Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 4, April-2016

Alternative to reverse osmosis for water treatment: A review of emerging treatment techniques

Mrs. Jini Sunil

Environment Engineering Department, Shri K.J. Polytechnic, Bharuch

Abstract — Reverse Osmosis is a water treatment process in which water is demineralised by forcing it through a semi permeable membrane. The demineralised water is called permeate and the water stream which carries the salt is called reject. But there are many problems associated with the treatment process and major ones are its high energy consumption due to use of high pressure pumps and environmental concerns related to high concentration of salt in reject water and health concern due to acidic permeate water which may cause calcium depletion from bones and teeth over prolonged use. This paper reviews the emerging technologies like Distillation, Capacitive desalination by Carbon Aerogel electrodes, Filtration by perforated graphene membranes, Nanotechnology for water treatment, which can be used to replace the reverse osmosis water treatment technology.

Keywords-Reverse Osmosis; Distillation; Capacitive desalination; graphene membrane filtration; Nanotechnology for water treatment

I. INTRODUCTION.

Reverse Osmosis is a process in which water is demineralised by forcing it through a semi permeable membrane. To understand Reverse Osmosis we have to understand Osmosis first. Osmosis is a natural process occurring in nature where low concentration salt solution will try to dilute the high concentration salt solution when they are separated by a semi permeable membrane. Now if pressure is applied to the water with more salt concentration, then water molecules will pass through the semi permeable membrane and mix into the water with low salt concentration and all dissolved solids will be blocked by the membrane. Thus the osmosis process is reversed by applying pressure which is greater than natural osmotic pressure. The demineralised water is called permeate and the water stream which carries the salt is called reject.

Reverse Osmosis

Reverse Osmosis is a process in which water is demineralised by forcing it through a semi permeable membrane. To understand Reverse Osmosis we have to understand Osmosis first. Osmosis is a natural process occurring in nature where low concentration salt solution will try to dilute the high concentration salt solution when they are separated by a semi permeable membrane. Now if pressure is applied to the water with more salt concentration, then water molecules will pass through the semi permeable membrane and mix into the water with low salt concentration and all dissolved solids will be blocked by the membrane. Thus the osmosis process is reversed by applying pressure which is greater than natural osmotic pressure. The demineralised water is called permeate and the water stream which carries the salt is called reject.

There are two major problems of reverse osmosis technique. First is that it is not cheap and second that it is not at all environmental friendly. The high pressure pumps required in reverse osmosis consume lot of energy. And the brine or reject water containing large amount of salts are discharged into the waste water stream which increases the load on waste water treatment plants. Moreover if the process is not efficient then the ratio of reject generation will be more than the permeate generation which indicates water loss. Usually the ratio for permeate and reject water is 1:3. As reverse osmosis mostly removes alkaline salts the permeate water will be acidic and drinking such water will cause calcium to deplete from bones and teeth to neutralize the acidity. So it becomes inevitable to device new technologies to overcome the demerits of reverse osmosis process. This paper presents a review of available technologies in the market which can be used as an alternative to Reverse Osmosis.

Distillation, Capacitive desalination by Carbon Aerogel electrodes, Filtration by perforated graphene membranes, Nanotechnology for water treatment are the technologies available in market which has the potential for replacing reverse osmosis process. Each process will be discussed in brief focusing on the pros and cons associated with it.

Distillation

This is a process in which external heat source is used to boil water. The water evaporates leaving behind the contaminants which have higher boiling point than water. The steam is then collected and cooled which gives

pure water free from minerals, bacteria and viruses. But this process also like reverse osmosis process produce acidic water. Moreover a large amount of water is wasted with the contaminants left after evaporation. The ratio of pure water and wasted water is generally 1:5.

Capacitive desalination by Carbon Aerogel electrodes

In capacitive desalination, saltwater flows through a capacitor with two electrically charged electrodes, and the positively and negatively charged ions that make up the salt are captured on the surface of these electrodes. In this process a electrochemical cell with a stack of carbon aerogel electrodes are used to remove variety of contaminants from water. These electrodes have high specific surface area (400 to 1100 m2/g) and very low electric resistivity(40 mΩ-cm). After polarization, cations and anions are removed from the electrolyte by the imposed electric field and held in electric double layers formed at the surfaces of electrodes. Pure water and salt concentrate streams are produced. In addition to these heavy metals and suspended colloids are also removed from water. No acid base or salt solutions are required for regeneration. Regeneration is done by electrical discharge or reverse polarization. Therefore unlike RO no secondary waste is generated and no high pressure pumps are used.

Filteration by perforated graphene membranes

Graphene is a porous membrane that is thinner than a nanometer.Graphene is a two-dimensional honeycomb-like film made of carbon atoms and the membrane consists of two layers of graphene. A major advantage of graphene is that thinner the membrane lower is the permeation resistance and thus higher the energy efficiency of filtration process. Moreover the graphene filter does not get fouled with bio growth at the rate that occurs with poly amide filters and is resistant to damaging effect of chlorine used for its cleaning. Polyamide filters can be easily replaced by graphene filters in existing plants. Energy consumption can be brought down to 15% for sea water desalination and 50% for brakish water desalination by using graphene filters. But the manufacturing cost of graphene and its perforation is its major disadvantage.

Nanotechnology for water treatment

Nano materials due to the advantage of high specific surface area and superparamagnetism help in development of high-tech materials for more efficient water and wastewater treatment processes, namely membranes, adsorption materials, nanocatalysts, functionalized surfaces, coatings, and reagents. Research is currently carried out in nanoadsorbents like carbon nanotubes, metal-based nanoadsorbents, zeolite and polymeric nanoadsorbents. Nano particles like silver ions can be embedded in porous structure of zeolite. They are released from zeolite matrix during exchange with other cations. The silver attack microbes and provide disinfection. Nanoscale metal oxide can be used in place of activated carbon to remove heavy metals. As these metal oxides are supermagnetic , low gradient magnetic field can be used for separation and recovery. Nanofiltration membrane are being developed wherein molecules and particles less than 0.5 nm to 1 nm are rejected by the membrane by pressure driven process. Specially designed coatings, such as nanosilver and TiO2layers, prevent fouling of membranes or heat exchangers and exhibit a decontamination effect on organic pollutants. TiO2 can also used as photocatalyst for oxidative elimination of micropollutants and microbial pathogens from water. But the effect of nano materials on waterbody and human health need to be studied in detail. Uptake of nanomaterials, especially nano-TiO2 via consumption of fish and toxicity related to it, needs to be studied in detail.

Conclusion

Through this review paper, an attempt has been made to introduce to the readers many emerging technologies available in the market which needs further research to prove the cost effectiveness of treatment technology for replacing the conventional Reverse Osmosis water treatment process. Filtration by perforated graphene membrane is also a good alternative but the manufacturing cost needs to be curbed. Commercial modules of captive desalination can be developed using carbon aerogel electrodes wherein solar power can be used as energy source. Nanotechnology for water treatment is also a promising alternative but more studies need to be undertaken to explore the environmental impacts.

REFERENCES

[1] Binnie, Chris, Kimber, Martin, & Smethurst, George. (2002). Basic water treatment(3rd ed.). London: Thomas Telford Ltd.
[2] Holland, F. A., Siqueiros, J., Santoyo, S., Heard C. L., & Santoyo, E. R. (1999).Water purification using heat pumps. New York: Routledge.
[3] Ramstorp, Matts. (2003). Contamination control in practice: Filtration and sterilization. Weinheim, Sweden: Wiley-VCH.
[4] Rona, Zolton P. and Martin, Jeanne Marie. (1995). Return to the Joy of Health. Vancouver: Alive Books.
[5] Vigneswaran, S. & Visvanathan, C. (1995). Water treatment processes: Simple options. Boca Raton, Florida: CRC Press.
[6] Joseph C. Farmer, David V. Fix, Richard W. Pekala, Jacquelyn K. Nielsen, Alan M. Volpe, and Daniel D. Dietrich Lawrence (1996), The use of carbon aerogel electrodes for environmental cleanup, Livermore National Laboratory Livennore CA 94550
[7] Ilka Gehrke, Andreas Geiser, and Annette Somborn-Schulz (2015), Innovations in nanotechnology for water treatment, Dove Medical Press Limited