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Desalination of Sea Water – A Solution to Water Scarcity

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Abstract:- Water resources in our world are immense since 97% of the earth's surface is Sea water. Unfortunately less than 1% of the available water resources are potable or sweet water fit for human consumption. Sadly, Over 30% of the worlds countries with substantial population are water deficit countries. The WHO (World Health Organization) has stipulated a Minimum of 50 liters per head as the minimum requirement of sweet /fresh water for an individual to maintain a level of Hygiene but except some developed countries most face perineal shortages as a result the residents of these underdeveloped and developing countries are able to source only a fraction of the WHO recommendation for clean water for their personal use Removal of salt from sea water has been known for many centuries as a concept and practice but only recently have various processes been developed by Researchers, Scientists and Engineers to commercially process sea water to yield sweet water or potable water. The article below describes briefly the several available processes and technologies to process sea water to yield sweet water in commercial quantities and at the most economical operating conditions.

I. INTRODUCTION

According to the World Health Organization, [1] less than 1% of the world's water resources are clean and accessible to the human body while 97% of the earth's surface is covered by seawater.

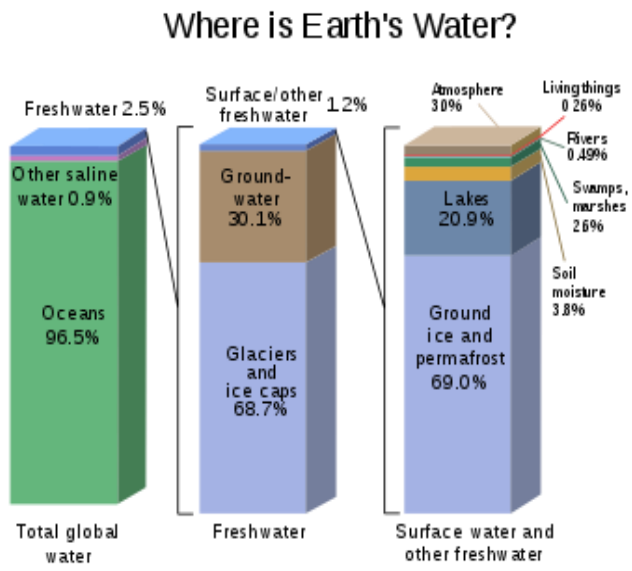

Fig 1Where is the earths water?

On our planet, the water sources are vast. According to estimates, our hydrosphere has 1,386 million km2, of this area; most are covered by seas. The terrestrial hydrologic cycle (evaporation, cloud formation, rainfall and runoff) is responsible for the existence of renewable and renewable water sources (a period of warm ice regeneration years of 10,000 years and approximately 17 years of ice). The average number of renewable energy projects with 42,750 km3 hydrons per annum.

Thirty-one countries, with less than 8% of the world's population, suffer from chronic water shortages. But by 2030 it is predicted that forty-eight countries will face this shortage, affecting more than 2,800 million citizens. In the next 25 years countries like Ethiopia, Peru, India and Nigeria will face water shortages, and countries like China will face water shortages elsewhere.

Seawater comprises 97% of the world's water resources 3% by weight, making it completely unsuitable for use or cultivation. The remaining 3% is pure water, but 70% of this freshwater is available as ice and ice in the form of glaciers at the South Pole and North Pole. Existing groundwater such as lakes, rivers and active dams up to only 0.3%!.

Human life depends on clean water. The World Health Organization (WHO) estimates 50 liters per person / day as the minimum amount of water needed to maintain a certain level of hygiene and to prevent the spread of infectious diseases. Of these only 50 liters 0.75 liters for drinking and some for cleaning, cooking, washing, etc

II. DE-SALINATION

Removal of salt from Sea water has been known in history for a thousand years as a concept, and later as a practice, though it was a limited method. The ancient Greek philosopher Aristotle observed in his book Meteorology that "salt water, when evaporated, The condensate does not remain salty," alos noting that a thinly wax container may hold drinking water on immersion in sea water long enough since the wax functions as a membrane which has served as a filter for desalination. There are many other examples of salt extraction experiments throughout Antiquity and the Middle Ages, but desalination has never occurred on a large scale until the modern era.

Prior to the Industrial Revolution, the extraction of salt from the oceans was a major concern for marine vessels, which had to remain in freshwater. When the Protector (1779 frigate) was sold to Denmark in the 1780s (like the ship Hussaren) the desalination plant was processed and recorded in great detail.

According to the International Desalination Association, as of June 2015, 18,426 desalination plants worldwide produce 86.8 million cubic meters per day of desalinated water, providing water to 300 million people. [2] This figure increased from 78.4 million cubic meters in 2013, an increase of 10.71% over 2 years. One major salt extraction project is Ras Al-Khair in Saudi Arabia, which produced 1,025,000 cubic meters per day in 2014, although the plant is expected to be surpassed in California. [3] Kuwait produces a higher proportion of freshwater from sea water than any other country that meets almost 100% of its freshwater needs by separating the water from the sea water.

III. INDIAN SITUATION

India, with about 16 percent of the world's population, has only 4% of fresh water sources [4]. There are huge differences in the provinces of India regarding the availability of water through tropical rains Some find plenty while others continue to be short of. The Indian government has long been considering merging the country's rivers to better supply water to the country. However, there has been little or no progress in this regard. Countries like Rajasthan, large, geographically and demographically, share only 1% of water resources. Less than 15% of India's water, which comes from heavy rains, is stored by the government in dams, lakes and wetlands. Various climates, droughts, floods and water pollution are advertising this growing problem of water scarcity.

Rapid industrial development, urban sprawl, and increased food production will create greater demand in countries with access to water resources. With such a planned growth in agriculture and infrastructure a report by the World Bank warns in advance that India's water demand will exceed the supply in the near future.

Although fresh water resources are limited in our country, the Indian Ocean and the Bay of Bengal combined [5] hold more than 20% of the world's oceans sea water which by technology can be considered to produce enough fresh water to meet the country's water shortages. and meet current and future needs for clean water. Table- 1 below shows the volume of water in the world's oceans

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Table 1, World Oceans volumes of water and area:-

Ocean	Area[+] (km2)	% Ocean Area	Volume (km^3)	% Ocean Volume	Avg. Depth (m)	Max Depth (m)
Arctic Ocean	15,558,000	4.3	18,750,000	1.4	1205	5567
Atlantic Ocean	85,133,000	23.5	310,410,900	23.3	3646	8486
Baltic Sea	**406,000**	**0.1**	**20,900**	**0**	**51**	**392**
Mediterranean	**2,967,000**	**0.8**	**4,390,000**	**0.3**	**1480**	**5139**
North Atlantic	**41,490,000**	**11.5**	**146,000,000**	**10.9**	**3519**	**8486**
South Atlantic	**40,270,000**	**11.1**	**160,000,000**	**12**	**3973**	**8240**
Indian Ocean	70,560,000	**19.5**	264,000,000	19.8	3741	7906
Pacific Ocean	161,760,000	44.7	660,000,000	49.4	4080	10,803
North Pacific	**77,010,000**	**21.3**	**331,000,000**	**24.8**	**4298**	**10,803[#]**
South Pacific	**84,750,000**	**23.4**	**329,000,000**	**24.6**	**3882**	**10,753**
South China Sea	6,963,000	1.9	9,880,000	0.7	1419	7352
Southern Ocean[*]	21,960,000	6.1	71,800,000	5.4	3270	7075
Total:	**361,900,000[¤]**	**100**	**1,335,000,000**	**100**	**3688**	**10,803**

Seawater usually contains about 3% salt in our oceans The Indian ocean is the largest source of water in our country. Therefore processing of seawater from coastal areas to produce clean water is a viable solution to the Indian situation as long as a practical technology is used.

❖ *The Many Ways to Remove Salt*

[6] There are several ways to extract salt from water. Each has its advantages and disadvantages

Chart below Depicts the various processes for desalination and extent of their commercial exploitation

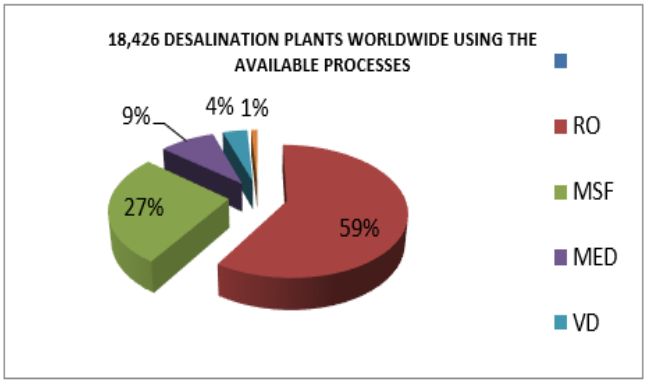


Fig 2 Desalination plants worldwide using available processes

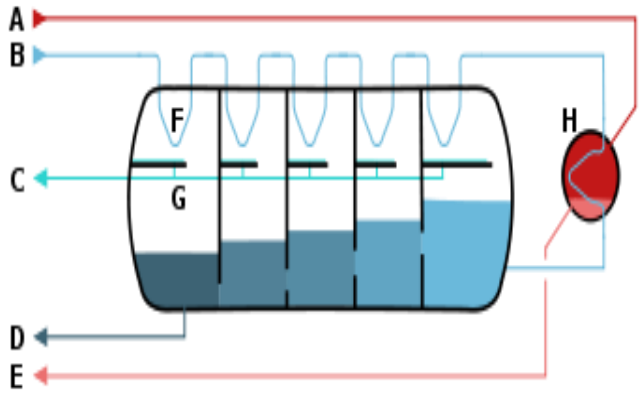
➢ *Vacuum Distillation (VD)*

The most common process used in these operations is vacuum distillation actually boiling to leave impurities behind and to evaporate evaporating water like recycled water. In the removal of salt from the water, the atmospheric pressure is reduced, thereby compressing the boiling point (in other words, less energy). The liquid boils when the vapor pressure is equal to the ambient pressure and the vapor pressure rises with the temperature. However, to use more energy and make this process more economical / efficient waste heat from industrial power plants or industries such as boilers, generators need to be employed

➢ *Multi-Stage Flash Distillation (MSF):*

Seawater evaporates in multi-stage flash distillation vessels with a series of flash evaporator. Each subsequent flash process uses energy released from the evaporation of water in the previous step. [7] Thus saving energy. Figure 3 shows the Multi stage desalinater framework.

Fig - 3 Schematic of multistage flash desalinater



A - Steam in, B - seawater - drinking water discharged, D - spill, E - steam evaporation, F - heat exchange G- salt collection H- water heater

➢ *Multiple Effect Distillation (MED)*

Multiple effect distillation (MED) works through a series of steps called “effects”. [7] Incoming seawater is pumped into straight pipes or, more commonly, straight and then heated to remove steam. The steam is then used to heat the next portion of seawater. [7] To increase efficiency, steam used to heat seawater can be extracted from nearby power stations. [7] Although this method is most thermodynamically effective, there are a few limitations such as high temperature and a large number of effects

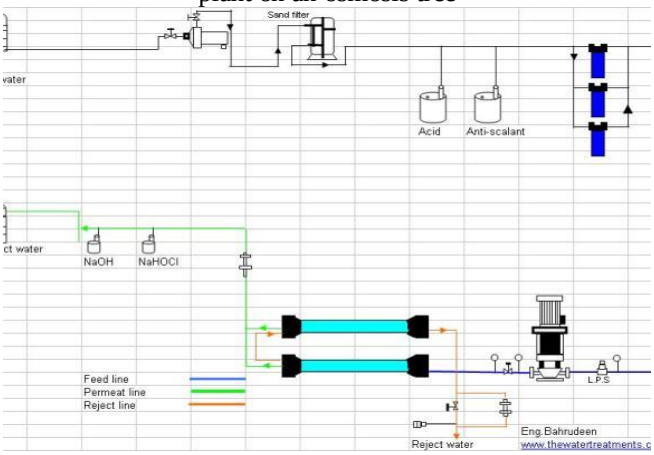
➢ *Vapor Compression Distillation (VD)*

Vapor compression involves the use of a mechanical compressor or jet stream to compress existing vapors above liquid. Compressed vapor is then used to provide the heat needed to evaporate from all other seawater. [8] Since this system only requires energy, it works best when used on a small scale.

➢ *Reverse Osmosis (RO)*

This is The main competing process.It uses a membrane to extract salt from salty water, primarily using reverse osmosis (RO). [9] The RO membrane processes use an micro pore membrane. Pressure applied (on the side of the membrane feeder) specifically selects water penetration through the membrane while rejecting salt. Osmosis plant extracts are generally less energy efficient than desalination processes. The processes of desalination are driven by thermal (e.g., distillation) or electrical (e.g., RO) as primary energy sources. The cost of energy in desalination processes varies greatly depending on the salinity of the water, the size of the plant and the type of process. Currently the cost of seperating salt from seawater, for example, is higher than conventional water sources, but it is expected that the cost will continue to decrease with technological advances including, but not limited to, reduction of salt concentrations, improved plant performance and efficiency, more efficient feed treatments, and less expensive energy sources. [10] Figure 4 shows a process diagram of the normal Reverse Osmosis plant process.

Fig 4, Flow Diagram Drawing Process for a desalination plant on an osmosis tree



➢ *Solar Evaporation*

Solar evaporation imitates the natural water cycle, in which the sun heats up enough seawater to evaporate. After water evaporates and forms clouds, the vapor from the solar eclipse is transported to a cooler place to condense into the water. However, this process is only academically beneficial but not economically feasible.

Electro dialysis / Electro dialysis Conversion: Electro dialysis uses electrical energy to transport salt through membranes. [11]

➢ *Energy Consumption*

The desalination capacity of seawater has reached less than 3 kWh / m3, [11] which includes pre-filtrations, It is similar to the energy consumption of natural clean water transported over a large distance, [12] but much higher than local clean water using 0.2 kWh / m3 or less. [13]

It is determined that the minimum energy consumption in the desalination of seawater is about 1 kWh / m3, [14] [15] without profit making and pumping / pumping out. Less than 2 kWh / m3 [16] achieved with reverse osmosis membrane technology, leaving a limited area for additional power reduction. Therefore, the selection of the desalination process in the country should be (RO) REVERSE OSMOSIS.

It is estimated that Providing all households water through sea water i.e to seperate salt from the water can increase household energy by about 10%, This will be about the amount of energy used by household refrigerators. Home use is a very small fraction of all used water. [17] [18] .Table 2 shows the energy consumption / cubic meter of a salt water extracted using different processes.

Table 2, Power consumption of various salt extraction methods in seawaterElectrical energy (kWh / m3).

Desalination Method >>	**Multi-stage Flash MSF**	**Multi-Effect Distillation MED**	**Mechanical Vapor Compression MVC**	**Reverse Osmosis RO**
Electrical energy (kWh/m^3)	4–6	1.5–2.5	7–12	3–5.5
Thermal energy (kWh/m^3)	50–110	60–110	None	None
Electrical equivalent of thermal energy (kWh/m^3)	9.5–19.5	5–8.5	None	None
Total equivalent electrical energy (kWh/m^3)	13.5–25.5	6.5–11	7–12	3–5.5

Note: "Electrical equivalent" refers to the amount of electricity that can be generated using a given amount of thermal energy and the appropriate turbine generator. These figures do not include the power required to build or repair the materials used in this process.

Table 3 QUALITY OF WATER:

Pure- 0.3 PPM Deionized - 3PPM Fresh water (poor) - <1000PPM
Brackish - 1,000-10,000 PPM Ultrapure - 0.03PPM Saline - 10,000-30,000 PPM
Marine - 30,000-50,000 PPM Brine - >50,000 PPM

Table 4 provides data on moderate water use and the cost of salt extraction in seawater. Factors that determine the cost of extracting salt from water include volume and type of location, location, water supply, personnel, capacity, funding, concentrate disposal, Desalination stills, pressure control, temperature and brine concentration for optimal performance.

Table 4

Area	**Consumption US gal / person / day**	**Consumption liter/ person / day**	**Desalinated Water Cost US $ / person / day**
USA	**100**	**378**	**0.38**
Europe	**50**	**189**	**0.19**
Africa	**15**	**57**	**0.06**
UN *	**13**	**49**	**0.05**
*** recommended minimum**			

While noting that costs are down, and often in line with the technology of affluent coastal areas, a 2004 study stated, “Salt water may be a solution to some water stress areas, but not to poorer, deeper areas. the interior of the continent, or at a very high point. Unfortunately, that includes some of the major water problems areas. ", And," Of course, one needs to raise water 2,000m (6,600 ft.), Or transfer it to a transportation cost equal to the cost of extracting salt in an area of more than 1,600 km (990 mi).) Therefore, it may be more economical to transport fresh water from a place than to extract salt from remote areas of the sea, such as New Delhi.

In coastal cities, desalination is increasingly considered a competitive option. Environmental Impact: Discharge Processes: Plants for desalination process produce large amounts of salt water, which may be above local temperatures, and contain traces of treatment chemical and cleaning chemicals as well as their reaction products and heavy metals due to corrosion. Pre-chemical treatment and cleaning is a requirement for many desalination plants to limit the natural impact of recycling sea water, which can be purified by another sea water, such as the discharge of a wastewater treatment plant or power station. Another way would be to clean the brine and mix it with a diffuser in a mixer.

- *Guidelines For Designing And Creating A System Of Osmosis [19]*

The design of the reverse osmosis (RO) system is Modular process plant in the water purification industry. The RO system is a design with “building blocks” that are membranes and compression vessels . For commercial and

industrial use, components and pressure vessels come in standard sizes that are standard for suppliers. The main advantage of modular design is that the system can be measured in size by assembling these construction layers in a way that meets the water production requirements of the application.

IV. CONCLUSION

Due to their poor energy efficiency, desalination is often more expensive than freshwater from rivers or groundwater, recycling and water conservation. However, these alternative methods are not always available and depletion of underground water is a major problem worldwide. Currently, about 1% of the world's population depends on salt water for meeting daily needs, but the UN expects 14% of the world's Population eventually getting dependent on desalinated sea water to meet their daily needs of fresh water in the near future.

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