

## DESALINATION: PRESENT, PAST AND FUTURE

Javed Ul Islam<sup>1</sup>, Nikita Bomb<sup>2</sup>, Khushboo Agarwal<sup>3</sup>.

<sup>1</sup>Assistant Professor, Department of Civil Engineering, VIT, Jaipur,

<sup>2</sup>B.Tech Student, Department of Civil Engineering, VIT, Jaipur,

<sup>3</sup>B.Tech Student, Department of Civil Engineering, VIT, Jaipur,

**ABSTRACT-** Desalination generally refers to removal of salt minerals and other impurities from water. Desalination process is being used worldwide in commercial, municipal and industrial applications. Since there is only 0.3% of freshwater sources available which is potable, new methods are being developed in order to eradicate the water demand worldwide in which the most popular method is desalination of seawater. The major advantage of using this technique is that the ocean is practically limitless and drought proof and seawater desalination provides a logical solution for the sustainable, long-term management of growing water demand. The main technologies used to perform desalination are thermal or membrane separation. The first seawater desalination plant to be built is in Texas, United States in 1961. Since then many countries have adopted the use of desalination which includes India too. Desalinating the water is very costly but many efforts are being made nowadays to reduce the cost. It has also been considered not a useful way to provide potable water since these plants consumes a surfeit amount of electricity which is generated by water. In order to reduce the use of water to generate electricity one such effort is made by Saudi Arabia in which they introduced the utilization of solar panels which does not require electricity produced by water. This paper discusses a review study of the desalination techniques, plants being used worldwide and technologies currently used to minimize the utilization of water to generate electricity.

**KEYWORDS-** Desalination, Surfeit, Eradicate, Membrane Separation, Solar Panels.

### I. INTRODUCTION

Most of India's population is dependent upon ground water sources and reservoirs and due to less rainfall the ground water table has gone down severely and so is the water available in the reservoirs. So, the need of desalinating the oceans came into existence as they are practically limitless and drought proof. Desalination is basically like reverse osmosis which involves forcing water through semi-permeable membranes to remove salts and other impurities. The earliest stage of this was first invented by Thomas Jefferson (USA) in 1791 where he described the simple desalination process. The process was printed and put on the back of board ships so that they could drink fresh water in case of an emergency. It was considered that surroundings where freshwater sources were minimum the process of desalting should be done in order to meet the water requirements of the living beings. "The Saline Water Act" was passed by Congress in 1952 to provide federal support for desalination. Desalination has proven to be an effective way to reduce the water problems but the answer to these questions are that it is a viable process as many countries including India have desalination plants. It is also very expensive technique, requires a large amount of electricity created by water and cannot be adopted by developing countries. Therefore efforts are being made to reduce the electricity requirement by these plants so these plants can be constructed in the developing countries as well.

### II. LITERATURE REVIEW

**The largest Solar Powered Desalinating Plant (2019):** Saudi Arabia has long been a leader in desalination. In fact, it's the biggest producer of desalinated water in the world. Most recently, the desalination technologies taken to the next level by introducing desalination powered by renewable, solar energy – a resource that's plentiful in this desert nation. It is the home to the world's largest solar photovoltaic (PV) desalination plant in the city of Al Khafji. By 2019, Saudi Arabia will make all desalination plants to be powered by solar technology.

**Solar-Powered Pipe (2016):** the new design, called "The Pipe," use a magnetic field to pull salt out of water. The pipe would stretch about 600 meters, and would sit on top of an existing breakwater in the Santa Monica Bay. Inside, the plant would send drinking water back to the city—roughly 4.5 billion liters a year, or half of the city's needs—and use the salinated water in indoor swimming pools.

**Minjur Seawater Desalination Plant, India (2010):** Reverse osmosis (RO) is the technology which is employed at the plant to desalinate the sea water, which contains up to 6.4 ppm aluminum and about 50 NTU of turbidity. Energy recovery units helps to increase the efficiency of the system by recovering kinetic energy from the brine solution and transferring the same to the desalinated water that has passed through the osmotic membrane.

**First Mega Capacity Desalination Plant (2005):** In Ashkelon, Israel, the first mega capacity desalination plant was built. Mega capacity states that it generates huge amounts of fresh water per day.

**First Seafaring Desalination Plant (1980):** The Rumaith, a boat, becomes the first seafaring desalination plant in the world. The Rumaith was launched from the United Arab Emirates. The desalination plant was built on a boat so that fresh and drinkable water could be brought to towns located on the coast.

**World's first commercial reverse osmosis plant (1965):** The first large-scale modern desalination process to appear was multi-stage flash distillation (MSF) during the mid-20th century in the USA (1955). In the following year the University of California invented the first synthetic and functional reverse osmosis membrane made of cellulose acetate. This membrane was capable to block the salts while allowing water to pass through it at a reasonable rate of flow under high pressure. Because of this invention the first desalination plant was inaugurated in California in 1965.

**Desalination Demonstration Plant Built in United States (1961):** One of the first seawater desalination demonstration plants in the United States was built at Freeport, Texas in 1961. It was built to demonstrate the desalination process of converting salt water to fresh water.

### III. METHODOLOGY

The two major types of technologies that are used around the world for desalination can be broadly classified as either thermal or membrane. Both these technologies require energy to generate fresh water. These technologies are then further subdivided into following:

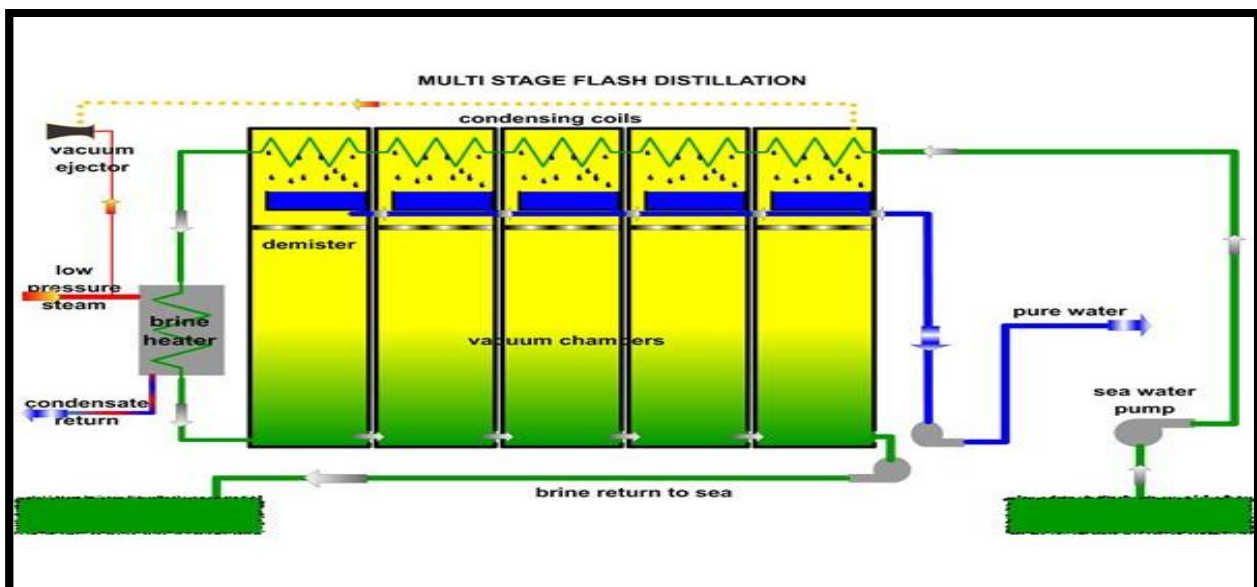
Table I

<i>Thermal Technology</i>	<i>Membrane Technology</i>
Multi-Stage Flash Distillation (MSF)	Electro dialysis (ED)
Multi-Effect Distillation (MED)	Electro dialysis reversal (EDR)
Vapor Compression Distillation (VCD)	Reverse Osmosis (RO)

**A). Thermal Technology:**

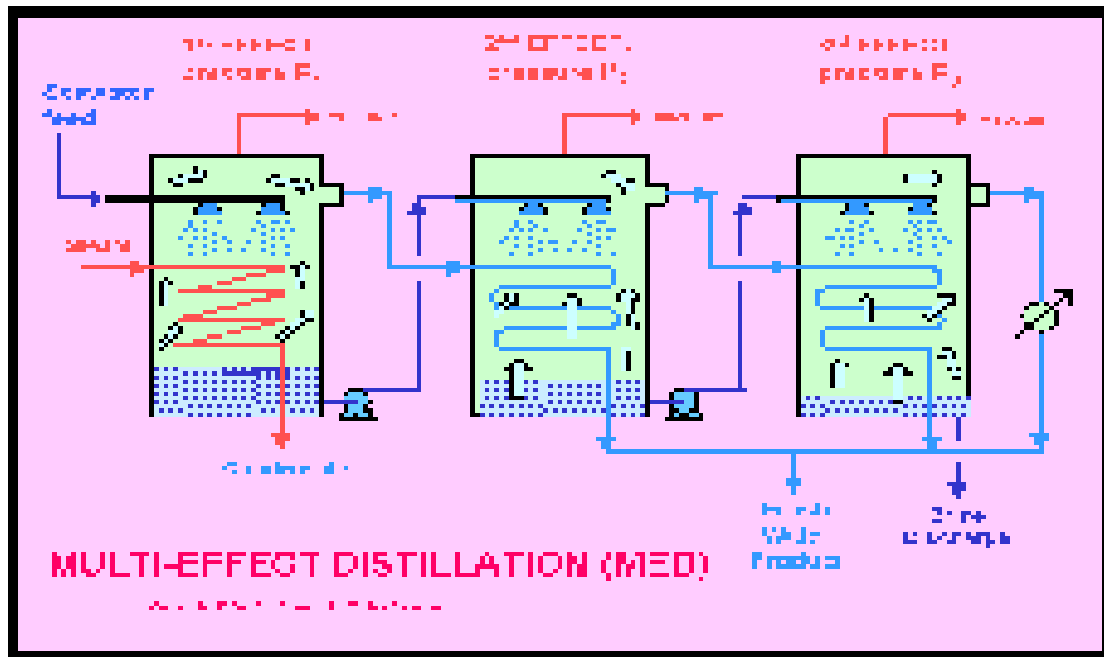
Refineries, power plants and other industries need high purity water. In the thermal process the water is first evaporated and is then condensed. Therefore in refineries and power plants where surfeit waste heat and sufficient energy is available thermal process is quite viable and efficient solution. Thermal technologies had been rarely used for brackish water desalination, because of the high costs involved. They have however been used for seawater desalination and can be sub-divided into three groups: Multi-Stage Flash Distillation (MSF), Multi-Effect Distillation (MED), and Vapor Compression Distillation (VCD).

(i) **Multi-Stage Flash Distillation (MSF):** One of the common method for desalination is using Multi Stage Flash distillation. Almost all existing desalination plants use this method. This method has been proven and in service for the last three decades. The feed water is first heated under high pressure, and is sent into the first 'flash chamber', where the pressure is released, which results in the water to boil rapidly resulting in sudden evaporation or 'flashing'. The portion of the feed continues in each successive stage, because the pressure at each stage is lower than in the previous stage. The water vapor so generated is then collected through condensing it which leads to the conversion of salty water to fresh water.



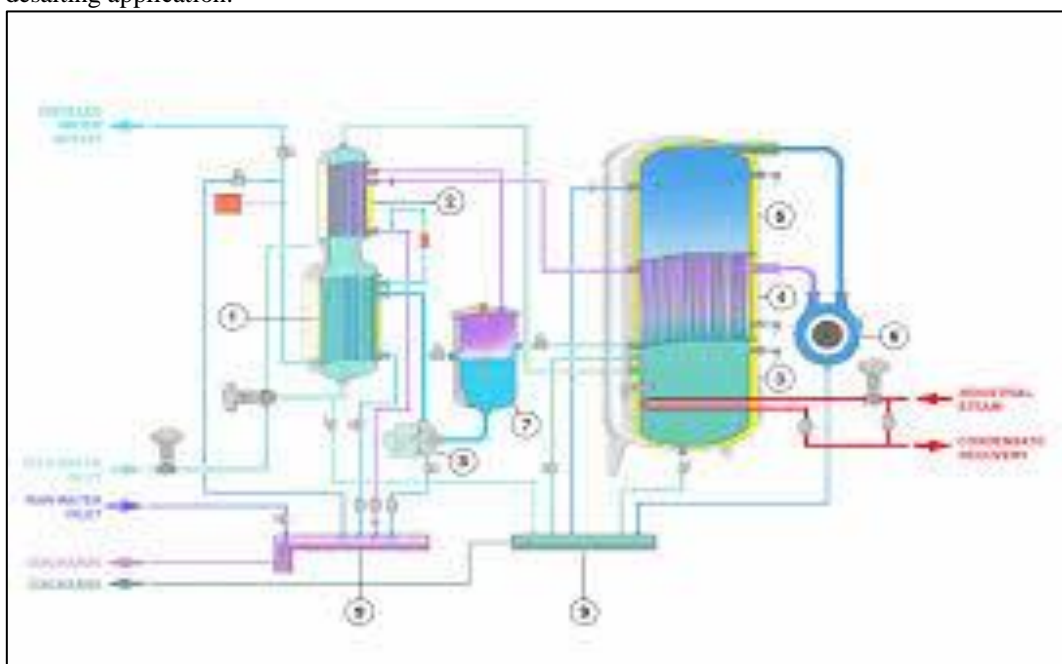
*Figure 1. Multi Stage Flash Distillation*

(ii) **Multi-Effect Distillation (MED):** Like the MSF distillation, separation takes place in a series of vessels (known as effects), each operating at a lower pressure. In the MED plant, the seawater entering the first effect is sprayed onto the surface of a bank of tubes inside which steam is flowing. A part of the water is evaporated off the surface, and the rest of the seawater is collected at the bottom of the first effect. Steam condenses in the tubes and is taken out for recovery. The evaporated hot water vapor acts as a heat source for the second effect. It then flows into a bank of tubes on the second effect. Seawater from the first effect is pumped to the second effect and is sprayed over the tubes carrying the vapor from the first effect. Now evaporation occurs on the tubes surfaces, while the rest of the seawater is collected at the bottom of the second effect. At the same time, the vapor condensed inside the tubes and is withdrawn as fresh water from the second effect. Vapor produced from evaporation in the second effect is likewise routed to the third effect, where it is used to separate the seawater from the second effect. Up to 8 or 16 effects can be used in this way.



*Figure 2 Multi-Effect Distillation*

(iii) **Vapor Compression Distillation (VCD):** In the vapor-compression system, heat is provided by the compression of vapor rather than by direct heat input from a boiler. When the vapor is rapidly compressed, its temperature rises. Some of the compressed and heated vapor is then recycled through a series of tubes passing through a reduced-pressure chamber, where evaporation of salt water occurs. Electricity is the major source of energy for this process. It is used for small-scale desalting application.

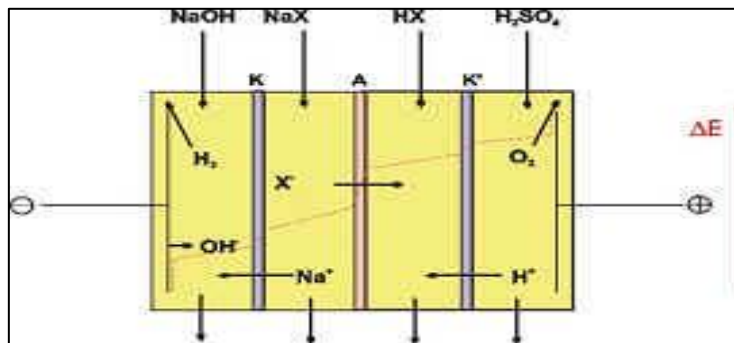


*Figure 3. Vapor Compression Distillation*

**B). Membrane Technology:**

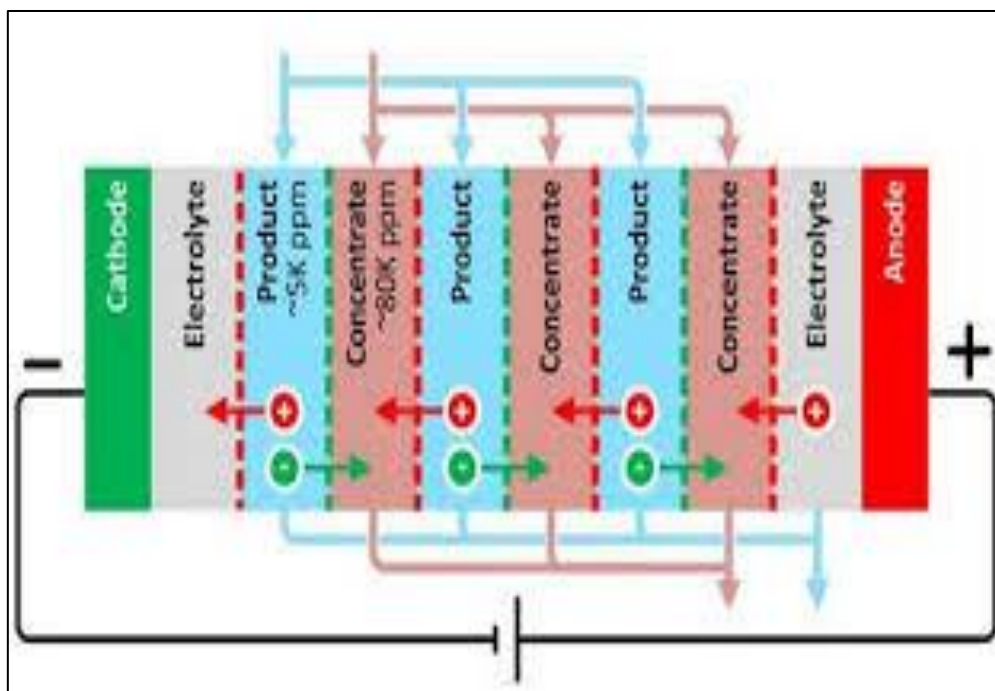
Membrane technologies can be subdivided into two broad categories: Electrodialysis/Electro dialysis Reversal (ED/EDR), and Reverse Osmosis (RO).

(i) **Electrodialysis(ED):** Electro Dialysis (ED) is a membrane process, during which ions are transported through semi permeable membrane, under the influence of an electric potential. The membranes are generally cation- or anion-selective, which basically means that either positive ions or negative ions will flow through. Cation-selective membranes are polyelectrolytes with negatively charged matter, which repels negatively charged ions and allows positively charged ions to flow through. In some columns concentration of ions will take place and in other columns ions will be eradicated. The concentrated saltwater flow is circulated until it has reached a value that enables precipitation. At this point the flow is discharged. This technique may be applied to remove ions from water. Particles which does not carry an electrical charge are not removed. Sometimes pre-treatment is required before the electro dialysis can take place. Suspended solids with a diameter that exceeds 10  $\mu\text{m}$  need to be eradicated, or else they will plug the membrane pores. There are also some substances that are able to neutralize a membrane, such as large organic anions, colloids, iron oxides and manganese oxide. These disturb the selective effect of the membrane.



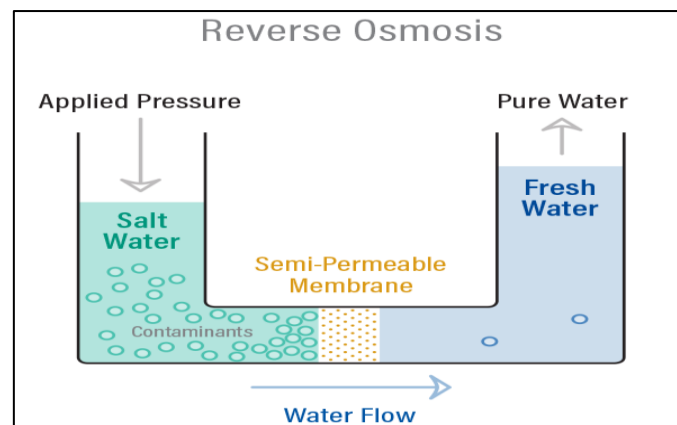
**Figure 4. Electro dialysis**

(ii) **Electro dialysis Reversal (EDR):** Electro dialysis reversal (EDR) is an electro dialysis reversal water desalination membrane process that has been commercially used since the early 1960s. Electro dialysis reversal desalination is a water desalination process in which electricity is used and then applied to electrodes to pull naturally occurring dissolved salts through an ion exchange membrane to separate the water from the salts. EDR produces two discharging streams: a low salinity product water and a high salinity concentrate.



**Figure 5. Electro dialysis Reversal**

(iii) **Reverse Osmosis (RO):** In relation to thermal processes, Reverse Osmosis (RO) is a relatively new process that was commercialized in the 1970s (Buros, 2000). Whereas Osmosis occurs naturally in which energy is not required, to reverse the process of osmosis you need to apply energy to the more saline solution. A reverse osmosis membrane is a semi-permeable membrane that allows the passage to the water molecules but the majority of dissolved salts, organics, bacteria and pyrogens are removed. Reverse Osmosis operates by using a high pressure pump to build-up the pressure on the salt side of the RO and force the water across the semi-permeable RO membrane, leaving most of the (around 95% to 99%) dissolved salts behind in the reject stream. The amount of pressure required depends on the concentration of salt of the feed water. The more saturated the feed water, the more force is required to overcome the osmotic pressure. The desalinated water thus obtained that is demineralized or deionized, is called permeate (or product) water. The water stream that carries the concentrated contaminants which does not pass through the RO membrane is called the reject (or concentrate) stream.



**Figure 6. Reverse Osmosis**

#### IV. CONCLUSION

Established technologies, like sedimentation and filtration, have seen minor advances since their initial use for water treatment several centuries ago; but new, more effective desalination membranes, innovative thermal membranes or hybrid desalination technologies, and equipment improvements, are liberated every few years. No major technology advancements are expected to dramatically decrease the cost of seawater desalination in the next several years. But the steady decrease in production costs, coupled with increasing costs of water treatment driven by more stringent regulatory requirements, are expected to accelerate the current trend of increased reliance on the ocean as a water source.

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