WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Innovations in Solar Desalination Technologies for Sustainable Water Production

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ABSTRACT—

This study explores advancements in solar desalination technologies aimed at addressing global water scarcity challenges. Focusing on harnessing solar energy for desalination processes, we review key methods such as solar stills, solar- assisted multi-effect distillation, and solar-powered reverse osmosis. The analysis includes an assessment of efficiency, cost- effectiveness, and environmental impact. Additionally, the paper discusses integration strategies with existing water infrastructure and emphasizes the potential of these technologies in providing sustainable and accessible freshwater resources in arid regions. The findings contribute to the ongoing discourse on environmentally friendly desalination solutions, supporting the pursuit of water security in an era of increasing demand and climate uncertainty.

Keywords— **Solar stills, Solar osmosis, Solar Concentrator, Solar basin, Fresnel lens**

I. INTRODUCTION

Using the sun's energy to create fresh water from saltwater or brackish water, solar desalination is a creative and sustainable response to the world's water shortage problem. Water shortages in many locations are made worse by climate change, and as the world's population grows, the need for effective and environmentally responsible desalination methods grows. Reverse osmosis and thermal desalination are two examples of traditional desalination techniques that frequently demand large energy inputs, raising worries about the environment and raising operating costs. Solar desalination, on the other hand, uses solar energy, a plentiful and clean resource, to power the desalination process. The idea behind solar desalination is to promote water's evaporation with sun energy, thereby removing contaminants and salt. Different methods of solar desalination.

II. LITERATURE RIVEW 1.Hybrid solar-wind water distillation system

Hybrid solar-wind water distillation system consists of conventional single basin solar still & wind water heater operation simultaneously. This system has its ability to operate day and night and therefore, it produces large quantities of distilled water even in cloudy days with good winds. The system consists two main parts, the first one is wind water heat(WWH) and second part is simple solar still. Rotational kinetic energy relases heat . Through heat

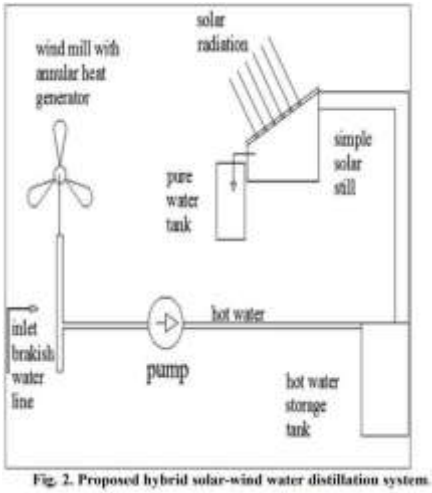

Fig. 2. Proposed hybrid solar-wind water distillation system.

exchanger hot water passes into storage tank. The yield can be three to four times more than conventional solar distillers. solar radiation increases vaporization rate of water[1].

2. Development and performance evaluation of an active solar distillation system integrated with a vacuum-type heat exchanger

This system consists of solar concentrator and vacuum-type heat exchanger. During the evaluation period, the environmental parameters of solar radiation, air temperature and wind speed are considered. Energy and exergy efficiencies are plays vital role in this system. The maximum distillate production of the distillation device was recorded to be 1.5 kg/m^2/day with the average solar radiation of 1227.68 w/m^2 under the heat exchanger vaccum pressure of 0.5 bar. Effects of the environmental parameters on the thermal performance of the concentrator. variation of the oil temperature entering into the heat exchanger with the environment.

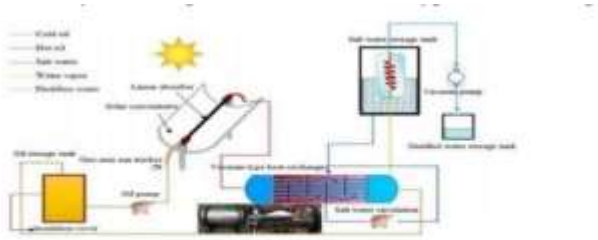

Fig.3. vacuum-type heat exchanger

3. Thermodynamic analysis of a solar powered adsorption cooling and desalination system.

The working characteristics of an adsorption desalination system are examined in this research. Different operating temperatures affect how well the system performs.System performance is affected by the temperature of the condenser, cooling water, and hot water inflow.System performance is enhanced by low cooling water temperatures, low condensation temperatures, and high hot water inlet temperatures. Adsorption desalination is an environmentally benign and energy-efficient process[3].

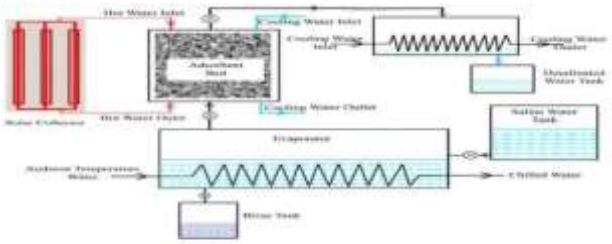

Fig. 4. Schematic diagram of an adsorption desalination system

4. Performance of seawater-filling type planting system based on solar distillation process: Numerical and experimental investigation.

In this paper described about solar seawater distillation and planting system .In this system seawater directly use in agricultural irrigation.It combines solar energy concentration, seawater desalination and agricultural cultivation, which produces fresh water. That fresh water direct supplied to the root system of plants. According to experimental results, under a real weather condition in Beijing in may, the experimental device has a freshwater production 2.1kg/m^2/day.The proposed seawater-filling type planting system consists of a solar concentrator , a seawater tank, a condensation cavity and a planting cavity. Based on the solar energy, the system produces fresh water and supplied to the root system of plants. Sunlight enters into the top surface of the device. A small amount of sunlight enters the seawater tank directly from the bottom layer base to heat seawater. Sunlight is reflected by the concentrator before entering the seawater tank. Seawater tank is heated upto 60-70 clesius and evaporate quickly. Steam enters the condensation cavity through to top surface of seawater tank. Condensation cavity is in contact with planting cavity. In the evening, the concentrated seawater in the tank can be replaced with fresh seawater for operation of the system next day[4].

5. Solar Powered Water Desalination Using Fresnel Lens Tracking System.

This paper introduces a simple scheme used to transform seawater into the freshwater suitable for human being. The system uses a direct method of solar desalination system. The direct desalination system technique combines solar collection and desalination in one freshwater distillate production system by directly introducing the gathered solar energy to seawater. This is achieved by using both solar basin and Fresnel lens for efficient heating and increased output. Due the solar radiation water gets heated.By using Fresnel lens we can form a narrow beam of light on water. Maximum temperature absorbed from 13 to 15 hours. Approximately 15 liters of distilled water collected[5].

6. Advanced designs of solar desalination systems.

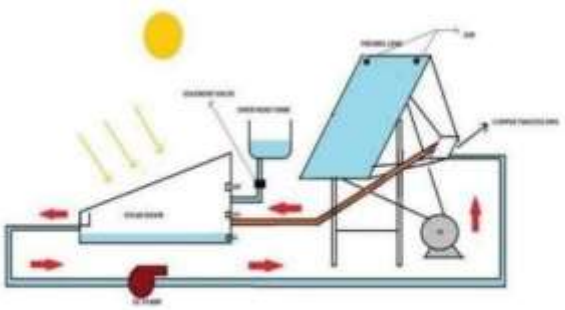

Fig.9. Schematic diagram of desalination process

The research reviews solar stills as significant solar energy devices.There is discussion of other solar still designs, including as double, triple, and multi-effect models. Double basin solar stills are 36% more productive than single basin stills.Compared to other varieties, the inverted absorber triple basin solar still produces a higher yield.It is determined that the vertical still absorber with a 3.5 m2 area is ideal. Tubular solar still productivity can be increased by cooling the air and water flow. Stepped solar stills with pebbles, sponge, and fins can yield a 98% increase in productivity.A cost analysis reveals that while some solar stills have low fixed costs and low cost per liter, others have high fixed costs and high cost[6].

IV. CONCLUSIONS

Solar desalination is a ray of hope in the face of growing problems with water scarcity. Through the utilization of solar energy, this novel method provides a sustainable means of producing fresh water from brackish or marine sources. Not only does solar desalination help the environment, but it also has the ability to completely transform the world's water supply infrastructure. Solar desalination systems are flexible enough to adapt to a wide range of geographical and demographic conditions because of their modular and scalable design. These systems can be implemented in dry areas, isolated settlements, or combined with pre-existing infrastructure with flexibility to meet different water demand levels. This flexibility helps democratize access to water resources by enabling local communities to self-sufficiency in securing their water supply.

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