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STUDY OF DESALINATION METHODS

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Abstract **-**The paper presents the over view on the developments in the methods of desalination. The process of desalination aims to convert sea water into portable water or drinking water.This process of desalination was started because of deficiency of water in societies, as rains don't be available everywhere. The people need to start using sea water for their personal and drinking purposes. Different methods of converting sea water into portable water is mainly used in countries like Saudi Arabia, United Arab Emirates, Spain, Italy, Greece, Japan, China, Australia and now in India also. It is mostly seen in middle east countries because those are near to equator. The process of desalination helps in softening the hard sea water, but it also has some negative effects on the environment. But the process is more expensive. As the use of this processes are increasing it is becoming cost-effective. There are two desalination plants in India.

Keywords: Desalination, sea water.

I. Introduction

The chemical process of changing seawater into potable or fresh water is called desalination. It is a process that extracts excess salts and mineral components from saline water. Thermal distillation and membrane processes are the two main approaches used around the world to desalinize water. Salt water is desalinated to produce water suitable for human consumption or irrigation.

Fig (1).Main inputs and outputs in a desalination process. Source: CLAYTON (2007)

In most desalination processes, saltwater (also called "feed water") is treated and two streams of water are produced. Treated freshwater that has low concentrations of salts and minerals. Concentrate or brine, which has salt and mineral concentrations higher. As shown in the above.

The pure water that is obtained after desalination must be re-mineralized to be adequate for human consumption. The concentrated brine produced in desalination processes needs to be disposed of properly. Due to its energy consumption, desalinating sea water is generally more costly than fresh water from rivers or groundwater, water recycling and water conservation. However, these alternatives are not always available and depletion of reserves is a critical problem worldwide.

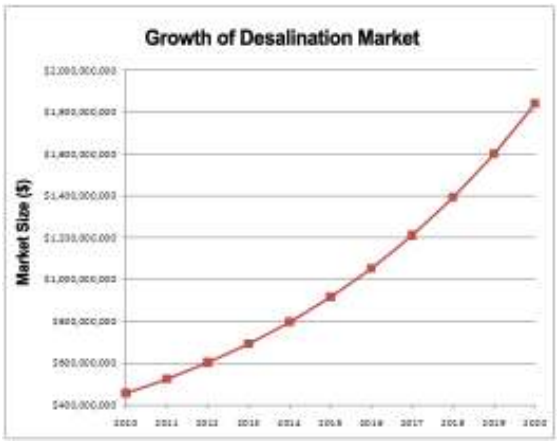

Fig (2) Increase in use of desalination in past few years.Source:Aqua membranes [TM]

Table 1: Desalination methods categories and description

Category Title	Short Hand Title	Description/Embedded Topics
Vacuum distillation	V D	Heavy hydrocarbon debris from altercation distillation unit is refining in a vacuum distillationunit for further separation of under reduced pressure.
Reverse Osmosis	RO	Filtration is the absolute clarification to improve the savor, odor and appearance of water.
Freeze-Thaw Distillation	FTD	It exudes the water by freezing technique.
Electro dialysis	EDD	In general, electro dialysis reversal are

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Distillation		voluntary more appurtenant for appliance in processes with low total dissolved solids.
Solar Evaporation	SED	Abolish salts from brackish or saline surface water and groundwater in adjustment to render it acceptable for human consumption or other uses.
Multi Effect Distillation	MED	The low categorization thermal process of obtaining fresh water by recovering the vapor of boiling sea water in a sequence of vessels, each maintained at lower temperature than the last.
Vapor Compression Distillation	VCD	The most attractive among the single stage desalination processes is vapor compression distillation.
Multi-Stage Flash Distillation	MSFD	MSF desalination process is mainly employed for large-scale, thermal desalination plants where thermal energy is available in the form of low-pressure steam (>2 bar a), e.g. in combination with thermal power plants or industrial complexes.
Iron Exchange Distillation	IED	Ion exchange is an eversible process, and the ion exchanger can be regenerated or loaded with desirable ions by washing with an excess of these ions.

The above figure shows that the increase in use of desalination, from 2010 and till reaching 2020 there is higher usage of desalination process.

This desalination process now has started in India also; there are only two plants in India. One in Gujarat and another in Tamil Nadu. And these plants are in progress in other states of India like Andhra Pradesh, Rajasthan, Orissa and West Bengal.

II. Methods of Desalination

A. Vacuum Distillation

The traditional process used in these operations is vacuum distillation essentially boiling it to leave impurities behind. In desalination, atmospheric pressure is reduced, thus lowering the required temperature needed. Thus, because of the reduced temperature, low-temperature "waste" heat from electrical power generation or industrial processes.

- Takahisajitsuno (2012) he develop a simple solar-powered vacuum distillation system for producing fresh water using only pipes as the main device. This system contains an evaporating pipe heated by solar-radiation and a cooling pipe cooled by air. This system only contains pipes, and no elements are consumed during operation.[21].
- Yongqing Wang(2014) he investigate experimentally the performance of a solar desalination system coupling a vacuum tube solar collector and a VMD unit. The experimental set-up was built in Xiamen, a seaside city in the southeast of China, with an average daily insulation of 12.6 MJ/m2 /d. The VMD unit used was first tested and examined using an electric heater, and then using the solar collector heater, as a combined system.[23]
- Xiaohua Liu(2014) As a new desalination method, NVD technology has many merits such as low grade thermal energy using, low electric power consumption, low corrosion and scaling rates, simple structures, convenient operation process and low cost in maintenance. These features will provide favorable conditions for its development in engineering. NVD technology developed quickly in recent 20 years. [22]
- Adnan AlhathalAlanezi (2016) An O-ring membrane module was constructed and specially designed to investigate the performance of the VMD process using PTFE and PVDF membranes. [1]

B. Reverse Osmosis

In the natural process of osmosis, when a seawater solution and pure water are separated by a semi- permeable membrane, the pure water will pass through the membrane to the seawater solution side. The natural driving force is osmotic pressure. Reverse osmosis systems require electrical energy for the high pressure pump. Fuel required to operate a reverse osmosis system is approximately 9.1liters of fuel per 3,785 liters of water produced. The Reverse Osmosis process is not maintenance free. It have some advantages like, operate at ambient sweater temperature reducing corrosion and scale formation,equipment size is small. but it also have some disadvantages like, the system's high pressure pump creates vibrations that may require special foundations, high pressure salt water requires special materials for the

system's high pressure piping and the following authors says

- Berge Djebedjian (2008) - In this paper, a methodology is developed for optimization of the reverse osmosis (RO) desalination system performance. The solution-diffusion model is used for the modeling.[3]
- Lauren F. Greenleea(2009) -The field of RO membrane desalination has rapidly grown over the past has improved, allowing significant increases in product production and cost savings.While the basic operating principles remain the same for all ROapplications, individualized applications have developed. Basedonfeed water quality. [15]
- Loreen O. Villacorte (2014) - the occurrence of HABs in seawater, their effects on the operation of seawater reverse osmosis (SWRO) plants, the indicators for quantifying/predicting these effects, and the pretreatment strategies for mitigating operational issues during algal blooms. [16]

C. Freeze Thaw Distillation

Freeze-thaw desalination uses freezing to remove fresh water from frozen seawater. One method, invented by Alexander Zarchin, used freezing and vacuuming of salt from seawater.

- Farah Hanim Ab. Hamid (2015)-s In recent century, the world is experiencing clean water supply shortage and the severity of this problem is increasing at an alarming rate. Introduction of new technologies for water purification is essential to accommodate the demand for clean water supply. [6]
- R.D.C. Shonet (1987) - The desalination of waters by freezing is a well-known process and relies on the principle that the structure of an individual ice crystal does not accommodate salts. Therefore, during the freezing of a salt solution, salts are rejected by the growing ice crystals. [19]
- J. Mauricio Pardo (2015) - It has not been implemented at an industrial level because its separation efficiency is lower than that of the traditional freeze concentration process. Therefore, numerous assisting techniques are being studied around the world to overcome this deficiency. [10]

D. Electro Dialysis Reverse Osmosis

Electro dialysis was developed in the mid-1950s to dematerialize brackish water at commercial scale. In general, electro dialysis and electro dialysis reversal are considered more appropriate for applications in processes with low total dissolved solids (TDS). Both processes have a good degree of resistance against scaling and fouling, which makes the technology attractive in brackish water desalination.

- Fernando Valero (2007) First commercial equipment based on Electro dialysis (ED) technology was developed in the 1950s to dematerialize brackish water over the past twenty years EDR has earned a reputation as a membrane desalination process that works economically and reliably on surface water supplies. [17]
- Marjolein Vanoppe (2014&2016) - This research focused on assisted reverse electro dialysis as a possible pre-treatment technology for reverse osmosis. This technology can decrease the overall energy demand for seawater desalination, without an excessive membrane area requirement, as is the case with Reverse Electro Dialysis. [18]
- Krishnaveni Venugopal (2013) - Desalination of brackish water, which is the source of drinking water in various world regions, is one of the large-scale applications of electro dialysis (ED). in the fields of both separation and purification due to its diversity, sophisticated functions and technological compatibility .[14]

E. Solar Evaporation

In 1870 the first US patent was granted for a solar distillation device to Norman Wheeler and Walton Evans. Two years later in Las Salinas, Chile, Charles Wilson, a Swedish engineer, began building a direct method solar powered distillation plant to supply freshwater to workers at a saltpeter and silver mine. Solar desalination of seawater and brackish groundwater in the modern United States extends back to the early 1950s when Congress passed the Conversion of Saline Water Act, which led to the establishment of the Office of Saline Water (OSW) in 1955.

- Amitava Bhattacharyya (2013) The author says that direct sunlight has been utilized long back for desalination of water. Solar distillation plants are used for supplying desalinated water to small communities nearby coastal remote areas. Solar stills are easy to construct, can be done by local people from locally available materials, simple in operation by unskilled personnel.[2]
- Hazim Mohameed Qiblawey (2007) The use of solar energy in thermal desalination processes is one of the most promising applications of the renewable energies. Solar desalination can either be direct; use solar energy to produce distillate directly in the solar collector, or indirect.[9]
- Hamid Mokhtari (2014): Traditional plants use fossil fuels to provide required steam but, nowadays, using

solar collectors has become more attractive to prevent global pollution. Multi objective optimization technique based on the genetic algorithm was proved to be a reliable tool for techno economic improvement of plants and has been used by many researchers.[8]

F. Multi Effect Distillation

Distillation is the oldest and most commonly used method of desalination. The world's first land-based desalination plant, a multiple-effect distillation (MED) process plant that had a capacity of 60 m^3/day, was installed on Curacao, Netherlands Antilles, in 1928. Multiple-effect distillation (MED) works through a series of steps called "effects".

- C. Frantza (2014) Decreasing water resources and steadily rising water demand drive research towards new approaches for safe and reliable water supply for the municipal, agricultural and industrial sectors. One solution for fresh water provision is sea water desalination using solar thermal energy.[4]
- Marios C. Georgiou (2013) The Multiple-Effect Distillation, or MED, process consists of several consecutive stages (or effects), maintained at decreasing levels of pressure (and temperature), leading from the first (hot) stage to the last one (cold). A schematic of a four-stage MED unit is depicted. however, typical MED plants can contain as many as 20 effects.[17]

G. Vapour-Compression Distillation

The most attractive among the single stage desalination processes. Vapor-compression evaporation involves using either a mechanical compressor or a jet stream to compress the vapor present above the liquid. The compressed vapor is then used to provide the heat needed for the evaporation of the rest of the sea water

- Jorge R. Lara - Vapor compression is a reliable and robust desalination technology that is attractive because of its capacity to treat large volumes of water with a wide range of salt concentrations. However, compared to other major desalination technologies such as reverse osmosis, mechanical vapor compression has had relatively high operating and capital costs.[12]
- JiangangJi (2015)process is generally used for small- and medium-scale desalting units. The heat for evaporating the water comes from the compression of vapor rather than the direct exchange of heat from steam produced in a boiler or other heat sources. The effects of the variations of operating condition on the system performance are investigated and analyzed.[11]

H. Multi-Stage Flash Distillation

Water is evaporated and separated from sea water through multi-stage flash distillation, which is a series of flash evaporations. Each subsequent flash process utilizes energy released from the condensation of the water vapor from the previous step and so on. The first multi stage flash plant was sold in Saudi Arabia, and Robert silver worked tirelessly to bring it on line. That plant established the commercial viability of multi stage flash process and its design was duplicated in many places. People started using it since 1950.

- S. Ravindran (2012)- In a steam power plant, the exhaust steam will be condensed in a condenser. The cooling fluid will be water, which intern gets cooled in a cooling tower. In a Multi Stage Flash (MSF) distiller, the condenser cum cooling tower units shall be replaced by a brine heater and series of flash chambers with condensers. The condensers of the MSF units are very large in terms of length and number of tubes.
- Hazim Mohameed Qibla wey (2007)- Solar desalination can either be direct; use solar energy to produce distillate directly in the solar collector, or indirect; combining conventional desalination techniques, such as multistage flash desalination (MSF), vapor compression (VC), reverse osmosis (RO), membrane distillation (MD) and electro dialysis, with solar collectors for heat generation.

I. Ion Exchange

Ion exchange is an exchange of ions between two electrolytes or between electrolytes. Using methods developed by Frank Speeding in the 1940s, ion exchange used to be the only practical way to separate them in large quantities, until the Liquid-phase (aqueous) ion-exchange desalination

- Hayani (2016) - In this work, the resin Doolittle 206A has been tested for softening, on the one hand, synthetic water containing Ca2+ and Mg2+, and secondly, brackish groundwater from the coastal area of El Jadida province (Morocco).
- L Karimi (2015) Electro dialysis reversal is a membrane based desalination process in which ions are transferred through ion exchange membranes under the influence of applied electric field. As discussed in this paper some parameters such as applied voltage and temperature.

III. Conclusion

The processes of desalination as a source for portable water have begun to become wider in country India. As being citizen sit is to be aware of the environmental aspects related to the various processes and in each case to consider the environmental costs as well as the requirements and the financial costs. In a paper, which

deals with the problems caused by processes of desalination, it is also important to go through the disadvantages and the advantages, of adding desalinated water to the existing water system. This process has been already started in India states like Tamil Nadu and Gujarat and it may also start in other states like Rajasthan, Andhra Pradesh and West Bengal. Because of water deficiencies and of lack of rains .The main purpose of seawater desalination is to offset present or future deficits in potable water, by producing water of good quality at a reasonable price. However, the amounts and the quality of the produced water highlight several additional environmental advantages. These advantages are dependent on the intended point of use of the desalinated water as well as on the volume and quality ratio between this water and the rest of the water in the water supply system.

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