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NOTA TÉCNICA

PROPOSAL OF A SOLUTION FOR WATER DESALINIZATION USING SOLAR ENERGY

PROPOSTA DE SOLUÇÃO PARA DESALINIZAÇÃO DE ÁGUA USANDO ENERGIA SOLAR

PROPUESTA DE SOLUCIÓN PARA LA DESALINIZACIÓN DE AGUA CON ENERGÍA SOLAR

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Mohamad H. Rabai[1] (mohamadrabai94@gmail.com)
Irenilza de Alencar Nääs[2] (irenilza@gmail.com)

[1] Al-Hussein Ben Tala University, Jordania.
[2] Universidade Paulista. São Paulo, SP, Brasil.

RESUMO

Although water is abundant on Earth, only about 2.5% is fresh water. This study's motivation was to search for a solution for lacking freshwater, converting brackish and seawater to potable water by using solar energy. The system's main components were the absorber plate painted black, glass cover, insulation, and vessels to collect fresh water. The plate delivers higher temperatures for saline water to be evaporated and condensed. The basin liner was made of an iron sheet, and the cover was of ordinary glass, while the basin was covered with glass using silicon rubber. We used 30° single slope solar to identify the efficiency of using black stone instead of without it (control). The results showed that the maximum output with black stone was 750 ml, and without it was 600 ml; therefore, the use of black stone can increase the productivity for the single slope solar still.

Keywords: Solar collector. Potable water. Brackish water.

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1 INTRODUÇÃO

According to the Worldwatch Institute (WI, 2017), more than two-thirds of the world's population may experience water shortages by 2025, affecting practically every country globally, including the developed, unless they reduce demand or develop additional water sources. Water desalination is one of the processes that can purify salty water into potable water. However, brackish water transformation into potable water requires costly energy input, and it relies on fossil fuel sources (Karagiannis and Soldatos, 2008). The authors point out that large desalination systems in many countries such as China or those in the Middle East can reach a daily production of nearly 500,000 m^3, mainly using thermal desalination methods. In these cases the cost of freshwater produced ranges between 0.40 h/m^3 (0.50 $\$/m^3$) and 0.80 h/m^3 (1.00 $\$/m^3$), respectively.

Solar energy is generated in the sun's core by nuclear fusion reactions between hydrogen atoms, releasing a large amount of energy. This energy travels through space in the form of electromagnetic radiation until it reaches the Earth's surface, and its intensity outside the Earth's atmosphere is about 1366 W/m^2 (extraterrestrial radiation). However, the total amount of solar radiation that reaches the Earth's surface is approximately 1000 W/m^2 at noon for many locations on the Earth (KANNAN and VAKEESAN, 2016). This decrease is due to many factors that affect the total amount of solar radiation received on the surface, like clouds cover, seasons of the year, time of day, and gas molecules that absorb and scatter the solar radiation (KELLY and GIBSON, 2009).

Solar desalination is a system that purifies salty water using solar energy. Regardless of its low performance, it seems to be a promising solution to provide salt-free water (ALTARAWNEHA et al., 2017, MURUGAVEL et al., 2010). It is a simple technology that does not require highly skilled labor for maintenance work and energy consumption, and also it is feasible, economical, and environmentally processed. Solar water desalination is similar to the natural hydrologic cycle, consisting of solar radiation absorption by a water layer. Heating and evaporating water, the water vapor rises through the atmosphere until it condenses (because the temperature difference is high), and finally, it falls like rain. Solar still is a system that includes stages as the natural hydrologic cycle, and the source of energy is the sun.

Enhancing solar efficiency has been previously studied (BASSAM et al., 2001; PANCHAL and SHAH, 2012). Most authors have suggested many approaches, like energy-

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storing material to provide higher temperatures and increase operating times after sunsets (MANCHANDA and KUMAR, 2018; MANOKAR et al., 2018). Other authors studied the water's surface area by adding porous materials to increase the evaporation rate, the effect of wind speed to increase condensation rate, and the effect of vacuum on the still yield (HASSAN and ABO-ELFAD, 2021).

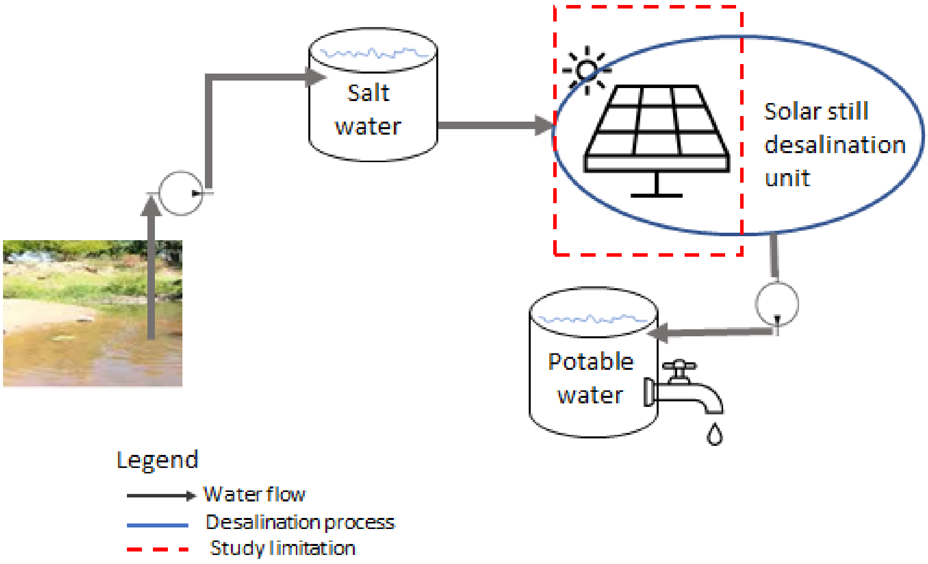
The present study's objective was to investigate energy-storing material's efficiency (black rock) to increase the solar still desalination unit's efficiency.

2 MATERIALS AND METHODS

The present study's principal components were the absorber plate painted black, glass cover, insulation, and vessels to collect fresh water. The system width and length are 1 m. The absorber plate is painted black to absorb solar radiation, preventing its reflection. This plate provides higher temperatures for saline water to be evaporated.

The basin liner was made of an iron sheet (1.4 mm thickness) of 100 X 100 cm with a maximum height of 10 cm; the cover was made of ordinary glass (6 mm thickness) with an average emissivity of 0.88, the basin was covered with glass using silicon rubber. This study's insulation material was rock wool placed at the bottom and sidewalls of the basin to reduce the system's heat loss. The flowchart smart picture of the idea in the present study is presented in Figure 1.

Figure 1 – Schematic of the desalination process and the delimitation of the study.



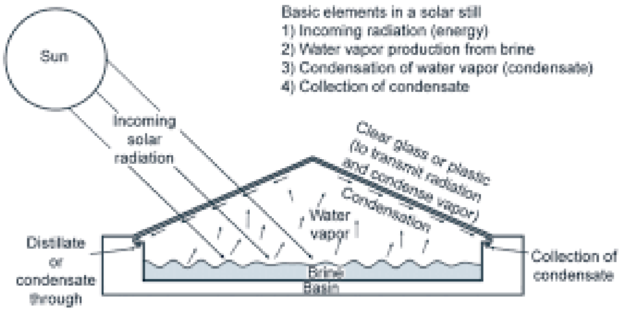
2.1. SOLAR DESALINATION

The basic principles of solar water desalination are similar to the hydrologic cycle. First, the sun heats the water until it starts to evaporate, the vapor rises, then the vapor is condensed on a surface, finally distilled water is collected through channels. This process results in clean water; since the water was evaporated, just water molecules rise by evaporation, leaving any impurities such as salts and undesirable metals.

Solar desalination using solar still is a powerful technology capable of removing many impurities ranging from salts to microorganisms and making drinking water from brackish water. As mentioned above, the working principles of solar still are; evaporation and condensation. Saline water is placed in a basin with a black-painted base. The basin is covered with a transparent tilted cover. This design allows an efficient amount of solar radiation to be trapped inside the still.

Solar radiation passes through the transparent cover and is absorbed by the black base of the basin, causing an increase in its temperature. Water starts to evaporate, leaving behind all undesirable components. The resulting vapor rises and condenses into the cover's inner surface as distillate water (Figure 2). Since the cover is tilted down, the droplets of distillate water scroll down to be collected. Finally, freshwater is obtained.

Figure 2 – Schematic of water desalination.



In Figure 2, it is noted that the water cycle inside the still is very similar to the hydrological water cycle in nature.

3 RESULTS AND DISCUSSION

Even though water is abundant on Earth, only about 2.5% is fresh water. Because most of that water is stored as glaciers or deep groundwater, only a small amount of water

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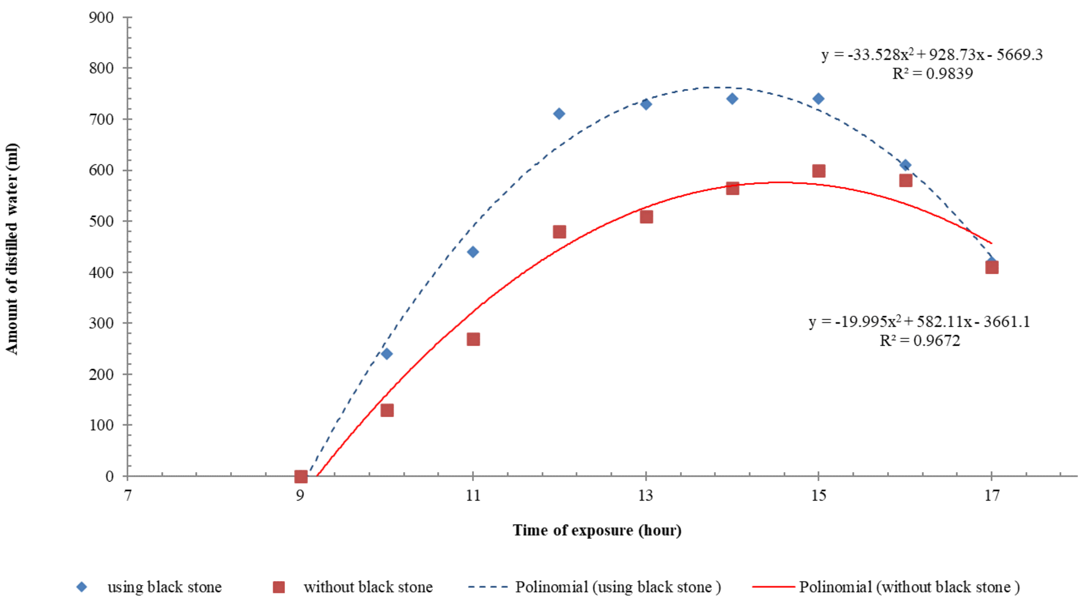
is easily accessible to humans and animals. Passive solar stills are used for solar distillation. However, the passive yield still is low and often fails to meet the demand (Manokar et al., 2018). On the other hand, energy is needed to desalinize water, making the process costly. The increase in freshwater yield depends on various environmental parameters and the rate of condensation that is directly related to the available solar radiation in the case of solar desalinization (KARAGIANNIS and SOLDATOS, 2008). The cost of producing fresh water using solar energy needs to be very efficient, and it comes to a solution to improve the way radiation is collected and used.

The results of the present study are shown in Figure 3. The first one was a conventional system (blue), and the other system was modified by adding black stone as an energy-storing material (red) to enhance the system's efficiency. The use of black stones effectively improved obtaining potable water by nearly 30% more in total during the day.

The 30-degree single slope solar performance of black stone was studied compared to other experimental techniques by recording the day's data. The experiment showed that the maximum output with black stone and without it was respectively 750 ml and 600 ml, so as a result, stone can increase the productivity for the single slope solar still.

Figure 3 – Comparison between the solar collector's testes schemes using black stones and without black stones.



According to Sivakumar and Sundaram (2013), in addition to an active distillation system, a forced convection technique can be incorporated to increase freshwater yield by

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decreasing cover temperature. However, such an initiative requires an increase in water production costs. Improving the solar collector's efficiency seems the less expensive alternative to maximize solar collectors' use (KANNAN and VAKEESAN, 2016; LINS et al., 2020) to produce fresh water. However, not all solar collectors can be improved when producing potable water (KELLY and GIBSON, 2009).

Solar still is a device used in the solar distillation process to produce potable water. The basic idea of a solar still is that salty water in a closed container is heated by solar energy, causing it to evaporate. The water vapor then condenses on an inclined glass covering a surface to let freshwater drain into a collection unit. Pure water evaporates, and the impurities do not, distilling water and making it safe to drink. This device is a cheap unit and can be designed from abundant and cheap materials.

Therefore, the current study aimed to improve the possibility of desalinizing water using the best array of solar collectors. In the present experiment, to increase the productivity of 30-degree single slope solar still, the black stone was used to reduce water quantity and increase exposure. The black stone can store energy and release it during night hours.

4 CONCLUSIONS

Water desalination is one of the processes that can purify brackish water to potable water, and this system requires energy input. Solar water desalination uses solar energy to make the process feasible, more economical, and sustainable. The present study showed that using black stones in the solar collector array for implementing freshwater collection improved.

Simultaneously, in this experiment, the use of black stone enhanced the production rate by 30.6%. This technology can be an efficient option for regions that lack freshwater, like desertic regions worldwide

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RESUMO
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Embora a água seja abundante na Terra, apenas cerca de 2,5% é água doce. A motivação deste estudo foi buscar uma solução para a carência de água doce, convertendo água salobra e salgada em água potável por meio da energia solar. Os principais componentes do sistema foram a placa absorvente pintada de preto, a tampa de vidro, o isolamento e os reservatórios de água doce. A placa fornece temperaturas mais altas para a água salina evaporar e condensar. O forro da bacia era feito de folha de ferro e a tampa era de vidro comum, enquanto a bacia era coberta com vidro usando borracha de silicone. Usamos 30° de inclinação única solar para identificar a eficiência do uso de pedra preta em vez de sem ela (controle). Os resultados mostraram que a produção máxima com pedra preta foi de 750 ml e sem pedra foi de 600 ml; portanto, o uso de pedra preta pode aumentar a produtividade para o destilador solar de inclinação única.

Palavras-chave: Coletor solar; Água potável; Água salobra.

RESUMEN

Aunque el agua es abundante en la Tierra, solo alrededor del 2,5% es agua dulce. La motivación de este estudio fue buscar una solución para la falta de agua dulce, convirtiendo el agua salada y salobre en agua potable mediante el uso de energía solar. Los componentes principales del sistema fueron la placa absorbente pintada de negro, la cubierta de vidrio, el aislamiento y los recipientes para recolectar agua dulce. La placa proporciona temperaturas más altas para que el agua salina se evapore y se condense. El revestimiento del lavabo estaba hecho de una plancha de hierro y la tapa era de vidrio ordinario, mientras que el lavabo estaba cubierto con vidrio con goma de silicona. Usamos solar de pendiente única de 30 ° para identificar la eficiencia de usar piedra negra en lugar de sin ella (control). Los resultados mostraron que la producción máxima con piedra negra fue de 750 ml y sin ella fue de 600 ml; por lo tanto, el uso de piedra negra puede aumentar la productividad del destilador solar de pendiente única.

Palabras-clave: Batería solar. Agua potable. Agua salobre.

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CONFLITO DE INTERESSES
Os autores declaram que não há conflito de interesses neste trabalho.

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Autor 1: Levantamento de dados e metodologia
Autor 2: Interpretação dos resultados e organização do manuscrito.

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[1] Universidade Estadual Paulista "Júlio de Mesquita Filho", FCE - Faculdade de Ciências e Engenharia, Tupã, SP, Brasil.