Seawater Purification by Using Solar Energy

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Abstract-The availability of potable water is vital for human survival. While the Earth possesses abundant water resources, only a fraction of them is suitable for consumption. Explored various water purification methods capable of treating brackish and seawater. However, these purification processes necessitate energy input, prompting a shift towards renewable energy sources across industries. Thus, there's a pressing need for a comprehensive assessment of solar powered purification systems.

This research endeavour aims thorough overview of existing studies and technologies pertaining to solar-powered water distillation.

Keyword: Humidification dehumidification (HDH), Solar Stills, Reverse Osmosis (RO)!

1. Introduction

Water purification involves the straightforward conversion of brackish or seawater into freshwater. Among the various purification methods available, distillation stands out as a particularly effective approach, utilizing heat energy. Harnessing Concentrated solar energy. offers A sustainable eco-friendly means of generating this thermal energy. During the is lost in vapor water is lost in vapor using solar energy, with the resulting steam condensing into clean water while leaving behind is lost in vapor dissolved minerals and impurities.

This purification is lost in vapor in general, there are two main categories of methods: groups: is lost in vapor phase shift procedures and membrane processes is lost in vapor Procedures for phase changes encompass multi-stage flash distillation (MSF), Mult effect distillation Distillation (MED), vapor compression (VC).

(while reverse osmosis (RO) Contains membrane processes and electrodialysis (ED).

This article delves into research conducted in the realm of irrigation drying technology, solar still settings, and reverse osmosis plants. The overarching goal is lost in vapor to aid in growth new projects aimed at producing affordable drinking water, particularly in underserved and impoverished areas. Addressing the pressing is lost in vapor the requirement for needs such as clean water requires sustained efforts from scientists to devise ecologically sustainable solutions capable of meeting the demands of our ever-expanding global population.

What is desalination?

The definitions "desalination" demarcates various methods usen to detoxify water from superfluous sodium and more minerals for it being appropriate for industrious usage, farming usage, and man ingestion!!!

Why Desalination

Water makes for humans drinking good and irrigation makes water appropriate for industry use. the world faces a scarcity of fresh water and the contamination of ground water can be hazardous.

- makes water suitable for human consumption and
- Irrigation
- makes water suitable for industrial application
- scarcity of fresh water in the world in the world
- hazardous contamination of ground water.

Water is the basic necessity for humans along with foods and airs. There is almost no water left on Earth that are safe to drink without purify. Only 1% of Earth's water are in a fresh, liquid stated, and nearly all of these are polluted by both diseases and toxics chemicals. For this reasons, purification of water supplies are extremely important.

Moreover, typical purifications systems are easily damages or compromises by disasters, natural or other wises. This results in a very challenging situation for individuals trying to preparing for such situations, and keep themselves and their families safe from myriad diseases and toxics chemicals present in untreating water. Everyone wants to finding out the solution of above problem with the available sources of energy in orders to achieves pure water. Fortunately, there is a solution to these problems. It is a technology that is not only capable of removing a very wide variety of contaminates in just one steps, but are simple, cost-effective, and environmentally friendly. That is use of solar energy Fresh water is primary requirement of human race. Water for drinking purposes and other industrials and agricultural purposes demands large quantity of freshwater. The solar desalination systems have the advantage of low maintenances and operational cost. Although solar stills have high investments cost, they are compatible with the environments.

About 6.3 billion peoples are livings on earth in which 400 million peoples are at livings in water scares area which would rise to four billion by mid-century. The fabrications of solar still is simples and can be constructed by locally available materials and unskilled people's Solar stills are widely used for desalinization's in small scales. According to an estimation, about 97% of available water sources are saline and/or consist of harms bacteria's and 2% are in the forms of frozen glaciers and polar ices. 1% of the Earths water can be used for drinking's and domestics purposes. The arisings requirements for water is primarily dues to the increase of populations and fast growths of industrials. The heats energy of suns can be used in solar collectors, solar cooking's, desalinations and cooling systems. Generally, for steam generations, water heating's processes and CPCs are used, as they are capable of producing's higher temperatures in comparison of flat plate collectors, they can also be used for desalinate purposes. Most of the arid, remote and semi-arid regions are lack natural freshwater in the southern parts of the countries and are dependent heavily on underground water for drinking's purposes. Higher productivities is obtained in multiple effect diffusion solar still (MEDS). Solar stills are largely used for water purification in rural and remote areas with limited demands and low populations when the potentials of brine water sources and solar energy are available.

PROBLEM IDENTIFICATION

1. Solar power desalination is recognized as a handy technique that can enhance water provisions and tackle water shortage issues.

2. Lack of renewable power source may result in sluggish process system.

3. Process system might differ from season by season.

4. One must keep in mind that desalinating water requires much energy, and there remains doubt regarding availability of sunlight in certain regions.

Weather changing can have a effect on stores solar power. Big scale desalination could face challenges with this.

2. REVIEW

2.1 Technology for desalination, humidification, and dehumidification (HDH)

Is vanished into vapor Rain is a natural process that utilizes solar energy.to naturally desalinate seawater. Through evaporation driven by solar heat, seawater transforms into vapor, eventually condensing into rain clouds and precipitating as freshwater. Inspired by this natural process, researchers have developed artificial desalination techniques tells que the wetting-drying desalinization (HDH) cycle.

The heat recovery cycle separates processes such as condensation, evaporation, absorption of solar radiation, and heat recovery into discrete phases to improve overall efficiency. For instance, The HDH framework incorporates separate components for condensation heat recovery, like a dedicated heat exchanger, enabling preheating of seawater. This segregation optimizes the solar collector independently from the condensation or humidification processes, promising improved efficiency.

Various studies have explored innovative approaches to solar desalination. According to Zhang et al., a hybrid solar desalination system integrating a multifunctional dehumidifier and a basin-type unit. Meanwhile, Cheng et al. introduced a method utilizing humidification of the air and drying to enhance freshwater yield, employing advanced solar heating technologies.

Amirpour et al. experimented with a HD desalination in two stages unit, demonstrating increased productivity and reduced energy consumption compared to single-phase devices. Similarly, Elkader tested a three-stage humidification with many effects (MEH) drying process, showcasing enhanced efficiency with increased seawater flow and the application of energy storage devices.

Blanco et al. analysed the AQUASOL project, focusing on developing cost-effective seawater desalination technology. The project aims to increase energy efficiency by using technology advancements such as new collector designs and hybridization with natural gas, targeting widespread applicability in regions like the Mediterranean.

These research efforts collectively aim to advance solar desalination technologies, increasing their economic viability and environmentally sustainable for widespread adoption, thereby addressing the pressing global need for freshwater resources.

2.2 Solar stills

The Solar Still is a simple way to obtain fresh water from brackish or saltwater by using solar electricity. It may be used in a public or private environment. The process is relatively simple: water within a clear container evaporates due to solar heat, and the Solar Still captures this evaporated water, transferring it to a cold surface to produce distilled water.

Essentially, The Solar Still effectively distils water consists of A broad, shallow pan painted black to maximize solar energy absorption and enhance evaporation rates. A transparent glass or plastic cover is positioned slightly angled to allow condensed water to drip into a collection tray. This setup makes a void that traps heat and facilitates condensation.

Developed A Solar-Powered Water Purifier based on this principle, achieving successful purification results as confirmed by laboratory testing. The purified water sample was found free of particles and pathogens, rendering it safe for consumption. Additionally, the installation's temperature reached as much as 70degrees Celsius within two hours, effectively pasteurizing the water and eliminating harmful pathogens.

Comparisons with conventional filters such as R.O. and UV filters revealed several benefits of solar water Purifier. It demonstrated lower production and maintenance costs and proved particularly suitable for deployment in slum and rural locations rich in solar energy resources but without access to power. This highlights its potential as an accessible and cost-effective solution in order to supply clean drinking water in resource-constrained environments

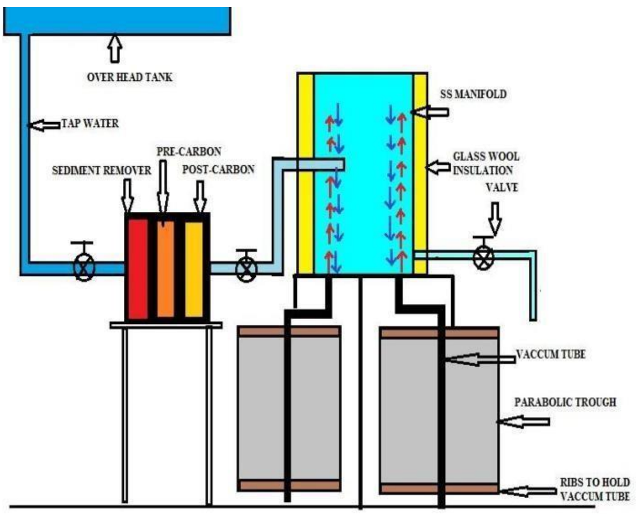

Fig -1: Solar Water Purifier's Layout

Conducted a numerical investigation on enhancing the act of a single-tank solar-powered method for purifying water by implementing a cooling water film on the glass coating. They found that optimizing film cooling parameters could improve purification efficiency increase of up to 20%, while improper parameter combinations could significantly diminish the system's effectiveness. Moreover, the existence of a cooling film mitigated the influence of wind speed on purification performance.

Examined a particular issue concerning the power structure of a roof-type solar distillation unit. They Designed and produced a two-effect laboratory setup primarily composed of polyethylene film, achieving consistent freshwater production from saltwater through test operations. Additionally, they discussed Materials for building solar panels and proposed replacing photovoltaic panels with heat-receiving plates.

I provided a model for modelling of multi- influence thermal diffusion. distillation systems, formulated based on Rate equations, mass balance and heat equations. They're The simulation findings corresponded nicely with laboratory test data, demonstrating the model's efficacy in predicting distillation productivity. They also identified key design and operational parameters affecting productivity, such as sun intensity. and brine feed rate.

Furthermore, they derived a correlation to optimize feed rates in each distillation stage to maximize efficiency, considering solar intensity and brine feed ratio between successive stages. Overall, this study offers important new information. regarding improving the efficiency and performance of Solar Water Filtration systems, facilitating advancements in sustainable freshwater production technologies

Water Filter

Sediment filter: Because of its micron-rating capacity, sediment filters can remove visual particulate matter as well as any dirt, sand, dust, and debris droplets. Turbits in water are eradicated by sediment filters as well. When there is a significantly number of suspended particulates in the water, it became turbid. The result is a brown, orange, or yellow tinge in the water. Heavy metals, germs, chemicals, and dissolved particles aren't removed by sediment filters. Water's taste or scent isn't enhanced by them. Their main purpose is to filter materials offensively and with preservation. Prefilters for additional filtration systems are the only use for sediment filters. This is why reverse osmosis and UV decontamination—two other filter techniques—often complement sediment filtration.

Carbon Filters: The water purifier comes with a different set of filters, each playing a crucial role in purification processing's. A carbon filters is one of them, which not just removes impurities but also acts as a tasting enhancer!

Carbon filters play a crucial role in the process of water purification, as they remover all the unwaning chemicals and organics compounds like chlorine, pestilences, and others Volatile Organic Compounds (VOCs) that may be present in waters!

They are also effectives in removing the smells and Odors from water, while bettering the tastings of water. As water passes through a carbon filters, the activated carbon particles absorb all these impurities along with the bad tastings and organics compound

Reverse osmosis (RO)

Reverse in Osmosis (RO) is a pressure-based process involving the use of pressure greater compared to osmotic pressure across a semipermeable membrane. This pressure difference drives Adding fresh water added to a strong salt solution a less concentrated one. In practical application, the brine feed is pressurized and forced in opposition to the membrane in a closed vessel. As When water travels across the membrane, the salinity of the leftover feed water rises, and a part of it is removed without going through the. The proportion of wastewater typically ranges from 20% to Seventy (70%) percent feed stream based on factors such as salinity, pressure, and membrane type.

A standard RO system for seawater typically achieves a recovery rate of around 40%. The RO desalination facility comprises four main systems: pretreatment, high pressure pump, membrane set, and posttreatment. Extensive pretreatment is crucial to prolong the membrane's service life, involving the removal of suspended solids and prevention of precipitate of salt or microbiological growth inside the membranes. Pretreatment commonly includes fine filtration and chemical additives to deter sedimentation and microbial growth.

The high-pressure pump is critical for producing the necessary pressure to drive water separate salts. Pressurizing salt highest energy consumption in RO systems. The working pressure is directly proportional to the osmotic pressure., which varies with salinity. RO is often preferred for purifying brackish water. due to its relatively lower pressure requirements compared to seawater desalination.

Operating pressures typically range from for brackish water, 15 to 25 bar (225 to 375 psi) and 54 to 80 bar (800 to 1180 psi) for saltwater, with an osmotic pressure of 25 bar. Recuperation of energy from high pressure brine leaving the reverse osmosis plant is essential to reducing the overall energy consumption of desalination, especially in large-scale plants

Fig -2: Reverse Osmosis Process

Detailed the evolution and evaluation an energy-efficient photovoltaic (PV) desalination system tailored for remote regions in the Australian desert where access to freshwater is limited, and high salinity borehole water is often the only option for drinking. The system employed an amalgamated membrane arrangement. comprising an ultrafiltration module for particle, bacteria, and virus removal, coupled with a nanofiltration membrane for dissolved salt removal. Successfully producing pure drinking water from a variety of feed waters, including bore water with high salinity (3500 mg/L), the system exhibited particular energy use in the range of 2 to 8 kWh/m3, contingent Based on the feed water's salinity and operational parameters.

Investigated the viability of small-scale solar-powered RO desalination systems, achieving a production capacity of 0.8 to 3 m3/day of potable drinking water.

Their study focused on the impact of feed pressure. on product water quality, system productivity, and Total amount of energy used. Operating at a supply Four water pressure8 bar, particular energy use was 16.3 kWh/m3, with a productivity of 124 l/h and a the permeate concentration is 450 ppm. Increase Set to 63 bars. resulted in reduced energy consumption (15 kWh/m3) and improved productivity (155 l/h) with a lower permeate concentration (330 ppm).

Schmid J et al. conducted A feasibility study on Desalination of water in the desert of Egypt and rural areas, where fresh water is scarce despite ample sources of brackish water, using solar electricity as the principal energy source. They proposed a financing model for small-scale solar-powered RO desalination systems, estimating a production cost of approximately $3.73 per m3 of freshwater.

Scaling up the system capacity and daily operational area was suggested To Diminish the cost of freshwater generation in these regions. Additionally, the authors advocated for the adoption of renewable energy-powered systems to preserve the environment and improve living conditions in rural locations.

Solar still used direct solar radiation from the Sun for desalinating salty water. Based on evaporation and condensation process, the still has a basin where salty water goes in, fully insulated on all sides, and sealed with clear glass lid for solar energy to flow.

When the radiation hits the salty water in the basin via the glass lid, water evaporates, creating vapor that rises and gets trapped by the glass lid above the basin. This leads to condensation forming below the glass lid, and the distillate is collected from there.

Flow Chart

- Solar still
- Contaminated water
- Reciprocating pump
- Filter 1(RO)
- Filter 2(carbon filters)
- Pure water

Objectives

- To utilize the solar still to its fullest potential in order to produce pure drinking water by condensing pure water vapor and removing impurities.
- To employ sustainable energy sources to raise the drinking water's microbiological purity.
- To capitalize on renewable energy sources and local resources
- Replicable at a minimal cost of investment; applicable at the home level

3. CONCLUSIONS

The comprehensive literature review highlights the diverse array of water distillation methods under development, each tailored to meet specific demands for fresh water, water source quality, and cost considerations. While traditional Systems for reverse osmosis are prevalent in Finland, they pose challenges Due of their generation of significant wastewater volumes. Conversely, non-traditional purifiers such as solar scrubbers exhibit immense are current. underutilized Due of their limited capacity.

Among the various distillation methods, the wet drying process emerges as a promising Choice of fresh water. production, especially when integrated with systems for simultaneous hot water generation. Additionally, a multi-stage distillation approach shows promise for bulk creation of clean water.

In light of these findings, there's a clear need for the evolution of hybrid water treatment systems capable of addressing the limitations inherent in existing methods. Such systems would combine the strengths of different purification technologies to optimize performance and efficiency, ultimately ensuring reliable access to clean water while minimizing environmental impact.

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