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THE STUDY OF REMOVAL OF HEAVY METALS IN POLLUTED WATER USING NANOTECHNOLOGY

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ABSTRACT

Nanofiltration (NF) method used for the purification of the dissolved solid impurities such as monovalent as well as multivalent ions and salts present in water which is polluted by the sewage and untreated industrial effluents. This porous system filters the impure water and converts into the potable water without filtering the essential amount of nutrients and also softens the water while the reverse osmosis method removes whole minerals in the water.

KEY WORDS : Nano filtration, Monovalent ions, Multivalent ions, Reverse Osmosis

INTRODUCTION

Recently, when the world is facing serious issues of drinking water, experts found that nanomaterial is better option to treat wastewater because it has some unique properties like nano size, large surface area, highly reactive, strong solution mobility (Wu *et al.*, 2019). Many industrial activities where chemicals or wastes are released into the environment, either intentionally or accidentally, have the potential to pollute groundwater (Akpor and Muchie, 2010). Groundwater here is the major source of water supply in both urban and rural areas and its significance for the existence of human society cannot be over ruled (Shyamala *et al.*, 2008).

Naturally heavy metals are available in soil, water and living organisms in a minimum quantity and they are crucial for healthy life. Some of these metals like Zn, Cu, Mn, Ni, and Co are micronutrients which necessitate the plant growth, while others have unknown biological function (Akpor and Muchie, 2010). These metals can enter the soil environment from a variety of sources like industrial wastes, fertilizers, vehicle emission, domestic and urbanwaste (Wuana and Okieimen, 2011). As these metals pass from one trophic level to the next higher one, they are concentrated and may become a dominating and sinister stress at a considerable ecological distance from the point or trophic level of its initial introduction into the biosphere (Roy, 2010).

The increasing world population and annual metal usage per capita both lead inevitably to ecological problems because of wide dispersal of potentially toxic metals into the natural environment (Sherene, 2012). Sewage- irrigated land recorded significantly higher concentrations of heavy metals (Cr, Ni, Pb and Cd) than bore well water- irrigated land due to gradual accumulation of heavy metals in sewage- irrigated soils (Salakinkop, and Hunshal, 2014). The contamination of water is directly related to the degree of contamination within ambient environment (Chary *et al.*, 2008). The pollution of heavy metals in soil undesirably affects its physicochemical criteria important to infertility and

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low yield of crops due to their toxicity (Khan *et al.,* 2009). Wastewater from tanneries, industries or other sources carry a large amount of toxic heavy metals such as Ca, Fe, Mg, Na, Ni, Cr, Cd, Pb, Zn etc. which are responsible for the contamination of agricultural soil (Rahman *et al.,* 2012).

Heavy metals in water refers to the heavy, dense, metallic elements that occur in trace levels, but are very toxic and tend to accumulate, posing serious health hazards (Abdul Jameel *et al.,* 2012). Human activities like agriculture and domestic release a large number of pollutants into the water bodies. In India, ponds, rivers and groundwater are used for meeting the water needs of domestic and agricultural users (Pramod *et al.,* 2011). Membrane filtration is a pressure driven process in which membrane acts as *selective* barriers to restrict the passage of pollutants suchas organics, nutrients, turbidity, microorganisms, inorganic metal ions and other oxygen depleting pollutants, and allows relatively clear water to pass through (Mulder 1997).

Traditionally, the effluents from the anodizing industry are treated by operations involving neutralization, flocculation, settling and press filtration and the sludge is often disposed on land (Correia *et al.,* 2005). Membrane processes have gained significant attention as a replacement of traditional unit operations in desalination and wastewater treatment (Drioli *et al.,* 2017). The simulation of nanofiltration processes in order to design, analyze, and optimize the membrane systems requires suitable model-based process simulation tools. Water reclamation applications such as indirect oreven direct potable reuse target therefore at a complete removal of pathogens and trace contaminants to minimize the risk and reach drinking water quality (Wintgens *et al*., 2008). The persistence of heavy metals in wastewater is due to their non-biodegradable and toxicity nature (Jern, 2006). The wastewater is a readily available and reliable source, and its treatment and recycling would reduce the extensive amount of water extracted from the natural environment (Toze, 2006).

Significance of Nanofiltration study

Water is very essential resource. Due to increased pollution, the water gets affected and contains excess of heavy metals which cause hazardous effects to the environment. The study of nanotechnology to treat the polluted water will help to recycle the polluted water and wastewater into the potable water for purposes. The nanofiltration techniques which used to remove the heavy metals and pollutants in water will also help to remove pollutants present in groundwater sources. Now a days groundwaters are also affected by the pollutants from industrial effluents. These water is converted into drinking water by using nanotechnology. In future these techniques may play the vital role in water treatment.

MATERIALS AND METHODS

Nanofiltration

Nanofiltration is one of the important membrane filter technologies for water treatment such as ultrafiltration, microfiltration, reverse osmosis. Nanofiltration method helps to recycle the waste and polluted water. This method of filtration is similar to that reverse osmosis method of water purification. But the Nanofiltration (pore size 1-5nm) membrane lies between the ultrafiltration method and reverse osmosis method of purification of water. While the method of the ultrafiltration consists of porous membrane (pore size 5 -20 nm) and the reverse osmosis consists of non porous membrane. The reverse osmosis method purifying water by removing minerals by filtering the monovalent, multivalent ions in water and let the water without minerals and there are no essential nutrients in the water after the reverse osmosis process. In nanofiltration, this left the monovalent ions and filters the multivalent ions which contains heavy metals and impurities where filtered. The multivalent ions in water were removed more than 90 percentage, but the monovalent ions were removed only 20 percentage.

Table 1 shows that how the nanofiltration method differs from the other methods of water treatment in major aspects such as the size of the pores, types of membranes, pressure requirements etc. by this table we can clearly define about the instrumental overview of nanofiltration method.

The water purified using the nanofiltration method contains essential nutrients such as some minerals like monovalent ions as per the world health organization standards and the nanofiltration reduces the hardness of the water by removing low amounts of dissolved solids that remove organic matter and soften water.

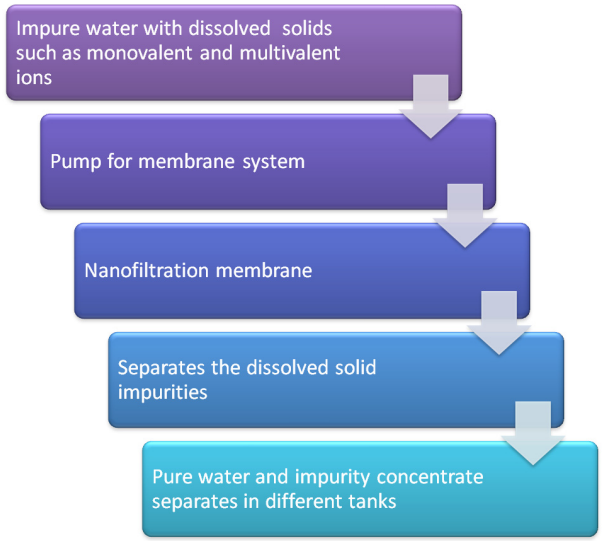
Therefore this membrane for filtration is known

as the softening membrane.Nanofiltration is not cost effective and it can work at even low water pressure .There is no pretreatment required for this method while reverse osmosis require this pretreatment.

To treat the polluted water by this type of filtration methods there are three types of the pressure systems such as full-flow, partial flow, recycle flow pressurized systems are used. According to the impurity level in the water the pressurized systems varies to filter the impurities.

In the nanofiltration method the raw or impure water which consists of impurities such as monovalent, and multivalent ions, dissolved solids and salts, etc., is passed into the pretreating pathway of the nanofiltration system and the enters the membrane pump which pumps the water into the nanofiltration membrane (contains 1-5 nm size of pores).

This membrane filters the impure water with the application of pressure in the membrane, then the impure water which contains dissolved impurities such as solids were separated and the pure water passed into the purified water storage tank for culinary purposes by passing through the another distribution pump . The impurities removed from the raw water were taken to another tank for non culinary purposes. By the nanofiltration method the impure water is converted into the potable water.



Flow Chart 1. Shows working method of Nanofiltration system.

The above 1. flow chart represents the working method of Nanofiltration system to purify the impure water. This method helps to remove the excess amount of the heavy metals present in the water and let the essential amount of dissolved solids and then soften the water .The permissible amount of the heavy metals for the potable water is given by the following Table 2.

RESULTS AND DISCUSSION

By using Nanofiltration method, we can get the purified potable water at low cost effective and less energy consumption. The excess of heavy metals and the dissolved solids can cause the hazardous health effects to the person who consumes more. This is prevented by removal of the monovalent, divalent ions solid impurities in water and left the essential nutrients by the partial demineralization of the water. Nanofiltration is mostly used for

Table 2. Permissible limits of some heavy metals for potable water

Metals	mg/L
Iron (Fe)	0.3
Manganese (Mn)	0.4
Cadmium (Cd)	0.003
Arsenic (As)	0.01
Chromium (Cr)	0.05
Nickel (Ni)	0.07
Silver (Ag)	0.1
Zinc (Zn)	3.0
Lead (Pb)	0.01
Copper (Cu)	**2.0**

Table 1. Comparitive study of reverse osmosis,nanofiltration,ultrafiltration.

Method	Reverse osmosis	Nanofiltration	Ultrafiltration
Membrane used	Non porous membrane	Finely porous membrane	Porous membrane
Size of pore(nm)	Non porous	1-5 nm	5-20 nm
Required pressure(atoms)	20-100	7-30	1-10
Pure water flux ($Lm^{-2}h$)	10-100	20-200	100-200
Treatment of solution	Small molecules and ions (both monovalent and multivalent)	Small molecules and ions (low amount of monovalent)	Colloids and macromolecular impurities

desalination process for the potable water. This method lies between the porous ultrafiltration and the non porous reverse osmosis type of membrane systems. The Table 1 shows how the Nanofiltration method differs from the ultrafiltration and reverse osmosis methods. Therefore the Nanofiltration is the best method for getting the potable healthy water. The flow chart 1 gives the information about the working of Nanofiltration system.

CONCLUSION

Now a days water scarcity problems arises in many areas, on the other hand more amount of water getting wasted in our environment and many ponds, lakes get polluted by the mixing of the sewage water and the untreated industrial effluents directly passing into the water streams. These may cause water pollution and affect the environment. The dissolved impurities are separated by the Nanofiltration method which are available at low cost and effective in water treatment to convert the impure waterinto the potable water with essential amount of nutrients left into the water due to involvement of the partial demineralization process. Therefore the Nanofiltration method is suggested for the purification of impure water.

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