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Increased Stepped Solar Stilled Efficiency by Adding Natural Materials

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ABSTRACT

A solar distiller is a good way to get water in remote areas. In this research, a stepped solar distiller with four basins and one slope was used. In experiments, natural materials from the local environment were used to improve the distiller's efficiency. The best materials used were black sand, followed by yellow sand and black paint for the basin. Where was the highest efficiency of black sand at 3 p.m. with 65 % boundaries? Also, the efficiency with yellow sand was 60%, and with plant leaves was 43%. The decrease in water attributed to the basin was found to increase efficiency. Most experiments were conducted in the winter months, i.e., the distillation works well in winter.

Keywords: Solar energy, Solar still, Stepped solar still, Desalinated water, Saline water.

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زيادة كفاءة المقطر الشمسي المتدرج بإضافة مواد طبيعية

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قسم الفيزياء، كلية العلوم، جامعة تكريت، تكريت، العراق

الملخص

يعتبر المقطر الشمسي من الطرق الجيدة للحصول على المياه في المناطق النائية. في هذا البحث تم استخدام المقطر ذو الاحواض المتدرجة، حيث كان يحتوي على اربع درجات كما استخدم في التجارب مواد طبيعية من البيئة المحلية لزيادة كفاءة المقطر وجد ان افضل المواد المستخدمة كان الرمل الأسود وبعده الرمل الأصفر والطلاء الأسود للحوض .حيث كانت اعلى كفاءة للرمل الأسود عند الساعة الثالثة عصرا

بحدود (65 %)، كما كانت كفاءة عند استخدام الرمل الأصفر (60 %) وعند استخدام أوراق النباتات (43 %) كما وجد ان انخفاض المنسوب للمياه في الحوض يعمل على زيادة الكفاءة معظم التجارب تمت في اشهر الشتاء أي ان المقطر يعمل بكفاءة جيدة في الشتاء.

الكلمات المفتاحية: الطاقة الشمسية، التقطير الشمسي، التقطير الشمسي المتدرج، تحلية المياه، المياه المالحة.

INTRODUCTION

Solar desalination is a technique that converts salty or brackish water into potable water, and solar distillers are useful and economical devices for producing drinking water. Many solar distiller designs have also been developed worldwide [(1)]. The present study experimentally investigates the effect of the solar stepper distiller. The five input parameters are the rate of saltwater flow, the angle of the device, the color of the absorption plate, and the number and spacing of threads that conduct distilled water in each row, which affect the amount of fresh water produced as the output variable. The use of plastic strands to create channels on the surface of the covered glass led distilled water to the freshwater tank. So the results showed that when the inlet saltwater flow rate was (50 ml/min), the angle of the device was (40 degrees), and the absorption panel was black. The number of threads conducting water in each row was (2), the distance of rows was (8 mm), and the largest production of freshwater was produced at (1975 ml/m^2). The amount of water produced per unit has also been increased by the use of two waterproof strands in each row, (8 mm) apart [(2)]. Experimentally evaluated the performance of the solar stepper distiller. Added an equivalent basin-shaped collector used to heat saltwater entering the solar distiller. Flat external reflectors were also used to increase the amount of light reaching the steps and to reduce the system's complexity. A new paragraph indicates that two external flats should be used, and reflectors were more effective than the small basin complex. The simultaneous application of both mechanisms was also more effective than their separate application and use [(3)]. Solar desalination energy efficiency using activated carbon is also good. Porous media has been enhanced by (94.14 %). Solar desalination plant productivity using aluminum and the ratio of fin and black steel wool fiber as porous materials increased by (42.3 %) and (20.9 %), respectively [(4)]. The impact of the use of fabric as an absorbent material and associated variables on the amount of fresh water production. In this research, a solar distiller was built and included variables related to the tissue and the tested interaction. The variables examined in the experiment are: the type of cloth, the color of the cloth, the number of layers of cloth, the level of the machine's drawer and the angle of the cloth relative to the level of the drawer and the height of the water overflow at each degree, as well as the color and magnitude of the cloth were identified as the most effective factors in increasing the volume of freshwater [(5)]. Modify the dam-type solar inclined distillation device into a modified model for solar distillers, focusing on the effects of dam height, the distance between dams, and the distance between the absorption panel and the intense cover on the production of solar distillate water. The results showed that the operational variables of the inclined solar distiller system significantly affect water production, indicating that the maximum (3.5 cm) and the (15 cm) distances between dams are optimal. The maximum and minimum quantities of water produced were obtained at (6.64125 and 1.79792 kg). Accuracy in forecasting the maximum quantity of fresh water production was noticeable (97.49 %) [(6)] via the five different solar distillers, one hemispherical and the second tube-shaped, the third pyramid-shaped and the fourth two-mile inclined surface. The primary objective was to determine which distillers would be more effective at the test site. Initially, it was evaluated without any changes. Second, external reflectors were added to four of them. Third, tubular hemispheres were used

with reflectors and phase change material (PCM), along with nanoscale silver (Ag nanoparticles). Finally, tests were conducted using reflectors, a fan and external condensate on the hemispheric distiller and tube. The results showed that the increase in the productivity of the hemispheric, tubular, pyramid and double slope distillation without adjustments is (107, 97, 66.5, and 30 %) greater than those found in conventional distillation, respectively. Furthermore, the results showed that the use of reflectors improved the high productivity in tubular, spherical half, hierarchy, and double slope to be higher than conventional productivity by (168, 153, 113, and 85 %), respectively. In addition, the effect of using PCM-Ag (with an inverter) increases productivity by 202% and 212%, respectively. Enhance the performance of conventional fixed solar power (double slope type) by creating an in-room vacuum and using paraffin wax (PCM) as energy storage material. Modified solar power performance is examined and compared to conventional fixed solar energy in terms of productivity, distillation efficiency and energy efficiency. Performance analyses show that hourly productivity and daily cumulative productivity increase by 22.33% and 63%, respectively, from 5.46 to 7.03 L/m2 for adjusted distillers compared to conventional distillers [7].

THEORETICAL PART

The rate of heat transfer by convection ($Q_{c,w}$) can be obtained through the following equation (1) [8].

$$Q_{c,w} = h_{c,w}(T_w - T_g) \quad \text{..... (1)}$$

$Q_{c,w}$: Rate of heat transfer from the water surface by convection and radiation in (W/m^2). T_w represents the water temperature in (^{o}C), T_g represents the glass temperature (^{o}C), and $h_{c.w}$ represents the thermal load heat transmission coefficient that depends on the properties of the fluid in (W/m^2.C), engineering composition, liquid speed, surface roughness, and other factors. [9]. The rate of heat transmission by vaporizing (Q_{ew}) in (W/m^2) can be expressed in the following experimental formula (2) [10]:

$$Q_{ew} = h_{ew}(T_w - T_g) \quad \text{..... (2)}$$

As he represents the vaporizing heat transmission coefficient in (W/m^2.C). The rate of radiation heat transmission (Q_{rw}) can be obtained from the following formula (3) [11].

$$Q_{rw} = h_{rw}(T_w - T_g) \quad \text{..... (3)}$$

Where h_{rw} represents the radiation heat transmission coefficient in (W/m^2.C). The efficiency for the solar still in equation (4):

$$\eta = \frac{m_w \times L}{A_s \times I(t)} \quad \text{..... (4)}$$

Where L represents the underlying heat of water evaporation, A represents the area of the system (basin), and I represents the intensity of solar radiation in (W/m^2).

EXPERIMENTAL WORK

Locally manufactured distiller was used as in figure (1) (130 cm) long, (48 cm) wide, (45 degree angle). It was made of (1.5 cm) thick galvanized iron. Installed in a southeastern direction. The machine was cleaned, and a certain amount of salt was removed. Temperature scales were placed inside. Outside the glass, the silicone glass was installed, and the machine was placed in an open place for radiation access.

Fig. 1: Solar still.

RESULT AND DISCUSSION

Using a different level of water in the distiller without any additives, and again when adding a layer of thick sand (1.5 cm) to see the effect of placing black sand in the basin, when the distilled water contains sand, it has the highest (54 %) efficiency at 3:00 pm. At the same time, it is lower

without any additives at (33 %), figure (2), because of the high solar radiation that has raised the sand temperature, as black sand absorbs heat at high speed and leads to an increase in water and glass temperatures. The heat is high at all times because of its dark color and the basin's high thermal conductivity. In Figure 3, when 2 liters of water are added to the basin, and the same procedures are followed, the curves show that the highest efficiency (58%) is obtained when a layer of sand is placed at 3 o'clock. While the highest value for efficiency with any addition is (38 %), efficiency has decreased due to the high-water level of the basin, which has reduced absorption and thus reduced heat and the evaporation process is consistent with researchers [12-18].

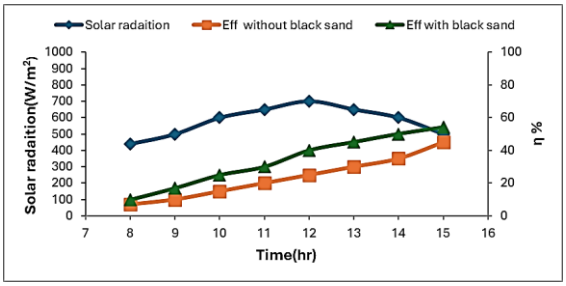

Fig. 2: Relation between solar radiation and efficiency with time.

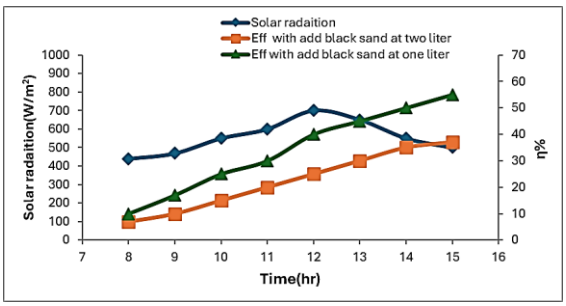

Fig. 3: Relation between solar radiation and efficiency with time when adding one liter and two liters.

The efficiency of the solar distiller (figure 4) was also compared between painting the basin black and adding yellow sand once, and blackening it again. Adding sand to the basin was found to improve efficiency over time, but black sand is better than yellow sand because it absorbs more radiation. It was noted that the highest efficiency for a black base without additives is 45 %. While in the case of the addition of yellow sand, the efficiency was (60 %), in the addition of black sand, the efficiency was about (64 %), which is compatible with [14, 15].

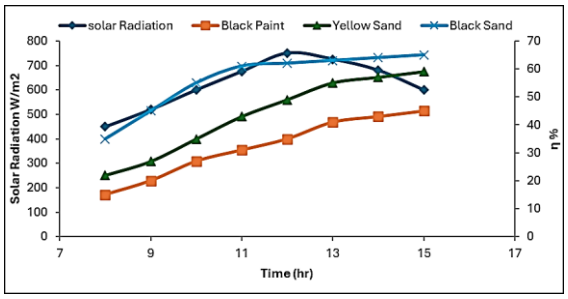

Fig. 4: Relation between solar radiation and efficiency with time.

In Figure 5, when adding green leaves in the basin for a 1 mm thick solar distillation, the efficiency was 64 % with green leaves, while (50 %) without adding, because green leaves increase efficiency because the leaves absorb radiation in the visible range, thus increasing evaporation speed, increasing productivity, and are compatible with [16-18].

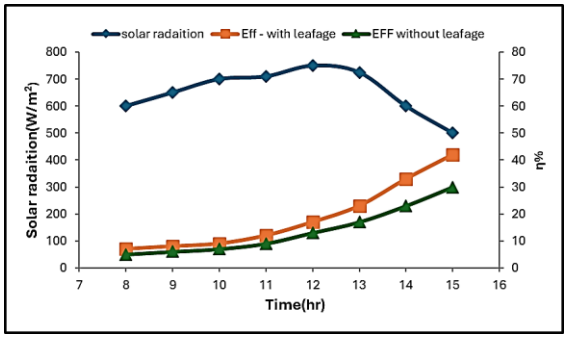

Fig. 5: Relation between solar radiation and efficiency with time.

Water analysis results, measured by atomic absorption spectroscopy, were used to determine salt concentrations before and after water distillation, as shown in Table 1.

Table 1: Analysis results for water before and after dictation.

Sample	K (PPm)	Ca (PPm)	Mg (PPm)	Na (PPm)
Before	1.259382	97.49864	34.94775	38.25176
After	0.671346	34.05256	13.916092	17.81567

CONCLUSIONS

Experiments have demonstrated the possibility of using the solar distiller in winter. The addition of sand types, such as black sand and yellow sand, has increased efficiency. The use of leaves for plants has also increased efficiency. The closure provisions have increased the distiller's effectiveness. The decline in basins' water levels has increased productivity and efficiency. Distilled water in winter is good for drinking.

Conflict of Interest: The authors declare that there is no conflict of interest in relation to this research.

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Author Contribution: The first author (principal investigator) collected the research information, studied it and interpreted the results, while the second author contributed by supervising the research and assisting in research-related activities

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