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Optimal Water Treatment In Pharma Industry

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ABSTRACT:-Pharmaceutical Industry needs high quality of water as a major solvent and utility. Most of the Pharmaceutical Industry uses Ground water as a primary means, however some industries use, water from other sources like rivers and lakes. The specifications of water stipulated by several regulating agencies are stringent, therefore all stringent norms are to be met, at optimal cost of purification. Present paper deals with optimal water treatment process developed through different techniques including membrane filtration and Ultra filtration. Water for study was collected from different sources in Hyderabad, especially from the close vicinity to Pharmaceutical industrial zone. Several experiments were conducted and an optimal method has been derived for use in Pharmaceutical Industry

KEYWORDS: - Drinking Water, Pharma Industry, Treatment through membrane

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I INTRODUCTION

The quality of water depend on physical, chemical, biological as well as radiological traits of water. It's been a measure of the situation of water in response to the requirements of multiple biotic components and as well as any human need and purpose [2]. It's been conventionally used with reference to a series of standards against the compliance, in general achieved through processing water, which can be evaluated. The utmost common standards referred to estimate water quality in response to health of ecosystem, hygiene, and safety of human safe systems, and potable water. The index of water quality is estimated with FWQI's index, and the results indicate that these values of WQI as well as FWQI were possessing similar characteristics regarding the water quality and its index [1]. Potable water and hygienic condition coverage has been still feeble, truly in rural zones. Raw water sources and resources, especially with those of high purity, are yielding scarce because of increase in population and urbanization [1]. The availability of superior quality water is very important for food safety and process production. Water may contaminate food, like protozoa, virus, and in few cases even pathogens can be spread from polluted water to the food. Water of such quality is not potable for drinking and or using in food preparation might yield to full spread to acute as well as chronic illness. The water will influence the quality and taste of processed food and its response to spoilage. In such case, the availability of organic matter, odour, taste, and appearance is non compatible in water to be used in food and beverage unit processes and operations and the operations must be removed. Waste generated from food processing is synonymous to the food as it is. More of concentrated waste water come from processes of where food was transformed in some or other way, such as the processing the vegetables or pickling the meat [2]. The quantity and pollution level of waste water from food processing all depends on which type of process and size and durability of the plant, and the pertinent season. In general waste water is mainly very high in organic content. Biological oxygen Demand (BOD) may be as high as 10000 ppm in waste water emanated from breweries and distilleries. Water from agri farms are high in total dissolved solids as high as 3000 ppm. Water being recycled with in an industrial process plant usually integrated into industrial processes. Food processing practices based on good accepted science will be required to determine the synonymous effects of hybrid technologies [3]. The reuse of recycled water needs the development of enzymes, and the use of particle science, and other new processes. In general good discussion regarding the microbial and chemical hazards of how these new treatment methods will enable them to be applied as a general convention. In general and professional acceptance of any research on identifying appropriate indicators of mini and microbial responses of microbial levels in determining human health factors. The utmost sustainable alternative source has been discussed, not only from the actual point of view of municipal companies and local authorities, and other environmental organizations, but also in all cases, public opinion is to be considered in all aspects.

II PROCESS WATER

The processed water is being used in washing and sanitizing of raw materials, process treatment and ancillary requirements as well as green house. Water has to have the safe potable water standards. It should be clear, that taste, colour, odour and or with other words free of contaminants which affects the organs [5]. Constraints involved in the process of beverage and food industries are to be fully studied and should be able to prepare sustainable processed water. The standard and compliances with the quality of specifications of a finished product should be ensured. Most of the enterprises provide noval solutions for water supply requirements and their quality of system is to ensure reliable supply of high quality water and its proper control. Most important is also the systemic design, execution, and maintenance.

A. Pre-Treatment Process

As a conventional practice, it is necessary to have water pre-treatment in-line with the principles of established methods. In order to promote aesthetics and acceptability, and the removal of toxins or health-hazard materials. The detailed discussion and benefits are described in proceeding chapters. It is always believed that ground water is reliable resource, but current researchers have estimated that the potable water is contaminated by numerous organic pollutants, such as soluble organic substance (SOC), persistent chlorinated by phenyls(PCB), and heavy metals etc., Such pollutants are assessed along with surface water and among them in many rivers and ponds. These substances are mostly are odourless and taste less. Water use and reuse in industry can be exploited, and in except for food and pharmaceutical applications.

In general the variation in quality traits regarding an end product is with regards to the quality of water used in the process and not the result of raw material of processes. Processors must be knowing with certainty of that the water supply meets the following requirements:

- Reliable– An appropriate redundancy so as a supply within an appropriate pressure range and is assured in regards of drought or other adverse weather impacts.
- Quality consistency.
- Consistency in specifications
- Techno-economic cost.

The quality of public water supply must require treatment prior to many uses. Public supplies are treated and tested to ensure as they meet specified drinking water standards for organic, inorganic pollutants as well as radiological impact. Water must be tested on a regular basis to assure standards. Water which is used for cooking are added directly to the product and should be potable, which infers free from impurities.

B. Removal of organic matter:

Most commonly used systems are the accepted conventional practices, such as precipitation, coagulation, filtration, and sedimentation. Dispersed, suspended as well as colloidal particles producing turbidity and waters colour, cannot be removed sufficiently by the actual sedimentation and or other processes. In addition, a coagulant, mixing, and stirring the water cause the formation of settable particles. These flocks are huge enough as to settle rapidly subject to nature's gravity, and can be removed from the suspension by the method of filtration. Chemical precipitation units, coagulation and flocculation aids are usually being added, to facilitate the formation of huge agglomerated particles. These tiny particles are very simple to remove from the water. The precipitants, as well as other suspended solids, are often have similar or other neutral surface charges which repel one another. The coagulants, bounding to particles in the waste water systems, especially convert the surface charge, yielding, opposite charges from between particles, making them to form agglomerates. Use of inorganic metal salts, normally Al and Fe for agglomeration is very well conventionalized in the area of water treatment. Flocculent additives, typically anionic polymers, and are added to furthermore to enhance the coagulation of tiny particles. The degrees of clarification obtained will depend on the quantity of chemicals, being used, time of mixing, and control of process. One of the high disadvantages of coagulation is the processing and disposal of sludge resulting from chemical precipitation process. The volatile organic compounds are being removed by aeration.

Air diffusion into the water is responsible for the act. The equilibrium estimated between ΦVOC in solution phase and cVOC in the gas phase, has been estimated according to Henry's famous law:

$KH = \Phi VOC/cVOC$ (1)

KH – Henry's Law Constant.

At a constant temperature as well as pressure, the actual concentration of a particular substance in vapour phase is proportional to its concentration in aqueous phase. Soap as well as detergent residues to have carefully removed, in order to not to produce viscous scum and curd. The organic contaminants are being removed by biological processes. The bacteria adapted to in-site of a specific conditions are able to degrade the organic contaminants. As the pollutants are degraded, the adapted bacteria will grow.

At constant temperature and pressure, the concentration of a substance in the vapour phase is proportional to its concentration in the aqueous phase. Soap and detergent residues have to be carefully removed, in order not. The waste produced in biomass can be managed.

C. Colour, odour, and taste removal:

The iron and or manganese if is present in the water, both the metals will be oxidized (by the action of dissolved oxygen) and, with this consequently, coloured precipitates are will be formed, not only in water but also on to the equipment, vessel(s), pipes and fixture(s). A common treatment has been an ion exchange and the use as of iron filter(s), and will be mostly filled with catalytic type materials, which are very efficient in for iron and manganese removal, as well as it require fewer chemicals for their regeneration.

The Adsorption of granular (GAC) and power activated carbons (PAC) has been the most commonly used conventional method and the utmost successful adsorbents used for organic matter as well as for colour, odour and taste removals. The activated carbon will be prepared by activation at a very high temperature of around 800 °C – 900 °C, from variety of the carbonaceous materials [6]. Before its carbonization, these raw materials are powdered and blended with a binder and pelletized under pressure to give 5 mm – 10 mm sphere sizes. After this pyrolysis at about 500 °C, the thermal activations followed in the presence of CO2, which produces a complex of macro- and micro pores structure. As a GAC surface area ranges from 760 m2/g – 1550 m2/g allows its organic substance as to be adsorbed from the water. The adsorption will depend on the nature of the adsorbents, surface areas and pores structure, particle sizes, and its surface chemistry. Increasing temperatures will decrease adsorption rates. Adsorption has been a three step process:

• Transportation of adsorbate from the solution outer surface of the adsorbent particle (diffusion controlled);

• Transportation from outer surface to the interior sites by diffusions within the macro- and micro-pores structures;

• Adsorptions at site in the micro pores of this is the most rapid step. Overall rate will be determined with the slowest steps. A Reverse osmosis equipment can remove taste, colour as well as odour from the water. It can remove all known established micro-organisms and the most other health contaminant(s). The reverse osmosis unit and mechanism has been shown in the below Figure 1 & 2.

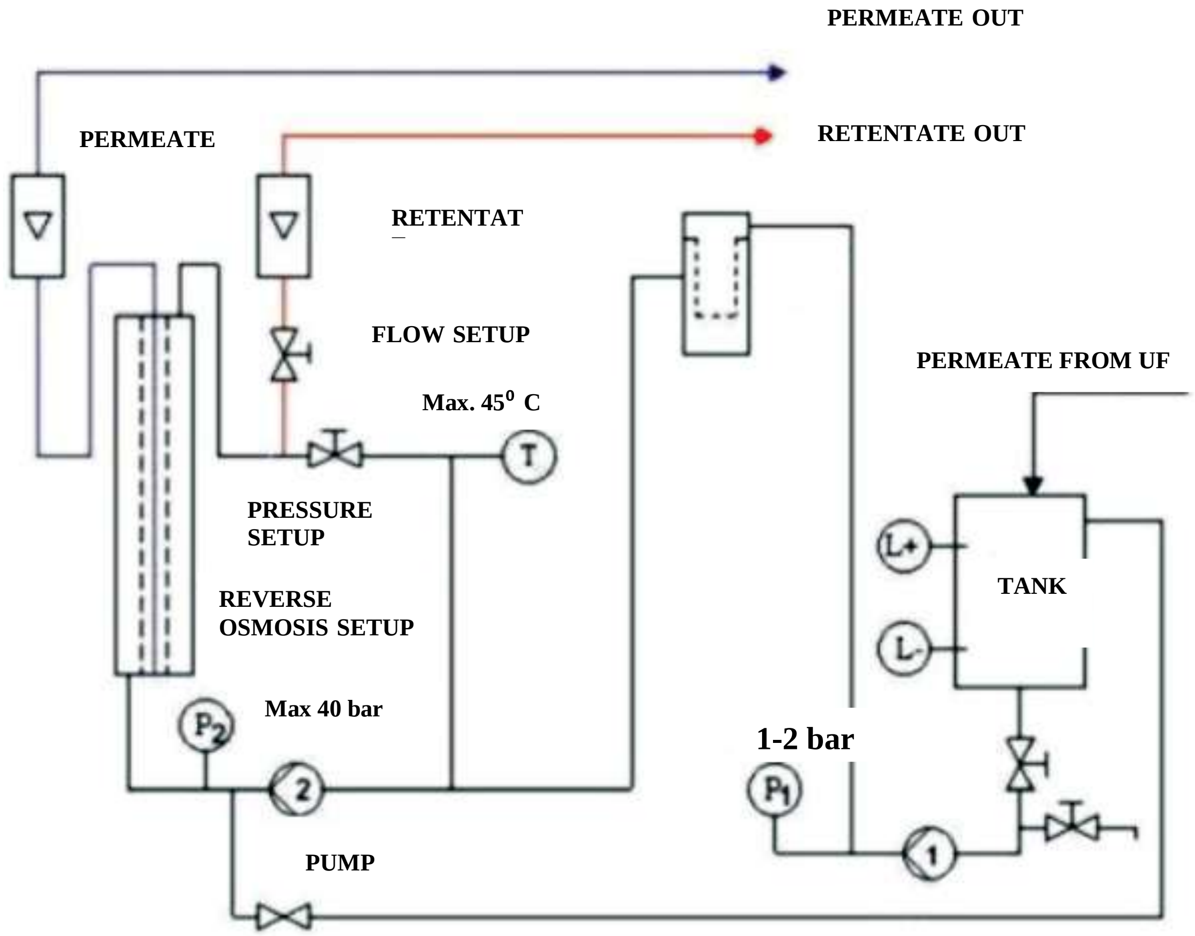


Figure 1: Reverse Osmosis Unit

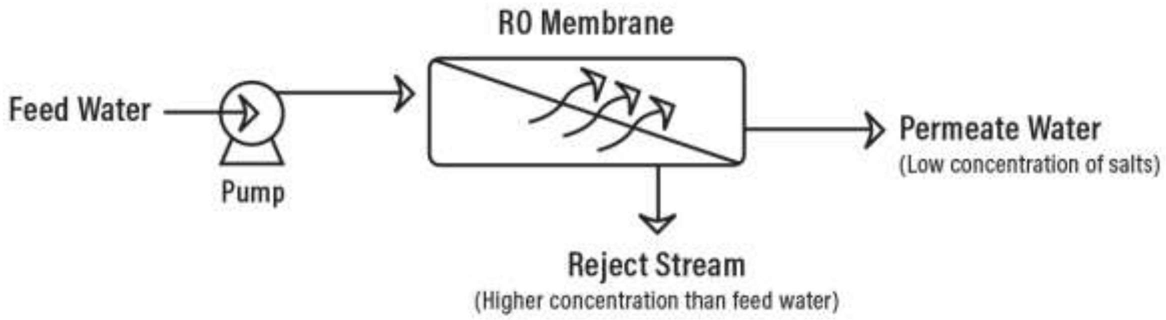


Figure 2: Reverse Osmosis Mechanism

The membrane processes have been characterised by the fact that the feed stream will be divided into two streams, as into the retentive or concentrate, and the other is permeate one. In all membrane process operations separation can be achieved by membranes, which may be considered as a perm selective barrier existing between any two homogeneous phases. Transportation through the membranes will takes place when the driving force is applied to the components in the feed stream. In most membrane processes, driving force will be the pressure difference and or a concentration difference across the membranes. High pressures on the source sides forces, water to reverse the natural osmotic processes, with a semi permeable membrane permitting these passage of water while rejecting most of other contaminants. Such specific process is being called ion exclusion, where ions form a barrier for substances at any membrane's surface and except for the water molecule(s). The Hydrodynamic flux controlling factors are shown in the below Figure 3.

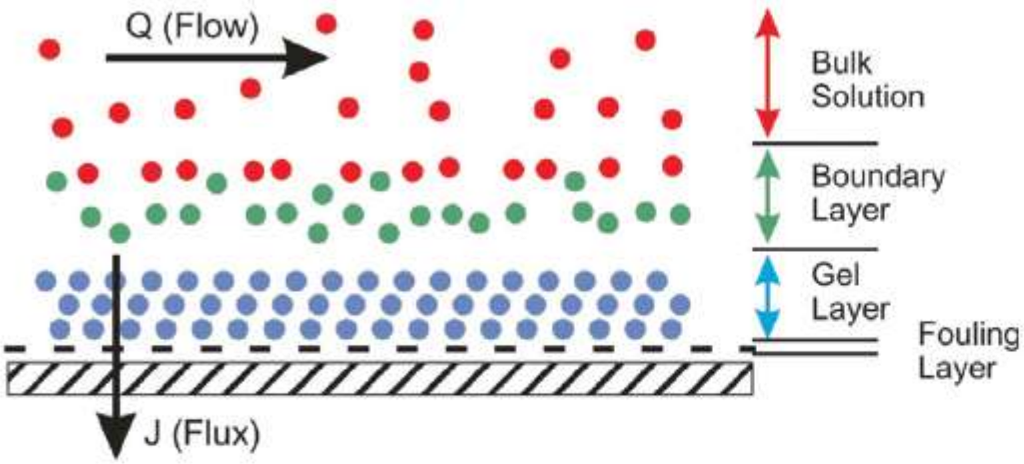


Figure 3: Hydrodynamic flux controlling factors

D. Water desalination:

Selection of a water supply must be based on available volumes, quality, and techno-economics of development, and investigating usable as well as re-usable fresh surface water and groundwater very thoroughly, prior to considerations of sources requiring desalinations. When fresh water sources do not exist, saline water sources is to be considered. Most commonly utilized parameter is to differentiate between the saline water qualities is the total dissolved solids (TDS), which are defined as the total of the dissolved organic materials and the inorganic salts/materials. Fresh water contains less than 1000 ppm of total dissolved solids. Brackish water contains 1000 ppm – 20000 ppm of total dissolved solids. Sea water contains at least 20000 ppm of total dissolved solids. And well water will contain between 500 ppm to 3000 ppm of TDS and electricity will be inexpensive. Electro dialysis reversal or very high flux reverse osmosis will be indicated. Without adequate pre-treatments, desalination facility has reduced life-times, maintenance costs and produced shorter periods of operations. The Solids can be removed by a modern up-flow sand filters with a continuously cleaned up filter bed, making its shutdowns for backwashing of its filter bed additionally [4]. The reservoirs for such wash water and sludge liquors can be easily be spared. The feed will be introduced at the top of the filter and flows through downward and an opening between the feed pipe and airlift housing. Feed is introduced into this bed through a series of feed radials which will be opened at the bottom. As this influent flows upward through the moving sand bed filters, the solids are removed. The filtrate exits at the top of the filter. Simultaneously, all the sand bed, along with the accumulated solids, will be drawn downward into the airlift pipe, which is located in the centre of the filters. The sand and solids are transported through the airlift into a washer or separator with a centrally reject compartment. As the sand keeps falling through the washer, which contain several concentric stages, of which a small amount of filtered water will pass upward, by washing away the silt, while allowing heavier, coarser sands to fall on to the bed. By way of setting the reject weir at a lower level than its filtrate weir, a steady stream of wash water is assured by its way. Continuous rejects exits near the top of the filter area. Optimal adjustment of the wash water quantity is possible by varying weir height. The production of saline water usually require a significantly larger quantity of saline feed than the quantity of pure water produced. After the desalination of sea water, more than 70 % of the intake, will be pumped as brine solution, and only up to 30 % for product water, while by its desalination of brackish water only 5 percent of the feed stream is rejected as a brine [6]. Reverse osmosis became the state of the art, for water desalination processes (Figure 4).

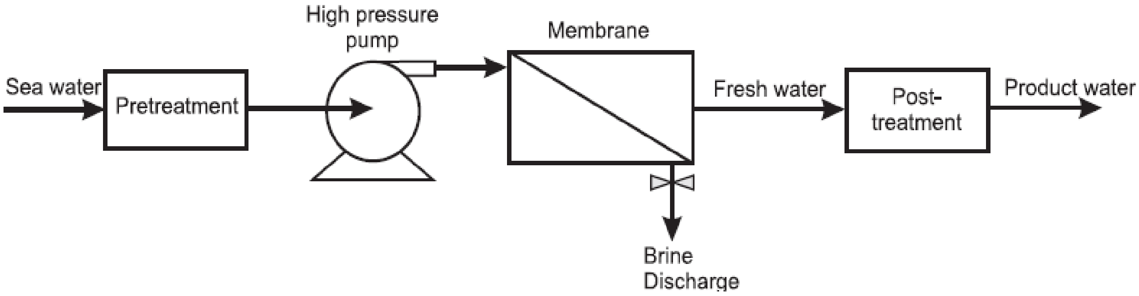


Figure 4: Desalination process

It is also applied for the production of drinking water, and industrial process water from brackish water sources. Similar kind of technology is also used in power plants, where, spirally wound elements are indispensable. Very high operating costs are still mostly connected to high rates of energy consumption. However, the product water costs have been dropped from 1 USD/m3 in the early nineties to 0.55 USD/m3 at present times. During membrane desalination operations at high the recovery ratios, the solubility limits of gypsum and calcite exceeded saturation levels, leading to crystallization on membrane's surface areas. The surface blockage of the scale results in permeate flux decline, reducing the efficiency of the process, and increasing operational costs. In the reverse osmosis elements, colloidal pollution can seriously sluggish performance by decreasing productivity. An early sign of this pollutant is usually an increasing pressure gradient. The sources of this pollution in feed water can vary greatly. They are usually bacteria, clay, and iron corrosion products. Those chemical products used during pre-treatment may also cause fouling of the membranes. The best available technique available for the determination of feed water fouling potential by colloids is the Modified Fouling Index (MFI) measurement. This is an important type of measurement which takes place prior to the design of a pre-treatment system. This measurement must have been done regularly when the reverse osmosis (RO) system is put to conventional use. The number of micro-organisms in the surface water, as well as in the feed water and in the concentrate can provide us with valuable information on the degree of water contamination (bio-fouling). The types and concentration of nutrients present in the feed water are the actual factors that determine bio film growth. Despite the fact that there are several investigators which determine the growth of bio films, it has not been fully researched as of now. Often the use of Millipore water is required, especially in the pharmaceutical industrial operations [8]. The principle has been, prior to RO membrane, some pre-treatment processes are needed, such as micro-filter and activated carbon filter for free chlorine and colloidal removal from tap water. Ion exchange resins have been continuously regenerated by means of an electric current applied within the module itself. It provides the advantage of using resins of very good quality all the time and needs of no chemical regeneration that would damages the resin beads. Two resins are placed between anion- and cation-permeable membranes, in a purifying channel each, and a concentrating channel is placed in-between them [7]. The anode electrode chamber will be placed on one side of the first purifying channel, and the cathode electrode chamber on the other side of the second purifying channel.

E. Scaling:

Hard water usually needs to be treated / softened to be acceptable for food and beverage processing. Hard water causes toughening of vegetable skin during blanching and canning. Softening is mostly required to avoid scale. The tendency to develop scale formation (CaCO3) during the treatment can be approximated by calculating either the Lonelier Saturation Index (LSI) or Ryzner index (RI) [8,9]. The most common softening processes are precipitation, cation exchange, as well as demineralisation. Ion exchange resins are well suited for cation removal, and because they have high capacities for cations, the resins are stable and readily regenerated, they are independent of temperatures and are very suitable for high volumes of systems in the food industries.

Most exchange material is processed and produced by polymerisation of styrene and divinyl benzene. It should be chemically activated to perform the ion exchange process. Each positively active group has its fixed electrical charge, which is free to exchange with another ions of the similar charge. The actual ion exchange material should be in-soluble, resistant to fracture, and process and uniform dimensions. Strong acid cation resins were formed by treating the beds with a strong acid (H_2SO_4 or HCl) [10].

Resins has its high affinity to ions with higher valences. A predominance of high valence ions may cause a higher rate of its reaction. Increasing temperatures can speed up chemical reactions. The exchange of reaction is a diffusion process, and the diffusion rate of the ion on the exchange site has the same effect. The strength of the exchange site, whether it is strongly acidic or basic, or weakly acidic or basic, affects the reaction rate, as well. The selection of an appropriate resin for a particular application is determined by feed water which analyses, the desired effluent quality.

F. Disinfection:

The easiest way to destroy micro-organisms is to add 5 ppm – 8 ppm chlorine solution, lower concentrations is used in a product to prevent off odour. A less suitable method is pasteurization, especially because of processing cost (high fuel requirements). It is to boil water rigorously at 115 °C for 10 – 15 minutes. Very powerful disinfection will be achieved by using ozone. It is prepared by electric discharge in air or oxygen at high direct voltage. The half-life period of water is 40 minutes at pH 7.6 and 14.6 °C, which exposes to a sphere of water, of 120 mm in diameter, to a point source of 254 nm radiation for 5 seconds is adequate for disinfection of bacteria and some other organisms. Groundwater contains only a few micro-organisms, while surface water contains a high volumes of many different kinds of micro-organisms. Microbial growth shall be controlled by physical methods including the use of heat, low temperatures, desiccation, osmotic pressure, filtration, and radiation processes. Chemical agents including several groups of substances that kill or limit microbiological growth. Factors affecting micro-organisms include temperature, pH, and oxygen and water pollution. Human pathogens in water supplies usually come from contamination of water with faecal materials. Many pathogens which leave the body through the faeces – many bacteria, viruses, and some protozoa will be present. Water is usually tested for faecal contamination by isolating Escherichia coli from a water sample. E. coli is called an indicator organism because it is a natural inhabitant of the human digestive tract. Its presence indicates that the water is contaminated with faecal material masses. Purification procedures for human drinking water are determined by the degree of purity of the water at its sources. Water from very deep wells or from reservoirs which are fed by clean mountain streams requires very little treatment to make it safe to drink. In contrast, water coming from rivers which contain industrial and animal waste as well as sewage from upstream towns, require extensive treatment before it is prepared safe to drink. Some micro-organisms may remain unaffected by chlorine treatment. For example the Legionella Species not only survive but multiplies in storage tanks as well as other water systems. In Worldwide, the most common bacterial diseases transmitted through water are caused by Shigella, Salmonella, enterotoxigenic Esherichia coli, Campylobacter jejuni, and Vibrio cholere. Viral infections include hepatitis A, B, C Rotavirus and Norwalk-like virus. Common parasites include Giardia lamblia, Cryptosporidium, and Entamoeba histolytica. The first water-borne outbreak caused by cryptosporidium occurred in Texas in the year 1985. A more serious problem was that several pathogens were more resistant to disinfection than coli forms. Chemically – disinfected water samples which are free from coli formed bacteria are often contaminated with enteric viruses. The cysts of Giardia lamblia and Cryptosporidium are so resistant to chlorination which eliminating them with this method is impractical. Mechanical methods, such as filtration and flocculation, are necessary to remove colloidal particles because the micro-organisms, which are mostly trapped by surface adsorption in the sand beds.

A Routine examination of water and wastewater for pathogenic micro-organisms will never be recommended, because, very well-equipped laboratories with well-trained technical personnel are needed [9]. Examination of routine bacteriological samples cannot be regarded Examination of routine bacteriological samples, which cannot be regarded as a providing means to complete or final information concerning sanitary conditions surrounding the source of any particular sample [11]. The results of examination using a single sample from a given source must be considered in-adequate. The final evolution should be based on examining, a series of samples collected over a known and protracted period of time period. The most effective microbiological monitoring of water source is to simply, rapidly, and inexpensively determine the presence of indicating bacteria: Coliform group, Faecal coliform bacteria, Heterotrophic plate count (HPC).

G. Drinking water indicators

The following is a list of indicators often measured by situational category:

- Alkalinity or basicity
- Color of water
- pH

- Taste and odours (geosmin, 2-Methylisoborneol (MIB), etc.)
- Dissolved metals and salts (Sodium,chloride, potassium, calcium, manganese, magnesium)
- Microorganisms such as fecal coliform bacteria (Escherichia coli), Cryptosporidium and Giardia lamblia and Bacteriological water analysis
- Dissolved metals and metalloids (lead,mercury, arsenic,etc.)
- Dissolved organics: coloured dissolved organic matter (CDOM),dissolved organic carbon (DOC)
- Radon
- Heavy metals
- Pharmaceuticals
- Hormone analogs

H. Materials and Methods

1. Materials: Reverse Osmosis Setup: A reverse Osmosis setup, supplied by Perma Municipal water was collected, Name of system: ‘’Perma make’’ pilot plant; Size of Membrane Modules: 2’’ x 12’’ long (RO System): 2’’ x 12’’ long (NF system): 2’’ x Membrane Type: Poly Amide spiral wound (RO system: Figure - 5)

2. Method: Water to be filled in CIP tank with the sample to be treated. Before filling the tank, the valve to be closed the bottom kept for flushing, which enables, the sample doesn’t run off from the tank.

The next step is be to open up all the valves for treatment like the feed valve, inlet valve and outlet valve for Permeate valve and Reject Flow from the system. The system then need to be started by pressing the “Low pressure by-pass” push button along with the Feed Pump button on the combined panel board. The feed flows through the Micron Cartridge Filters. Once the Low Pressure by-pass button is pushed, the sample flows through the Micron Filters, where the particles of micron size are removed from the sample. Then to start Membrane System pump (high pressure pump) after reaching a minimum pressure of 1.5 kg/cm2 on the inlet pressure gauge, and then to allow the system to run for few minutes, if any air or water left in the system would run off automatically.

Once the Membrane System pump starts functioning, the Feed starts to flow across the Membrane system (RO) which ever process it is connected to and from the process starts and can be seen an increase in outlet pressure. The readings are to be recorded.

Figure - 5: Reverse Osmosis Setup

Table I: RO Setup Specifications

Name of system	’Perma Make’’ pilot plant
Size of membrane modules	2’’ x 12’’ long (RO System)
	2’’ x 12’’ long (NF system)
	2’’ x 12’’ long (UF system)
Module Specification	HPA-100 (RO System)
	HPA-200 (NF System)
	HFUF-20 (UF system)
Membrane Type	Poly Amide spiral wound (RO system)
	Poly Amide Spiral wound (NF system)
	Poly Ether Sulphone tubular (UF system)

I. Results & Discussions:

A typical high TDS water was collected from the vicinity of Pharma Industry, and subjected to several tests. The result shows as follows:

Initial Feed Characteristics
Pressure 5 kg/cm2
Initial Conductivity 0.75 mS/cm
Initial TDS 990 ppm
Initial Feed volume 30 litres
Final Volume of Permeate and Reject
Volume of permeate 15 litres
Volume of reject 11.5 litres
COD Analysis
Feed 220 ppm
Permeate 7 ppm
Reject 982 ppm
Percentage Recovery 98.7%

Table II: Response of RO system

Time (min)	**Conductivity (mS/cm)**		**TDS (ppm)**		**Rejection %**
	Permeate	**Reject**	**Permeate**	**Reject**	
0	0.02	0.75	2	960	98.01
5	0.04	1.12	4	990	99.09
10	0.04	1.89	4	920	99.56
15	0.05	1.21	4	992	98.29
20	0.05	1.25	5	989	99.66
25	0.06	1.29	6	980	99.29

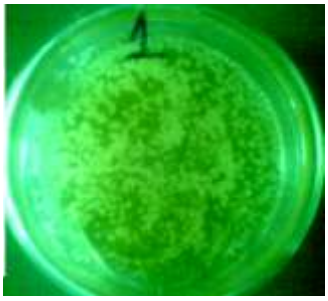
The above mentioned is the optimal result amongst several permutations and combinations. The product is then subjected to UV filtration. The results of microbial contamination before and after Reverse Osmosis as well as UV filtration, is shown through the images of petri dishes.

1. FLOW SHEET OF OPTIMAL TREATMENT PROCESS:

Raw ground water
↓
Micro Filter 1
↓
Micro Filter 2
↓
Reverse Osmosis Membrane
↓
UV Treatment
↓
Purified water

2 MICROBIAL DISINFECTION:

Before R.O



After R.O

After UV treatment

III CONCLUSION

The described processes, recommendations for use and removal of contaminants are gathered in the Table 1. Whilst the economic benefits are the central point of management, more emphasize should be given to equally consider the environmental and social aspects in future decision- making processes. Long time ago some authors [10] pointed out that economic benefits are significant for companies which are looking for more effective solutions to pollution through conservation-oriented technologies by reducing water use and waste generation, because in food plants pollution prevention is more economical than pre-treatment.

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