RO Water Purification with Zero Wastage

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Abstract— **Reverse osmosis is being a great solution for treating polluted water in industries and in homes for drinking purpose. RO (Reverse Osmosis) water purifier is a application mode of Reverse Osmosis process. Despite of being a better and effective method to treat polluted water there is enormous amount of waste water as byproduct. The range of waste water produced during RO purification process is more than the purified water that produced. To bring a solution to this problem the concept of De-ionizer is used. De-ionizer is another effective method to treat polluted water in industries. But it costs more than any of the water treatments. By making portable and cost-effective de-ionizer setup to treat the waste water the ratio of waste water to purified water can be reduced. The cost-effective deionizer setup would bring a solution to the problem which is faced by the consumers who are using RO water purifier in their homes.**

***Keywords*—Reverse Osmosis, Deionizer, TDS, pH, conductivity.**

I . INTRODUCTION

One of the primary resources for life is water. The bigger issue that our societies facing today is water scarcity and pollution. There are numerous methods to treat water and other elements. To treat the water the most effective and portable method is Reverse Osmosis. It is the process in which the natural phenomenon of "osmosis" is reversed by means of some external created pressure. In this method the water is forced to flow through very minute porous of sheets which are commonly known as RO (Reverse Osmosis) membranes. During this process the purified water is produced at higher standards. In addition to the purified water there is lot production of waste water. Which is harm to the human nature and can't be re-treated. The range of waste water producing is much time larger than the purified water. During such water scarcity the disposal of large amount of water as waste is not advisable.

The parameters that used to check the water standard for drinking are TDS (Totally Dissolved Salts), pH and conductivity. To achieve the potable range of TDS, pH and conductivity RO purifier is widely used in our homes than other purification methods. There are various methods to treat water such as boiling, filtration, ceramic filtration, flocculation and some other chemical methods yet RO purification stands at first due to it's purification level and cost effectiveness. The main problem associated with this method is waste water level. To bring a solution to this problem a portable cost-effective mixed bed de-ionizer is made and combined with RO water purifier. De-ionizer is the device which consist of resins that chemically treat the polluted water by making them cations and anions. Ions of polluting salts will be absorbed by resins and purified water is produced as a byproduct. Though De-ionizer being a great solution, it is not a portable for home purpose. By reducing the size and amount it can be a great solution. By combining the de-ionizer concept to the RO water purifier, the amount of waste water is enormously reduced even zero wastage can be achieved.

By this concept of combining RO purification process with de-ionization process the wastage that produced in home RO water purifier is brought to zero level at higher standards for drinking. Various tests has experimented and the results were proving that this cost-effective concept would be a great relief to the problem of water scarcity and pollution of this era.

II . METHODS AND MATERIALS

A. Reverse Osmosis

Reverse osmosis (RO) is one of the water purification technology that uses a semi-permeable membrane to get rid of contaminants and larger particles from drinking water. In reverse osmosis, an applied artificial pressure

is used to overcome osmotic pressure which is natural, a colligative property, that is driven by chemical potential differences of the solvent. Reverse osmosis filters many kinds of dissolved and suspended chemical particles as well as biological organisms from water, and is employed in both industrial processes and the production of potable water in homes. The result is that the solute is restricted on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. This membrane should not allow large particles or ions through the pores , but should allow smaller particles of the solution to pass freely.

Study made on the basis of the paper,Malcolm R. Snowball, St. Leonards-on-Sea, Great Britain et.al., (1998) [1] An ultra-violet ray water sterilizer comprising a container having two chambers connected together only adjacent the bottom internal surfaces of the chambers, one chamber containing a germicidal ultra-violet ray lamp extending up the chamber from the bottom surface thereof, the said one chamber having an outlet adjacent the top of the ultra-violet lamp, the second chamber having a water inlet. Thus, the water may be poured into the said second chamber and when this is to be dispensed upon tilting the units so that water emerges from the outlet at the top of the first chamber, all the water passes the ultra-violet ray lamp and becomes sterilized.

Study made on the basis of the paper,Theodore A. Kuepper, Marlin Way, et.al., (2000) [2] A water desalination and Softening System that can be used in a home or commercial environment which recirculates water past a membrane filter element in a very manner to self-clean the membrane and to forestall a buildup of salts and minerals on the membrane Surface. The System conserves water thus on end in close to Zero waste by recirculating water from a reservoir tank past the membrane. The System can operate in conjunction with a buildings water Supply and can operate without problems in either a Zero or low effluent mode or when water usage is frequent.

B. De-ionizer

Deionized water means with demineralized water that has had almost all of its mineral ions removed, such as cations like sodium, calcium, iron, copper and anions such as chloride and sulfate. Deionization is a process that uses specially manufactured ion-exchange resins, which exchange hydrogen ions and hydroxide ions from contaminated water, and then recombine to form water.

C. De-ionization Process

Deionization is a process that supplies large amounts of highly purified water as needed. Deionization process removes total dissolved solids (TDS) from water using ion exchange resins, controlling the electric charge of ions in the water to remove the TDS.

Deionization is the process in which removal of charged molecules or ions or atoms from a liquid. Deionization of the water takes place by passing it through two resins that facilitate in removing the charged anions and cations.

The cationic (negative) resins and the anionic (positive) resins are used in the deionization process. The anionic resins are made up of positively charged ammonium groups which are pre-charged with the hydroxide ions which are commonly known as strong basic anions. Anionic resins are attracting the negatively charged ions like chloride, fluoride, sulphate to release an equal amount of hydroxide.

Sulfonic groups (negatively charged) which are pre-charged with hydrogen ions make up for the cationic resin. The cationic resins are attracting the positively charged ions like magnesium, calcium, sodium in the water to release an equal amount of hydrogen ions which are commonly known as strong acidic cations.

II. METHODOLOGY

A. Construction

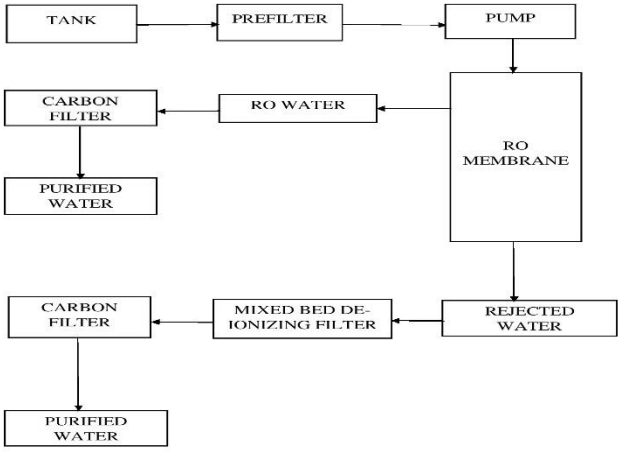

Fig 1 :Line layout of construction

B. Woking

The water that to be purified is sucked from the tank due to the pressure difference that produced by the pump. The sucked water is allowed to pass through three stages of pre filters such as sediment filters. Initially it is planned and implemented that a deionizing filter which was made with mixed bed de-ionizer resins is placed next to the three stage of filters. The pretreated water is allowed to pass through the de-ionizing filter where the totally dissolved salts reacted with resins and converted into anions and cations. The mixed bed resins consist of strong acid cation exchange resins and strong base anion resins combined to a ratio of approximately 40% cation resin to 60% anion resin which are having the nature of attracting and absorbing the ions of salts. When water is reacting with these resins it just broken into ions and get absorbed.

The water with reduced TDS level is entered into the RO membrane through pump. Here the normal reverse osmosis process is happening and purified water is obtained. By implementing the de-ionizing filter before to the reverse osmosis process the level of TDS get reduced before the actual RO process. Through experiment it was found that the normal pure water and waste water ratio is reduced to some appreciable value and it was found that the TDS level of the rejected water also in the potable standard. Even though the ratio of pure water to waste water is reduced and the reject water having the standard of potable level, it doesn't seems efficient. Resins has to be moisturized always once it is get dehydrated it would become waste. Through experiment it was found that suction of water through dehydrated resins is complicated and it affects the pump. The life of the pressure source in RO purifier will get reduced even the pump will get failure.

Even though the ratio of pure water to waste water is reduced and the TDS level of rejected water is at potable level, it is found that implementing de-ionizing filter before pump would cause problem in suction and lead to the pump failure.

The construction of model two differ from model one by the implementation of de-ionizing filter. The de-ionizing filter is placed next to the reverse osmosis membrane kit. But the allowed water to the filter is not RO water. The RO rejected water is allowed to flow through the filter after the RO process. The rejected water is highly contaminated with totally dissolved salts and not potable. The concept of purifying the rejected water resembles de-ionizer filtration.

The mixed bed resin consists of strong base anions which hold hydroxyl ions and strong acidic cations which hold hydrogen ions. When the contaminated water is flow through the filter the bond of totally dissolved salt would break. The cations and anions would get absorbed by the resins. TDS value of the

contaminated water would get reduced abruptly and it was proved through experiment. The outlet water from the de-ionizing filter is passed to a carbon filter for balancing taste and pH level.

The failure that occurred in the previous model is avoided in the second model by just changing the order of the processes. By implementing the de-ionizing filter, the RO reject water is completely converted into potable nature. The standard TDS, conductivity and pH levels are achieved by this implementation and it was proven. The actual pressure that created by the pump is fair enough to pass the water through the filter. The resin that used in this filter is a regenerative type. Once it get absorbed ions to its optimum level then it can be regenerated by using the strong acid and base such as hydro chloric acid and sodium hydroxide respectively. By means of using regenerative kind of resins the purifier can be used to its optimum level efficiently and economically. The implementation of this de-ionizing filter in an existing RO water purifier brings the level of water wastage to zero level and it was proven.

III. EXPERIMENT PARAMETERS

To check the potability of water there are certain tests and parameters. The important parameters are TDS, pH, conductivity.

A. Totally Dissolved Salts

TDS value describes the amount of salts that presented in the water. It determines the potability of drinking water. As per the standards the potable value of the TDS in drinking water is below 500 ppm. The unit that used to indicate TDS is ppm.

B. pH Value

The value that determines the acidic or basic nature of drinking water. If the pH value is above 7, then it is known as base. If the value of pH is less than 7, then it is known as acid. The potable water should have its pH level between 6.5-8.5.

C. Conductivity

The range that describes the capacity of water to conduct electricity is known as conductivity. It is a reciprocal of resistivity. It describes the value in the unit(Ω^{-1}). It also represents the turbidity. If the water consist of more contaminates, then it would have higher conductivity.

IV. RESULTS AND DISCUSSION

Initially the normal TDS, pH and conductivity values of various sources of water that are obtained from the local regions and they were tabulated.

TABLE I.

PARAMETERS FOUND IN LOCAL SOURCES

S.No.	RIVER	TDS (ppm)	PH	Conductivity (Ω^{-1})
1	Cauvery	**194**	**7.4**	**1.76**
2	Bhavani	**253**	**7.8**	**2.42**
3	Siruvani	**28**	**7.2**	**0.56**
4	Aaliyaru	**56**	**7.3**	**0.64**
5	Ambarampalayam	**62**	**6.9**	**0.72**

TABLE II.

PARAMETERS FOUND FOR WELL AND GROUND WATER

S.No.	Ground and Well water	TDS (ppm)	PH	Conductivity (Ω^{-1})
1	Coimbatore (Sundrapuram)-Ground	1400	8.2	3.24
2	Coimbatore(Kinathukadavu)-corp	546	7.8	2.14
3	Coimbatore(Kinathukadavu)-well	450	7.6	2.12
4	Coimbatore(Pollachi)-Ground	741	7.9	2.56
5	Erode (Bhavani)-Ground	471	7.6	1.96
6	Erode –Ground	656	7.7	2.65
7	Erode (Maranaicknour)-Ground	496	7.5	2.06
8	Erode (Maranaicknour)-well	377	7.4	1.62

The deionizing filter is initially placed before the RO membrane and result were analyzed and tabulated. The results of model one is matched with optimum standard of potable water.

TABLE III.

IMPLEMENTATION OF DEIONIZING FILTER BEFORE RO MRMBRANE

S.No.	Samples	TDS (ppm)	PH	Conductivity (Ω^{-1})
1	Reverse Osmosis pure water	160	6.5	0.74
2	Reverse osmosis reject without deionizing filter	224	9.6	2.56
3	Reverse osmosis reject with deionizer	77	7.9	0.56

After that the deionizing filter is placed after the RO membrane to treat the wastage water and the experiment values are found and tabulated. The values found through the experiments were matched with potable standard of drinking water.

TABLE IV.

IMPLEMENTATION OF DEIONIZINF FILTER AFTER RO MEMBRANE

S.No	Samples	TDS (ppm)	PH	Conductivity (Ω^{-1})
1	Reverse Osmosis pure water	164	6.5	0.76
2	Reverse osmosis reject without deionizing filter	544	8.2	2.54
3	Reverse osmosis reject with deionizer	28	7.8	0.24

V. CONCLUSION

By combining the water purification concepts of Reverse osmosis and De-ionizer, an effective water purification method with reduced wastage water is obtained. The deionizing filter plays a vital role in converting waste water that is rejected from the RO membrane into a potable drinking water. The quality of processed water is experimented and evaluated with the standards of potable drinking water. The results of test is proven that, the processed water from the deionizing filter is optimum for the drinking purpose and the entire concept and construction made the RO water purification from the maximum wastage to the zero level.

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