enhancing water treatment process. It is also an attempt to propose general ideas about mechanisms governing demineralization and ultra filtration. Advanced treatment processes such as reverse osmosis, nanofiltration, ozonation and adsorption are the usual industry-recommended processes for OMPs removal, however, natural systems, e.g., river bank filtration and constructed wet lands, are also potentially efficient options for OMPs removal. Ozonation is a new means of contaminants removal from drinking water and waste water. Its application is mainly limited to laboratory use. However, due to successful results further investigation is to be carried out. The majority of models proposed here represent more of a speculative approach to the problem than a hypothesis based on experimental data. A survey of the different techniques available for the removal of contaminants are presented here as a short overview, the aim of which is to raise awareness of possible new approaches to water purification.

KEY WORDS

Water treatment, Sedimentation, Chlorination, Demineralization, water for injection.

INTRODUCTION

Water treatment describes those industrial-scale processes used to make water more acceptable for a desired end-use. These can be use for drinking water, industry, medical and many other uses. The goal of water treatment process is to remove existing contaminants in the water. The processes involved in treating water for drinking purpose may be solids separation using physical processes such as settling and filtration, and chemical processes such as disinfection and coagulation. Biological processes employed in the treatment of waste water and these processes may include, for example, aerated lagoons, activated sludge or sand filters.

SOURCES OF WATER

Groundwater:

The water emerges from some deep ground water may have fallen as rain many hundreds, or thousands of years ago. Rock and soil and layers naturally they filter the ground water to a high degree of clarity and often it does not require additional treatment other than adding chlorine or chloramines as secondary disinfectants. Such water may emerge as springs, artesian springs, or may be extracted from boreholes or wells. Deep ground water is generally of very high bacteriological quality (I.e., pathogenic bacteria or the pathogenic protozoa are typically absent), but the water may be rich in dissolved solids, especially carbonates and sulfates of calcium and magnesium. Depending on the strata through which the water has flowed, other ions may also be present including chloride, and bicarbonate. There may be a requirement to reduce the iron or manganese content of this water to make it acceptable for drinking, cooking, and laundry use.

Upland lakes and reservoirs:

Typically located in the headwaters of river systems, upland reservoirs are usually sited above any human habitation and may be surrounded by a protective zone to restrict the opportunities for contamination. Bacteria and pathogen levels are usually low, but some bacteria, protozoa or algae will be present. Where uplands are forested or peaty, humic acids can color the water. Many upland sources have low pH which requires adjustment.

Rivers, canals and low land reservoirs:

Low land surface waters will have a significant bacterial load and may also contain algae, suspended solids and a variety of dissolved constituents.

Atmospheric water generation is a new technology that can provide high quality drinking water by extracting water from the air by cooling the air and thus condensing water vapor.

Rainwater harvesting or fog collection which collects water from the atmosphere can be used especially in areas with significant dry seasons and in areas which experience fog even when there is little rain.

Desalination of seawater by distillation or reverse osmosis:

Surface Water: Freshwater bodies that are open to the atmosphere and are not designated as groundwater are classified in the USA for regulatory and water purification purposes as surface water.

Potable water treatment[3]

Water purification is the removal of contaminants from untreated water to produce drinking water that is pure enough for the most critical of its intended uses, usually for human consumption. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, minerals such as iron, manganese and sulphur, and other chemical pollutants such as fertilisers

Drinking water treatment

A combination selected from the following processes is used for municipal drinking water treatment worldwide:

Pre-chlorination - for algae control and arresting any biological growth

Aeration - along with pre-chlorination for removal of dissolved iron and manganese

Coagulation - for flocculation

Coagulant aids, also known as polyelectrolytes - to improve coagulation and for thicker floc formation

Sedimentation - for solids separation, that is, removal of suspended solids trapped in the floc

Filtration - removing particles from water

Desalination - Process of removing salt from the water

Disinfection - for killing bacteria

Sewage treatment

Sewage treatment is the process that removes the majority of the contaminants from wastewater or sewage and produces both a liquid effluent suitable for disposal to the natural environment and sludge. At the simplest level, treatment of sewage and most wastewaters is carried out through separation of solids from liquids, usually by sedimentation. By progressively converting dissolved material into solids, usually a biological floc, which is then settled out, an effluent stream of increasing purity, is produced.

Industrial water treatment

Two of the main processes of industrial water treatment are boiler water treatment and cooling water treatment. A lack of proper water treatment can lead to the reaction of solids and bacteria within pipe work and boiler housing. Steam boilers can suffer from scale or corrosion when left untreated leading to weak and dangerous machinery, scale deposits can mean additional fuel is required to heat the same level of water because of the drop in efficiency. Poor quality dirty water can become a breeding ground for bacteria such as Legionella causing a risk to public health. With the proper treatment, a significant proportion of industrial on-site waste water might be reusable. This can save money in three ways: lower charges for lower water consumption, lower charges for the smaller volume of effluent water discharged and lower energy costs due to the recovery of heat in recycled wastewater. Corrosion in low pressure boilers can be caused by dissolved oxygen, acidity and excessive alkalinity. Water treatment therefore should remove the dissolved oxygen and maintain the boiler water with the appropriate pH and alkalinity levels. Without effective water treatment, a cooling water system can suffer from scale formation, corrosion and fouling and may become a breeding ground for harmful bacteria such as those that cause Legionnaires 'disease. This reduces efficiency, shortens plant life and makes operations unreliable and unsafe[4].

WATER TREATMENT METHODS

Water treatment consists of applying known technology to improve or upgrade the quality of water. Usually water treatment will involve collecting the water in a central, segregated location and subjecting the water to various treatment processes. Water treatment, however, can also be organized or categorized by the nature of the treatment process operation being used; for example, physical, chemical or biological. Examples of these treatment steps are shown below. A complete treatment system may consist of the application of a number of physical, chemical and biological processes to the water.

Some Physical, Chemical and Biological water Treatment Methods5

Water treatment process

1) Physical

a. Sedimentation (Clarification)
b. Screening
c. Aeration
d. Filtration
e. Flotation and Skimming
f. Degasification
g. Equalization

2) Chemical

a. Chlorination
b. Ozonation
c. Neutralization
d. Coagulation
e. Adsorption
f. Ion Exchange

3) Biological

a. Aerobic
b. Activated Sludge Treatment Method
c. Trickling Filtration
d. Oxidation Ponds
e. Lagoons
f. Aerobic Digestion
g. Anaerobic Digestion
h. Septic Tanks
i. Lagoons

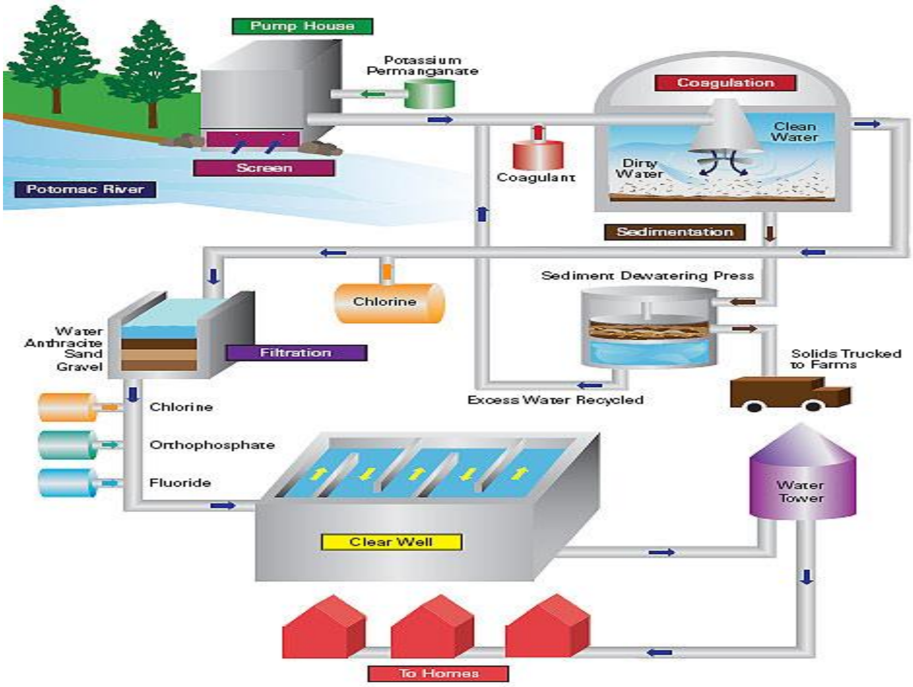

Figure 1

1) Physical methods:

These include processes where no gross chemical or biological changes are carried out and strictly physical phenomena are used to improve or treat the water. Examples would be coarse screening to remove larger entrained objects and sedimentation (or clarification).

a) Coagulation and flocculation[6]

One of the first steps in a conventional water purification process is the addition of chemicals to assist in the removal of particles suspended in water. Particles can be inorganic such as clay and silt or organic such as algae, bacteria, viruses, protozoa and natural organic matter. Inorganic and organic particles contribute to the turbidity and color of water.

The addition of inorganic coagulants such as aluminum sulfate (or alum) or iron (III) salts such as iron (III) chloride cause several simultaneous chemical and physical interactions on and among the particles. Within seconds, negative charges on the particles are neutralized by inorganic coagulants. Also within seconds, metal hydroxide precipitates of the aluminum and iron (III) ions begin to form. These precipitates combine into larger particles under natural processes such as Brownian motion and through induced mixing which is sometimes referred to as flocculation. The term most often used for the amorphous metal hydroxides is “floc.” Large, amorphous aluminum and iron (III) hydroxides adsorb and enmesh particles in suspension and facilitate the removal of particles by subsequent processes of sedimentation and filtration.

b) Sedimentation

In the process of sedimentation, physical phenomena relating to the settling of solids by gravity are allowed to operate. Usually this consists of simply holding the water for a short period of time in a tank under quiescent conditions, allowing the heavier solids to settle, and removing the "clarified" effluent. Waters exiting the flocculation basin may enter the sedimentation basin, also called a clarifier or settling basin. It is a large tank with low water velocities, allowing floc to settle to the bottom. The sedimentation basin is best located close to the flocculation basin so the transit between the two processes does not permit settlement or floc break up. Sedimentation basins may be rectangular, where water flows from end to end or circular where flow is from the centre outward.

c) Aeration:

Another physical treatment process consists of aeration- that is, physically adding air, usually to provide oxygen to the water.

d) Filtration:

After separating most floc, the water is filtered as the final step to remove remaining suspended particles and unsettled floc.

Rapid sand filters:

The most common type of filter is a rapid sand filter. Water moves vertically through sand which often has a layer of activated carbon or anthracite coal above the sand. The top layer removes organic compounds, which contribute to taste and odor. The space between sand particles is larger than the smallest suspended particles, so simple filtration is not enough. Most particles pass through surface layers but are trapped in pore spaces or adhere to sand particles. Effective filtration extends into the depth of the filter. This property of the filter is key to its operation: if the top layer of sand were to block all the particles, the filter would quickly clog. Some water treatment plants employ pressure filters. These works on the same principle as rapid gravity filters, differing in that the filter medium is enclosed in a steel vessel and the water is forced through it under pressure.

Advantages:

- Filters out much smaller particles than paper and sand filters can.
- Filters out virtually all particles larger than their specified pore sizes.
- They are quite thin and so liquids flow through them fairly rapidly.
- They are reasonably strong and so can withstand pressure differences across them of typically 2–5 atmospheres.
- They can be cleaned (back flushed) and reused
- Slow sand filters

Slow sand filters may be used where there is sufficient land and space, as the water must be passed very slowly through the filters. The filters are carefully constructed using graded layers of sand, with the coarsest sand, along with some gravel, at the bottom and finest sand at the top. Drains at the base convey treated water away for disinfection. Filtration depends on the development of a thin biological layer, called the zoogleal layer or Schmutzdecke, on the surface of the filter.

Membrane filtration

Membrane filters are widely used for filtering both drinking water and sewage. For drinking water, membrane filters can remove virtually all particles larger than 0.2 um—including *giardia* and *cryptosporidium.*

2) Chemical treatment

It consists of using some chemical reaction or reactions to improve the water quality. Probably the most commonly used chemical process is chlorination.

a) Chlorination

The most common disinfection method involves some form of chlorine or its compounds such as chloramine or chlorine dioxide. Chlorine is a strong oxidant that rapidly kills many harmful micro-organisms. Because chlorine is a toxic gas, there is a danger of a release associated with its use. This problem is avoided by the use of sodium hypochlorite, which is a relatively inexpensive solution that releases free chlorine when dissolved in water. Chlorine solutions can be generated on site by electrolyzing common salt solutions. A solid form, calcium hypochlorite, releases chlorine on contact with water[7].

b) Ozone disinfection

Ozone is an unstable molecule which readily gives up one atom of oxygen providing a powerful oxidizing agent which is toxic to most waterborne organisms. It is an effective method to inactivate harmful protozoa that form cysts. It also works well against almost all other pathogens. Ozone is made by passing oxygen through ultraviolet light or a "cold" electrical discharge.Some of the advantages of ozone include the production of fewer dangerous by-products and the absence of taste and odour problems. Another advantage of ozone is that it leaves no residual disinfectant in the water.

c) Neutralization

A chemical process commonly used in many industrial water treatment operations is neutralization. Neutralization consists of the addition of acid or base to adjust pH levels back to neutrality. Since lime is a base it is sometimes used in the neutralization of acid wastes.

d) Coagulation

Coagulation consists of the addition of a chemical that, through a chemical reaction, forms an insoluble end product that serves to remove substances from the wastewater. Polyvalent metals are commonly used as coagulating chemicals in water treatment and typical coagulants would include lime (that can also be used in neutralization), certain iron containing compounds (such as ferric chloride or ferric sulfate) and alum (aluminum sulfate).

3) Biological treatment methods

This method uses microorganisms, mostly bacteria, in the biochemical decomposition of wastewaters to stable end products. Generally, biological treatment methods can be divided into aerobic and anaerobic methods, based on availability of dissolved oxygen. The solids which are removed during treatment are primarily organic but may also include inorganic solids. Treatment must also be provided for the solids and liquids which are removed as sludge. Finally, treatment to control odors, to retard biological activity, or destroy pathogenic organisms may also be needed.

While the devices used in wastewater treatment are numerous and will probably combine physical, chemical and biological methods, they may all be generally grouped under six methods:

1. Preliminary Treatment
2. Primary Treatment
3. Secondary Treatment
4. Disinfection
5. Sludge Treatment
6. Tertiary Treatment

Preliminary Treatment

At most plants preliminary treatment is used to protect pumping equipment and facilitate subsequent treatment processes. Preliminary devices are designed to remove or cut up the larger suspended and floating solids, to remove the heavy inorganic solids, and to remove excessive amounts of oils or greases.

To affect the objectives of preliminary treatment, the following devices are commonly used:

1. Screens -- rack, bar or fine
2. Comminuting devices -- grinders, cutters, shredders
3. Grit chambers
4. Pre-aeration tanks

In addition to the above, chlorination may be used in preliminary treatment. Since chlorination may be used at all stages in treatment, it is considered to be a method by itself.

Primary Treatment

In this treatment, most of the settleable solids are separated or removed from the wastewater by the physical process of sedimentation. When certain chemicals are used with primary sedimentation tanks, some of the colloidal solids are also removed. The primary devices may consist of settling tanks, clarifiers or sedimentation tanks. Because of variations in design, operation, and application, settling tanks can be divided into four general groups:

1. Septic tanks
2. Two story tanks -- Imhoff and several proprietary or patented units
3. Plain sedimentation tank with mechanical sludge removal
4. Upward flow clarifiers with mechanical sludge removal

When chemicals are used, other auxiliary units are employed. These are:

1. Chemical feed units
2. Mixing devices
3. Flocculators

Secondary Treatment

Secondary treatment depends primarily upon aerobic organisms which biochemically decompose the organic solids to inorganic or stable organic solids. The devices used in secondary treatment may be divided into four groups:

1. Trickling filters with secondary settling tanks
2. Activated sludge and modifications with final settling tanks
3. Intermittent sand filters
4. Stabilization ponds

Chlorination[8]

This is a method of treatment which has been employed for many purposes in all stages in wastewater treatment, and even prior to preliminary treatment. It involves the application of chlorine to the wastewater for the following purposes:

1. Disinfection or destruction of pathogenic organisms
2. Prevention of wastewater decomposition
   (a)odor control
   (b) protection of plant structures

IJPBS |Volume 4| Issue 2 |APR-JUN|2014|07-18

3. Aid in plant operation -
   (a)sedimentation,
   (b)tricklingfilters,
   (c)activated sludge bulking
4. Reduction or delay of biochemical oxygen demand (BOD)

Sludge Treatment

The solids removed from water in both primary and secondary treatment units, together with the water removed with them, constitute water sludge. It is generally necessary to subject sludge to some treatment to prepare or condition it for ultimate disposal. Such treatment has two objectives -- the removal of part or all of the water in the sludge to reduce its volume, and the decomposition of the putrescible organic solids to mineral solids or to relatively stable organic solids. This is accomplished by a combination of two or more of the following methods:

1. Thickening
2. Digestion with or without heat
3. Drying on sand bed -- open or covered
4. Conditioning with chemicals
5. Elutriation
6. Vacuum filtration
7. Heat drying
8. Incineration
9. Wet oxidation
10. Centrifuging

Tertiary and Advanced Waste water Treatment

This merely indicates the use of intermittent sand filters for increased removal of suspended solids from the wastewater. In other cases, tertiary treatment has been used to describe processes which remove plant nutrients, primarily nitrogen and phosphorous, from wastewater.

DEMINERALISATION

Demineralization is the removal of minerals and nitrate from the water. The three that we will be discussing here are,

- Ion exchange
- Reverse osmosis
- Electrodialysis

These methods are widely used for water and waste water treatment. Ion exchange is primarily used for the removal of hardness ions like magnesium and calcium and for water demineralization. Reverse osmosis and electrodialysis, which are both membrane processes, remove dissolved solids from water using membranes.

Demineralized[9] water also known as Deionized water, water that has had its mineral ions removed. 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, and this process is quick and without scale buildup. A DM Water System produces mineral free water by operating on the principles of ion exchange, Degasification, and polishing. Demineralized Water System finds wide application in the field of steam, power, process, and cooling.

Ion Exchange

In the context of water purification, ion-exchange is a rapid and reversible process in which impurity ions present in the water are replaced by ions released by an ion-exchange resin. The ion exchange units are used to remove any charged substance from the water but are mainly used to remove hardness and nitrate from groundwater. Raw water is passed via two small polystyrene bead filled (ion exchange resins) beds. While the cations get exchanged with hydrogen ions in first bed, the anions are exchanged with hydroxyl ions, in the second one. The impurity ions are taken up by the resin, which must be periodically regenerated to restore it to the original ionic form.

The following ions are widely found in raw waters:

Cations	Anions
Calcium (Ca2+)	Chloride (Cl-)
Magnesium (Mg2+)	Bicarbonate (HCO3-)

Sodium (Na^+)	Nitrate (NO_3^-)
Potassium (K^+)	Carbonate (CO_3^{2-})

Ion Exchange Resins:

There are two basic types of resins: cation-exchange and anion-exchange resins. Cation exchange resins will release Hydrogen (H^+) ions or other positively charged ions in exchange for impurity cations present in the water. Anion exchange resins will release hydroxyl (OH^-) ions or other negatively charged ions in exchange for impurity anions present in the water.

Advantages of Ion Exchange

1. Ion exchange can be used with fluctuating flow rates.
2. Makes effluent contamination impossible
3. Resins are available in large varieties from suppliers and each resin is effective in removing specific contaminants.

Limitations of Ion Exchange

1. Pretreatment is required for most surface waters
2. Waste is highly concentrated and requires careful disposal
3. Unacceptable high levels of contamination in effluent
4. Units are sensitive to the other ions present.

Reverse osmosis

Reverse osmosis (RO) is a membrane-technology filtration method that removes many types of large molecules and ions from solutions by applying pressure to the solution when it is on one side of a selective membrane. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side.

In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (High Water Potential), through a membrane, to an area of high solute concentration (Low Water Potential). The movement of a pure solvent to equalize solute concentrations on each side of a membrane generates osmotic pressure. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. Reverse osmosis, however, involves a diffusive mechanism so that separation efficiency is dependent on solute concentration, pressure, and water flux rate. Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other substances from the water molecules. Reverse osmosis is a process that industry uses to clean water, whether for industrial process applications or to convert brackish water, to clean up wastewater or to recover salts from industrial processes. Reverse osmosis will not remove all contaminants from water as dissolved gases such as dissolved oxygen and carbon dioxide not being removed. But reverse osmosis can be very effective at removing other products such as trihalomethanes (THM's), some pesticides, solvents and other volatile organic compounds (VOC's) and this process removes over 70% of the following: Arsenic-3, Arsenic-4, Barium, Cadmium, Chromium-3, Chromium-6, Fluoride, Lead, Mercury, Nitrite, Selenium-4 and selenium-6,Silver.

The Reverse Osmosis Process

In the reverse osmosis process cellophane-like membranes separate purified water from contaminated water. RO is when a pressure is applied to the concentrated side of the membrane forcing purified water into the dilute side, the rejected impurities from the concentrated side being washed away in the reject water. RO can also act as an ultra-filter removing particles such as some micro-organisms that may be too large to pass through the pores of the membrane.

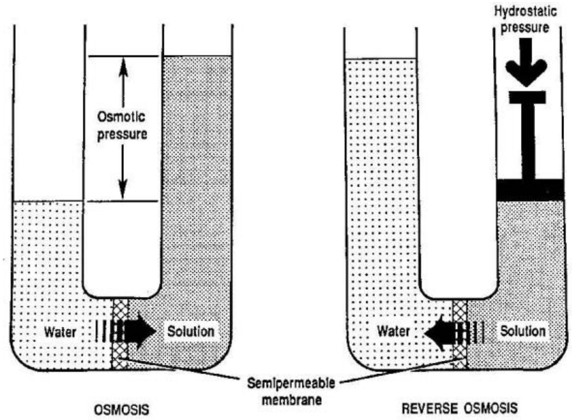

Figure 2

RO Equipment

RO units include the following:

- Raw water pumps
- Pretreatment
- Membranes
- Disinfection
- Storage
- Distribution elements

RO Membranes

Common membrane materials include polyamide thin film composites (TFC), cellulose acetate (CA) and cellulose triacetate (CTA) with the membrane material being spiral wound around a tube, or hollow fibres bundled together. Hollow fibre membranes have a greater surface area and hence capacity but are more easily blocked than spiral wound membranes. TFC membranes have superior strength and durability as well as higher rejection rates than CA/CTA membranes. They also are more resistant to microbial attack, high pH and high TDS. CA/CTA's have a better ability to tolerate chlorine.Sulphonated polysulphone membranes (SPS) are chlorine tolerant and can withstand higher pH's and are best used where the feed water is soft and high pH or where high nitrates are of concern.

Factors Affecting System & Process Performance

The performance of a system depends on factors such as membrane type, flow control, feed water quality, temperature and pressure. Also only part of the water entering the unit is useable, this is called the % recovery. For example the amount of treated water produced can decrease by about 1-2% for every 1 degree Celsius below the optimum temperature.

Advantages of Reverse Osmosis

1. Nearly all contaminant ions and most dissolved non-ions are removed
2. Suitable for small systems with a high degree of seasonal fluctuation in water demand
3. Insensitive to flow and TDA levels
4. Operates immediately without any minimum break-in period
5. Possible low effluent concentrations
6. Removes bacteria and particles
7. Simplicity and automation operation allows for less operator attention which makes them suitable for small system applications.

Limitations of RO

1. High operating costs and capital
2. Potential problem with managing the wastewater brine solution
3. Pretreatment at high levels
4. Fouling of membranes

Electrodialysis

Electrodialysis is effective in removing fluoride and nitrate from water. This process also uses membranes but direct electrical currents are used to attract ions to one side of the treatment chamber. This system includes a source of pressurized water, direct current power supply and a pair of selective membranes.

Electrodialysis Process

In this process, the membranes adjacent to the influent steam are charged either positively or negatively and this charge attracts counter-ions toward the membrane. These membranes are designed to allow the positive or the negative charged ions to pass through the membrane, where the ions move from the product water stream through a membrane to the two reject water streams.

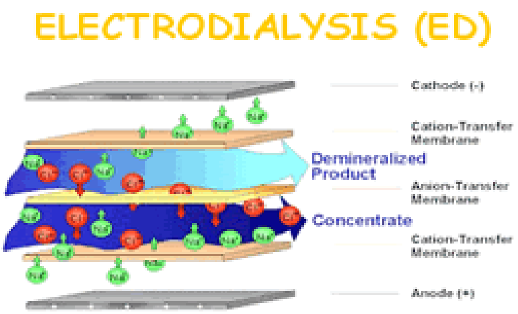

Figure 3

Electrodialysis Equipment

The electrodialysis system has three essential elements:

1. Source of pressurized water
2. Direct current power supply
3. A pair of selective membranes

Advantages of Electrodialysis

1. All the contaminant ions and many of the dissolved non-ions are removed
2. Insensitive to flow and TDS levels
3. Possible low effluent concentrations

Limitations of Electrodialysis

1. Operating costs and capital are high
2. Level of pretreatment required is high
3. Twenty to ninety percent of feed flow is rejected stream
4. Replacement of electrodes

ULTRA FILTRATION

Ultrafiltration[10] (UF) is a variety of membrane filtration in which hydrostatic pressure forces a liquid against a semipermeable membrane. Suspended solids and solutes of high molecular weight are retained, while water and low molecular weight solutes pass through the membrane. This separation process is used in industry and research for purifying and concentrating macromolecular (10^3 - 10^6 Da) solutions, especially protein solutions. Ultrafiltration, like reverse osmosis, is a cross-flow separation process. Here liquid stream to be treated (feed) flows tangentially along the membrane surface, thereby producing two streams. The stream of liquid that comes through the membrane is called permeate. The type and amount of species left in the permeate will depend on the characteristics of the membrane, the operating conditions, and the quality of feed. The other liquid stream is called concentrate and gets progressively concentrated in those species removed by the membrane.

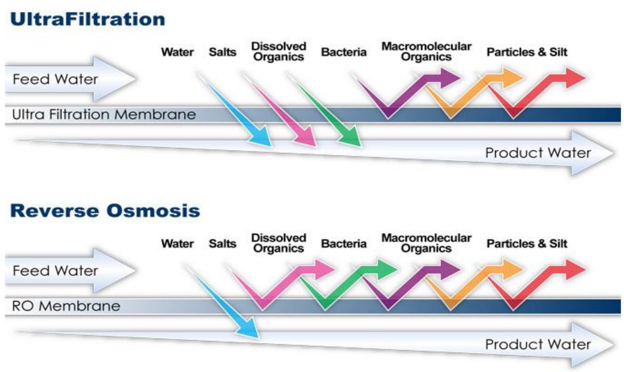

Figure 4

Recovery

Recovery of an ultra filtration system is defined as the percentage of the feed water that is converted into the permeate,

$$R = \frac{P}{F} \times 100$$

Where: R = Recovery
P = Volume of permeate
F = Volume of Feed

Ultrafiltration Membranes

Ultrafiltration Membrane modules come in plate-and-frame, spiral-wound, and tubular configurations. For high purity water, spiral-wound and capillary configurations are generally used. The configuration selected depends on the type and concentration of colloidal material or emulsion. For more concentrated solutions, more open configurations like plate-and-frame and tubular are used. Pore sizes for ultrafiltration membranes range between 0.001 and 0.1 micron.

Membrane Materials

A variety of materials have been used for commercial ultrafiltration membranes, but polysulfone and cellulose acetate are the most common. Recently thin-film composite ultrafiltration membranes have been marketed. For high purity water applications the membrane module materials must be compatible with chemicals such as hydrogen peroxide used in sanitizing the membranes on a periodic basis.

Factors affecting the Performance of Ultra filtration

There are several factors that can affect the performance of an ultrafiltration system. A brief discussion of these is given here. Flow across the Membrane Surface: The permeate rate increases with the flow velocity of the liquid across the membrane surface. Flow velocity is especially critical for liquids containing emulsions or suspensions.

Operating Pressure: Permeate rate is directly proportional to the applied pressure across the membrane surface. However, due to increased fouling and compaction, the operating pressures rarely exceed 100 psig and are generally around 50 psig. In some of the capillary-type ultrafiltration membrane modules the operating pressures are even lower due to the physical strength limitation imposed by the membrane module. Operating temperature: Permeate rates increase with increasing temperature. However, temperature generally is not a controlled variable

WATER FOR INJECTION

Figure 5

Description: Sterile Water for Injection, USP, is sterile, nonpyrogenic, distilled water in a single dose container for intravenous administration after addition of a suitable solute. It may also be used as a dispensing container for diluent use. No antimicrobial or other substance has been added. The pH is 5.5 (5.0 to 7.0). The osmolarity is 0**.**

Clinical pharmacology

Sterile Water for Injection USP is used as a diluent or solvent for other parenteral drugs. As such, Sterile Water for Injection USP contributes to the water for hydration when provided in parenteral drug and fluid therapy, after the introduction of suitable additives and/or mixture with suitable solutes to approximate isotonicity.

Indications and usage

Sterile Water for Injection USP[11] is indicated for use in adults and pediatric patients as a diluent or solvent in the aseptic preparation of parenteral solutions or as a vehicle for drug administration.

Contraindications

Sterile Water for Injection, USP is a hemolytic agent due to its hypotonicity. Therefore, it is contraindicated for intravenous administration without additives.

Warnings

Hypotonic and hemolytic. Do not inject until made approximately isotonic by addition of an appropriate solute, due to the possibility of hemolysis.

Precautions

- To minimize the risk of possible incompatibilities arising from the mixing of additives that may be prescribed, the final infusate should be inspected for cloudiness or precipitation immediately after mixing, prior to administration and periodically during administration.
- Do not use plastic container in series connection.
- If administration is controlled by a pumping device, care must be taken to discontinue pumping action before the container runs dry or air embolism may result.
- It is recommended that intravenous administration apparatus be replaced at least once every 24 hours.
- Use only if solution is clear and container and seals are intact.

Adverse Reactions

The administration of a suitable admixture of prescribed additives may be associated with adverse reactions because of the solution or the technique of administration including febrile response, infection at the site of injection, venous thrombosis or phlebitis extending from the site of injection, extravasation, and hypervolemia.

Dosage and administration

This solution is for intravenous use only. Do not inject until made approximately isotonic by addition of appropriate solute. The dosage and administration of Sterile Water for Injection USP is dependent upon the recommended dosage and administration of the solute used. Fluid administration should be based on calculated maintenance or replacement fluid requirements for each patient. Some additives may be incompatible. Consult with pharmacist. When introducing additives, use aseptic techniques. Mix thoroughly. Do not store. Parenteral drug products should be inspected visually for particulate matter and discoloration prior to administration, whenever solution and container per

Over dosage

Overdosage (hypotonic expansion) is a function of an increase in fluid intake over fluid output, and occurs when the increase in the volume of body fluids is due to water alone. Overdosage may occur in patients who receive large quantities of electrolyte-free water to replace abnormal excessive fluid losses, in patients whose renal tolerance to water loads is exceeded, or in patients who retain water postoperatively in response to stress.

Manifestations of water intoxication are behavioral changes (confusion, apathy, disorientation and attendant hyponatremia), central nervous system disturbances (weakness, muscle twitching, headaches, nausea, vomiting, convulsions) and weight gain.Treatment consists of withholding fluids until excessive water is excreted. In severe hyponatremia it may be necessary to cautiously administer hypertonic saline to increase extracellular osmotic pressure and excretion of excess water by the kidneys.

CONCLUSION

From the above survey of information it clearly indicates that it is very important to remove contaminants from water to make it useful for both household and industrial purpose. The available data appear to demonstrate the different methods used in water purification process.

This review provides information on,

- Water treatment methods
- Demineralization
- Ultra filtration
- Water for injection

REFERENCES

1. US Environmental Protection Agency, Washington, DC (2004). "Primer for Municipal Waste water Treatment Systems." Document no. EPA 832-R-04-001.

2. Combating Waterborne Diseases at the Household Level. World Health Organization. 2007. Part 1. ISBN 978-92-4-159522-3.
3. Water for Life: Making it Happen. World Health Organization and UNICEF. 2005. ISBN 92-4-156293-5.
4. Metcalf & Eddy, Inc. (1972). Wastewater Engineering. McGraw-Hill Book Company. ISBN 0-07-041675-3.
5. "Safe Water System", US Centers for Disease Control and Prevention, Atlanta, GA. Fact Sheet, World Water Forum 4 Update, June 2006.
6. "Household Water Treatment Guide", Centre for Affordable Water and Sanitation Technology, Canada, March 2008.
7. Lindsten, Don C. (September 1984). "Technology transfer: Water purification, U.S. Army to the civilian community". The Journal of Technology Transfer 9 (1): 57–59. doi:10.1007/BF02189057.
8. Water Treatment and the need for Boiler and Cooling Water Treatment.
9. EPA – *Demineralization*
10. Gaudet, P.W. "Point-of-use Ultrafiltration of Deionized Water and Effects of Microelectronics Device Quality, American Society for Testing and Materials", 1984.
11. B. Braun Medical Inc.

***Corresponding Author:**
B. Venkateswara Reddy
Email: basu.pharmacist@gmail.com