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Use of Cupric Oxide as Photocatalyst in Solar Desalination

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Abstract: Water is one of nature's most important gifts to humankind. Essential to life, a person's survival depends on drinking water. The over utilization of groundwater, poor recharge, uncertainty of monsoon, poor aquifer conditions, absence of proper monitoring and management have gradually influenced the quality of water. An effective, convenient and inexpensive method for the purification of water has investigated. A solar desalination plant fabricated to utilize solar energy to obtain distilled water. The effect of cupric oxide on the rate of production of distilled water and its quality made and it found that the rate of production of desalinated water increased to a remarkable extent. A comparative study of different parameters like pH, conductivity, concentration anions and cations, etc. was made between raw water and desalinated water under these conditions.

Keywords: Photocatalysts, solar still, solar energy, solar desalination, desalinated water**.**

INTRODUCTION

Water is a key component in determining the quality of our lives. Today, people are concerned about the quality of the water they drink. Although water covers more than 70% of the Earth, only 1% of the Earth's water is available as a source of drinking. Water is assumed as an infinitely available renewable resource but inordinate population explosion, modified agricultural operations and rapid industrialization is putting a great strain on its already scarce resource. Water purity is of vital concern for humankind since it directly linked with human welfare and where the demand of potable water exceeds the amount that fresh water source can meet; desalination of brackish water provides a reasonable fresh water source. Thus, it has become pertinent to do further research in this field to improve the desalination process.

A transient model was proposed for the solar desalination system by Reddy *et al.*[1]. Maroo and Goswami[2] studied theoretical analysis of a single-stage and two-stage solar driven flash desalination system based on passive vacuum generation. Effectiveness of desalination powered by a tracking solar array to treat saline bore water was proposed by Peterson and Gray[3]. They concluded that 57% of desalination variability predicted by daily global horizontal irradiation. Qtaishat and Banat[4] made a compelling overview of coupling solar energy to membrane distillation.

Cermenati *et al.*[5] proposed photocatalytic mechanism in water purification by use of quinoline, photo-Fenton generates OH radicals and superoxide dismutase. They investigated the membrane distillation process principle, configurations and manufactured the membranes. Gomri[6] proposed energy and energy analysis of seawater desalination system integrated with a solar heat transformer. He investigated that water and air recirculation in the process, enhances distillation performance. Nafey *et al.*[7] prepared a new visual library for design and simulation of solar desalination systems (SDS) whereas Wang *et al.*[8] studied evaporation processes under a free or forced convection mode. Multi-objective optimization of solar rankine cycles coupled with reverse osmosis desalination considering economic and life cycle environmental concerns are introduced by Salcedo *et al.*[9].

Photochemical reactors were also used for solar decontamination of water by Ibanez *et al.*[10] . Chang *et al.*[11] carried out an experimental study of a solar thermal powered membrane distillation desalination system with control function. Wind turbine-inclined still collector integration with solar still for brackish water desalination was proposed by Eltawil and Zhengming[12]. A comparative study of classical solar chimney power system and combined solar chimney system for power generation and seawater desalination was done by Zhou *et al.*[13]. Egerton and Matinson[14] carried out the comparative study of photo-oxidation and photo-reduction reaction on TiO_2 nanoparticles. Asadi *et al.*[15] introduced solar desalination for gas refinery waste water using membrane distillation process.

A hybrid solar desalination process of the multi-effect humidification dehumidification and basin type unit is studied by Hou and Zhang[16]. Photodecomposition of ammonia to dinitrogen and dihydrogen on Pt/TiO_2 nanoparticles in an aqueous solution was studied by Nemono *et al.*[17].Soric *et al.*[l8] focused their work on Eausmose project desalination by reverse osmosis and baterryless solar energy. Although a lot of work has been done and many technological advances have emerged for desalination, but a little has been done to use photocatalysts to improve the water quality and to increase the desalination rate (using conventional solar still and oxides are used as photocatalyst). Hence, the present work has been undertaken.

EXPERIMENTAL

Construction of Solar Still: The vertical heights of the still are 515 and 160 mm, respectively. A glass cover of 4 mm was used as a transparent material. This glass cover with inclination of 60° is fixed to vertical wall of the solar still, at the lower end of the glass cover; a provision to collect the condensed water was made by PVC pipe with the help of an adhesive (m-seal trade mark) to ensure that no vapours will be lost. The body of the solar still is 12 mm thick of water proof board to provide minimum heat loss from the bottom as well as from the sides of the still. To reflect incident radiations into the basin, a mirror is fitted on the rear vertical wall (inside the solar still).

Two galvanized trays (563×26350 mm) are placed inside the solar still and a galvanized plate (560×260 mm) containing a coat of CuO was placed inside the tray. Using rubber binder made the layer of photocatalyst on G.I. plate. 5 L water was placed in each tray. A provision for an inlet for raw water was made at the bottom and outlet for desalinated water was made at the vertical wall of the basin. The solar still was placed south facing just to receive maximum solar radiations throughout the year. The line diagram of the solar still is presented in **Figure1.**

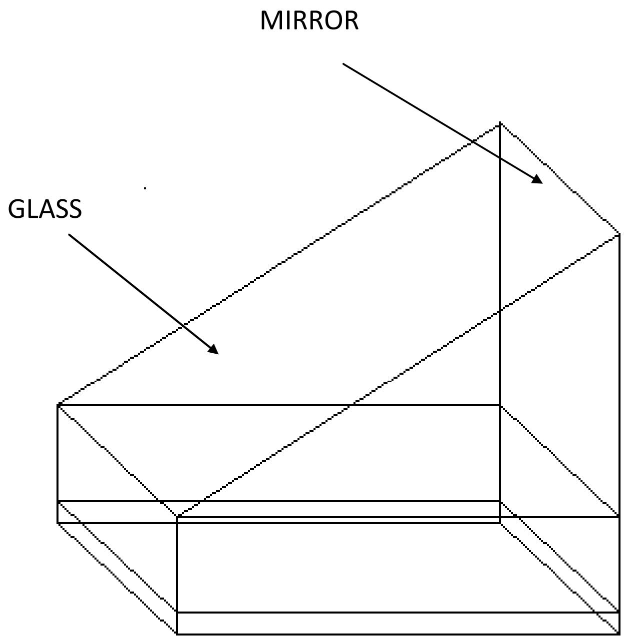

Fig.1: Schematic Diagram of Solar Desalination Still. Area of the still=598(L)×580(W) mm2, Height=515 mm (back Side) and 160 mm (front side); Galvanized tray size=563(L)×263(W)×50(H) mm3; two trays are used; Total glass size=580×698×4 mm3; Effective area=567×660×4 mm3.

Procedure: Samples have been collected in the monsoon season from the Sirohi District, which is situated in the South of the Rajasthan State in India. All the reagents used are of AR grade. All the solutions are prepared in doubly distilled water. pH of the solution is measured employing a digital pH meter (Eutech-CyberScan 1000), while the conductivity is measured using digital conductivity meter (Eutech Instruments 611/612). The absorbances of the solutions are measured using UV-visible spectro-photometer (Systronics Spectro-photometer 106). Ion Selective Electrodes (Eutech Instruments) are used to measure the quantity of ions like Fluoride, Chloride, and Cadmium etc. The analysis of water samples for its various parameters is done using standard methods for examination of water.

RESULTS

As the solar desalination improves, the quality of water, but the amount of water collected after desalination is relatively less and it may not fulfil the requirement. Secondly, some of the organic impurity also passes on with desalinated water. To overcome these problems, the base of the tray is coated with semiconducting oxides such as TiO_2, CuO, ZnO etc. to get not only the better quality of water but also a higher rate of desalinated water. It is a well-known fact that semiconducting oxides act as photocatalysts and therefore, their use can assist from both these viewpoint. In the present work, CuO is used as the photocatalyst. The total amount of water collected is measured everyday and the rates of production of desalinated water at regular time interval. The results reported in **Fig. 2 and 3.**

It is observed that the rates of production of desalinated water increases with sunlight and it reaches an optimum after 2-3 hr and therefore it decreases as sunset approaches. It may be explained on the basis that solar radiations are available maximum in midday while it decreases on either side. It is clear from **Figure 2** that CuO improves the rate of the desalinated water as compared to desalinated water production without photocatalyst.

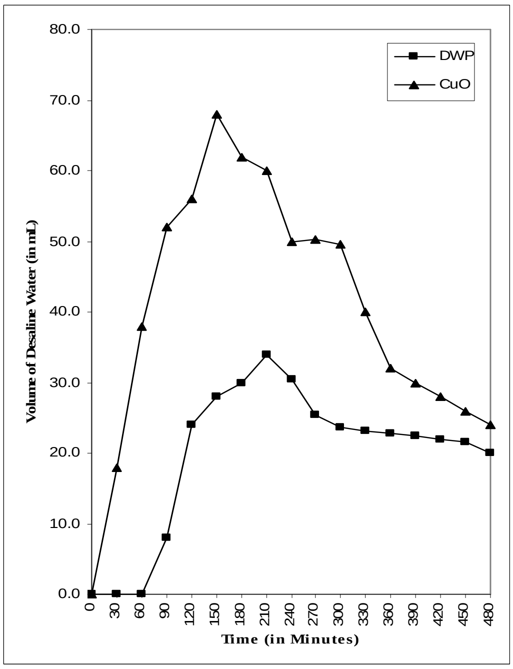

Figure 1: Rate of production of desalinated water in presence of CuO.

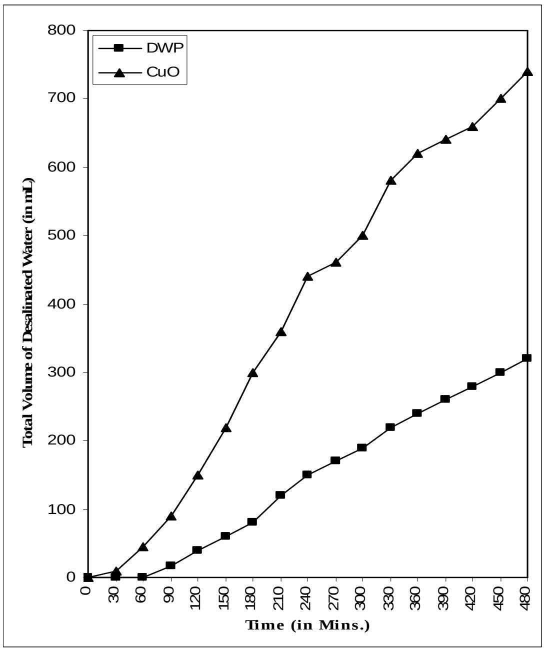

Figure 2: Total volume of desalinated water in presence of CuO.

As the period of exposure increases, the volume of desalinated water produced also increases **(Figure 3).** In this case also total desalinated water produced in presence of CuO is more as compared to without photocatalyst. Various parameters related to the quality of water are determined like pH, conductivity, TDS, fluoride, Fe etc. The results obtained for raw water and water obtained after desalination using CuO as photocatalyst, are reported in **Table 1.**

Table-1: A comparative study in quality of water (with and without photocatalyst)

Parameter	**Raw Water**	**Desalinated water without use of photocatalyst**	**Desalinated water with use of CuO**
pH	8.2	7.2	7.0
Conductivity	0.954	0.739	0.052
TDS	1500.0	850.0	55.0
Free CO_2	18.0	10.0	2.0
Total Alkalinity	160.0	32.0	8.0
Chloride	1050.0	85.0	28.0
Total Hardness as $CaCO_3$	350.0	68.0	24.0
Calcium	63.0	8.4	5.8
Magnesium	70.0	14.5	4.7
Fluoride	5.00	2.0	1.4
Ammonium	0.048	0.060	0.074
Nitrate	48.0	12.0	3.2
Cadmium	0.010	0.006	0.002
Iron	1.2	0.8	0.3
Sulphate	62.4	60.6	42.8

CONCLUSIONS

The use of CuO not only gives better quality of water but it also increases the rate of production of desaline water. It lowers the pH of raw water and reduces TDS, free CO_2, conductivity, total alkalinity of raw water. Use of CuO also lowers Chloride, Fluoride, Nitrate, Calcium, Magnesium, Iron, Cadmium contents and Total hardness of raw water. This may be considered as an advanced step towards betterment of water quality to fulfil the need of population in rural area. To conclude, this concept is worthwhile as it produces drinking water using solar energy without harming the environment.

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