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SOLAR WATER DISTILLATION (REPRODUCTION FRESH WATER FROM DIRTY WATER)

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ABSTRACT: - This paper presents the design of a solar distillation still for the reproduction of fresh water, safe to drink without any stuck impurities, from different samples of dirty water drawn from 5 sources (river, well, bilge water, pool & lake), in addition, two water samples prepared by adding NaCl and sugar to tap water, in order to show the effect of them on the distillation process. Also, the designed solar still is used as a collector to rain water, when it is used in rainy days.

The experiments were carried out within 10 hours for each mentioned sample. The amount of each drawn water was 20 litters as a standard for comparison between samples and their results, after distillation. The distilled samples were adopted after two hours for each one. The results were varied from one sample to another, but the successed samples are graduated as sweet water, river, well, pool, and lake, respectively. While the failure samples are salted water and bilge water, not proper for drinking.

This procedure was adopted to reproducing drinkable water in the semiarid areas or deserts, where there is no source of drinking water just one of the above mentioned sources. The results were analyzed and showed that 98.4% pure water is resulted from sweet water, 86% for river, 84.5% for well, 78% for pool, 76.7% for lake, 57.6% for salted water and 53.8% for bilge water. The remained percentages, as obtained in analysis, were the stuck impurities, slush, salinity, and toxicity. Finally; besides sweet water, river and well; pool and lake could be used as a proper source of drinking water.

Keywords: Solar distillation, water reproduction, dirty water, fresh water and rain collector.

INTRODUCTION

Water is considered as the life source for all creatures on the earth. Especially, human needs for water to perform daily functions and activities. Most human activities are intensively dependent on the water resources such as underground water, rains, lakes and

rivers. However, rapid industrial growth and the population explosion all over the world have resulted in a large escalation of demand for fresh water. Add to this, the problems of pollution of rivers and lakes by industrial wastes and large amounts of sewage discharged [1 & 2]. While water covers about three-quarters of the earth surface, only 3% of it is fresh water and not all of this limited quantity is suitable for drinking. Thus, water treatment is usually needed, and desalination is widely used for providing fresh water from brackish or seawater. Furthermore, supplying the required amount of potable water is already a problem in remote and arid areas which have limited supply of conventional energy, but have great potential for solar energy. Solar distillers based on renewable, safe, free and clean energy are a promising, cost effective solution [1].

The water sources are often brackish and/or include effective bacteria that could be harmful for human health and cause many diseases, therefore, cannot be used for drinking. In addition, there are many coastal places where seawater is abundant but potable water is not available. Clear water is very important for many industries and healthy requirements like hospitals and civilian needs [3]. Distillation is one of many processes available for water purification, and sunlight is one of several forms of heat energy can be used to power that process. Sunlight has the advantage of zero fuel cost but it requires more spaces, for its collection, and generally more costly equipments [4].

The study, is meant to take place in this research, is one of the ways to provide service and retrieve water from any source containing the filth and dirt or rancid swamp and even sea water (salted water), which allows the human to maintain his life in desolate places and desert. Note that this method is still scalable and is primarily dependent on the design of the system used in the solar distillation process and their effectiveness in these areas.

BASICS &THEORIES

There are many designs and drawings that have been implemented to activate solar distillation system, by many scientists and researchers. Each one of these designs showed different results in terms of the amount of water produced and the time period to produce it. The basic idea of reproduce fresh water from contaminated or brackish water by using solar radiation is very easy and simple in design. It is based on the phenomenon of evaporation, where the water is placed in a bowl and leave exposed to the sun to evaporate into the air. The purpose of the solar distillation process is catching the resulting water vapor and condensing it on the cold surface, often made of glass, through the use of solar energy to speed up the evaporation process [5, 6 & 7].

The evaporation rate should grow by increasing the water temperature and the space that gets through the contact between water and air. In addition, it is assumed that uses surface with certain specifications allow steam to condense and should be cooler than the water in the pot. This pot should be covered by a glass roof or translucent nylon and placed diagonally, in order to allow condensate water to drop from the underside of surface into the collector reservoir specified to collect pure water [4].

The practical experiments are proofed that the main features of operation are the same for all solar stills. The incident solar radiation is transmitted through the glass cover and is absorbed as heat by a black surface in contact with the water to be distilled. The water is thus heated and evaporated. The vapour condenses on the glass cover, which is at a lower temperature because it is in contact with the ambient air, and runs down into a gutter from where it is fed to a storage tank [8 & 9].

PRECEDING DESIGNS AND APPLICATIONS:

Many researchers and experts may have innovations and process designs to activate and apply the idea of solar water distillation. In the last decades, several designs for the solar stills have been proposed and investigated. The common objective behind these new designs is to maximize the output by increasing the efficiency of the system. It is possible to classify the passive solar stills as: basin, wick, diffusion or other type of stills [10]. Four designs are adopted as a newer types, for efficient evaluation.

The first design is the solar still principle on runoff water reservoirs in Budunbuto, Somalia. This design is obtained the different idea by adding the gutters for rain water and distillate collection at the edges of the roof. However, fundamental in the design is that the distillate condenses on the top cover as a film rather than as droplets. Droplets might otherwise drop back into the feed water and represent a loss of output. To prevent this from happening, the cover should be set at an angle $\geq 10°$ [11].

The second design is a conical multi stage solar still. For basic enhancement, a low pressure was used inside the distiller. This will increase the rate of evaporation and hence rate of condensation on the cooler surface. One more additional feature in the distiller that use the latent heat which is released during condensation to heat up the water at lower temperature. This is achieved by using an innovative staged still design [12].

The third design is a simple asymmetrical distiller, similar to solar powered water distillation. It is a singular, easy to maintain unit, and is made of relatively inexpensive materials. Also, it is easy to use and easy to clean, and can provide enough water for a small family. This still incorporates several innovative features involving either the modular design

and a water-depth regulating system. In addition to the recent development of still, it could be the efficient and the superior device to competing other devices, because it can provide enough water amount, while still exhibiting the lowest output to cost ratio [13].

The fourth design is a solar distillation system was integrated with biomass energy to operate during adverse climatic conditions for the on-farm processing of medicinal and aromatic plants. The auxiliary biomass system comprises of a boiler, biomass furnace, and economizer and equipped with all safety mountings and fittings. The boiler operates under natural draught with the help of a chimney for efficient combustion process and can be operated with firewood, bagasse, spent and other biomass material etc. The main object of the work is to utilize solar energy as a primary heat source and the biomass energy as a secondary heat source to make up any steam deficiency for continuous distillation processes. For this purpose, steam connection from the biomass boiler is injected into the distillation still while the bottom of the still is always exposed to the beam radiations [14].

MAIN FEATURES OF EFFICIENT DESIGN:

In order to make the type of solar distillation proper for the purpose of use, efficient and practical, there are some items should be accounted to achieve this animus which are [11 & 12]:

1) The designed still should produce an amount of water not less than 2 liters each 10 hours, as an average amount.
2) The materials used in manufacture are from local site and not expensive.
3) The materials used in manufacture should not be toxic.
4) The total designed still price is not exceed the cost of trade still.
5) The prepared still is proper to distill any type of water and not limited for specific type.

EXPERIMENTAL WORK:

The designed still is consist of thin glass, two mirrors, plastic spouts (PVC), steel stands, feeder tank size 20 liters (aluminum alloy) to warming water, thermal adhesive silicon, black oil paint, rubber rings, 1000 ml graduated cylinder, 100 ml flask and 1000 ml flask. 20 liters of dirty water drawn from 5 sources (Diyala river, home well, bilge water (rusted barrel), pool & Himreen lake) with prepared water by adding NaCl and sugar to tap water (manually by researcher), as sources of brackish water.

The prices of used materials are listed in Table (1) in order to evaluate the cost comparison and economic review.

Still Design:

The idea of the still, designed in this research, is inspired from other designs with some differences are done to give a newer and more efficient still as required for proper and efficient design, such as the designed still can be used as rain water collector at the same time according to the design itself as shown in Figures (1, 2, 3 & 4), respectively. The actual designed still is not shown in any picture because of the adoption of the secret scientific research as Know-How.

Experiments Procedure:

The procedure is done when the adopted amounts are add from the feeder tank, where the water is warm, to the designed still and remains 10 hours/day for 5 days for each sample, till the water vaporized and begin into the glass surface and condensated, because the temperature at the glass surface is lower than the temperature in the bottom of the still. The condensate vapour is sliding along the inclined surface toward the gutter available in the lower side of the still. Then the water droplets were collected in the bottom and drawn by the plastic spout (PVC) to the graduated cylinder used to measure the amount of distilled water.

The feed water used were 7 samples, 5 of them are drawn from river, well, bilge water, pool and lake while the remaining 2 samples were prepared by adding 100 grams of salt (NaCl) to one sample and 100 grams of sugar per liter of tap water to the other sample. Each sample was tested in the designed still for 10 hours a day and for 5 days where the distilled water is drawn each 2 hours as a final product and tested whether it is fit for drinking or not. The total capacity of the designed still is 20 liters and the feeder tank is made of aluminum in order to increase the temperature of inlet water and make the process quicker than without use of this type of tank. The process is depend upon the weather circumstances, so the amounts of distilled water, for each sample, were oscillated. And these tests were carried out at summer session.

For more benefits, the still is designed to collect the rain water, where a hole is available on the surface from the depressed side of the still. This hole collect water, when it is shed on the inclined surface and streamed toward it. This application is used during winter or rainy days for the purpose of increasing the amount of produced water.

Samples Analysis:

Table (2) shows the analysis of the samples before and after distillation. The analysis is carried out in Pathological Laboratory Analyzes to check the validity of water to be proper to drink and empty of any type of bacteria and toxic materials. Where the analysis results have given by the owner of the laboratory, so the methods of analysis are for its own and

because it's a commercial and not a governmental laboratory to get official documents for results.

RESULTS & DISCUSSION:

Distillation process by solar energy is applied for 7 different samples using the designed still, shown in Figures (1, 2, 3 & 4). The results for river water were taken each 2 hours from the distiller and registered for every day for the period of 5 days. These results are illustrated by Figure (5). The amount of produced water are varied according to the weather of the test days, i.e. the amount of sun beams dropped on the water inside the still, where the fifth drawn sample for the fourth day was lower than the fifth drawn sample for the fifth day and this could be the proof for the previous alleges. Figure (6) shows the variation of well water produced through the specified days with oscillated behavior as obtained by days' curves. Figure (7) shows the amounts of bilge water during the same period for the production of the purified water, but with some intersections in distilled samples, such as between day 1 and 2 curves. Figure (8) describes the pool water present at the same time of production with steady increments for produced amounts present by days' curves. Figure (9) shows the amounts for lake water out from the still for the specified days with similarity for produced amounts, such as day 2 and 4 curves. Figure (10) shows the salted water by NaCl during the production days with more intersections between all days' curves. Figure (11) shows the sugar water out from the still for the last 5 days of production with stable behavior as shown in days' curves.

These amounts of produced water from different water sources are varied during the operation of distillation according to the effect of sun beams and clouds present during the adopted periods. Some of these amounts are collected quicker than the others for each sample individually, while for all sources were slow. This operation is varied from region to another; for example, if the process applied in the south of the country it will be more efficient and more producible than in the north, although the other weather circumstances in these regions are unstable.

CONCLUSIONS

The work shows the following conclusions:

1. The designed still is efficient than the old one, as mentioned in preceding designs and applications item; because it is produce water with amount not less than 2 liters for almost samples, which will achieve the requirements of efficient design.

2. The process is easier for application at any region in comparison with the equipments designed for water production. These equipments are expensive and large for semiarid areas.
3. The produced water is healthy for use than the tap water itself, because of there is no impurities and fouling.
4. The process is very cheap because there is no use of energy and fuel source except clean energy, namely the sun.
5. The salted water is failed in comparison with sweet water during this process. So, this process is not proper for purification salted water because the produced water was remaining contains the salt impurities; according to the experiments results.

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Table (1): Materials Amounts and their Prices for the Designed Still in Iraqi Dinars (ID).

No.	Materials	Amount	Price (ID)	Total Price (ID)
1	thin glass	34 ft	500	17000
2	Mirror	8 ft	2000	16000
3	plastic spouts (PVC)	2	1500	3000
4	steel stands	2	5000	10000
5	feeder tank size 20 liter (aluminum alloy)	1	20000	20000
6	thermal adhesive silicon	1	2000	2000
7	black oil paint	1 can	3000	3000
8	rubber rings	5	50	250
9	1000 ml graduated cylinder	1	7500	7500
10	100 ml flask	1	4000	4000
11	1000 ml flask	1	15000	15000
Total Price (ID)				97750

Table (2): Pathological Laboratory Analyzes Results for Samples before and after Distillation.

No.	Sample	Before				After			
		* Purity %	* Impurity %	* Salinity %	* Toxicity %	* Purity %	* Impurity %	* Salinity %	* Toxicity %
1	River	74.9	25.1	22.7	* NA	86	14	6.6	* NA
2	Well	68.5	31.5	45.6	* NA	84.5	15.5	7.8	* NA
3	Bilge	40.8	59.2	18.7	* NA	53.8	46.2	12.7	* NA
4	Pool	64.1	35.9	11.4	* NA	78	22	10.2	* NA
5	Lake	70.3	29.7	41.5	* NA	76.7	23.3	11.5	* NA
6	NaCl in tap water	81.4	18.6	94.6	* NA	57.6	42.4	64.8	* NA
7	Sugar in tap water	93.7	6.3	6.7	* NA	98.4	1.6	3.4	* NA

Where:

* **Purity:** is the percentage of pure water without any impurities and planktons.
* **Impurity:** is the complement percentage for each total sample and it is sludge of impurities, muds, salts, toxic pigments, fouling, and planktons.
* **Salinity:** is the percentage of salted materials available in each sample.
* **Toxicity:** is the percentage of toxic materials if available in each sample.
* **NA:** Not Available, is the zero percentage of toxic materials if available in each sample.

]

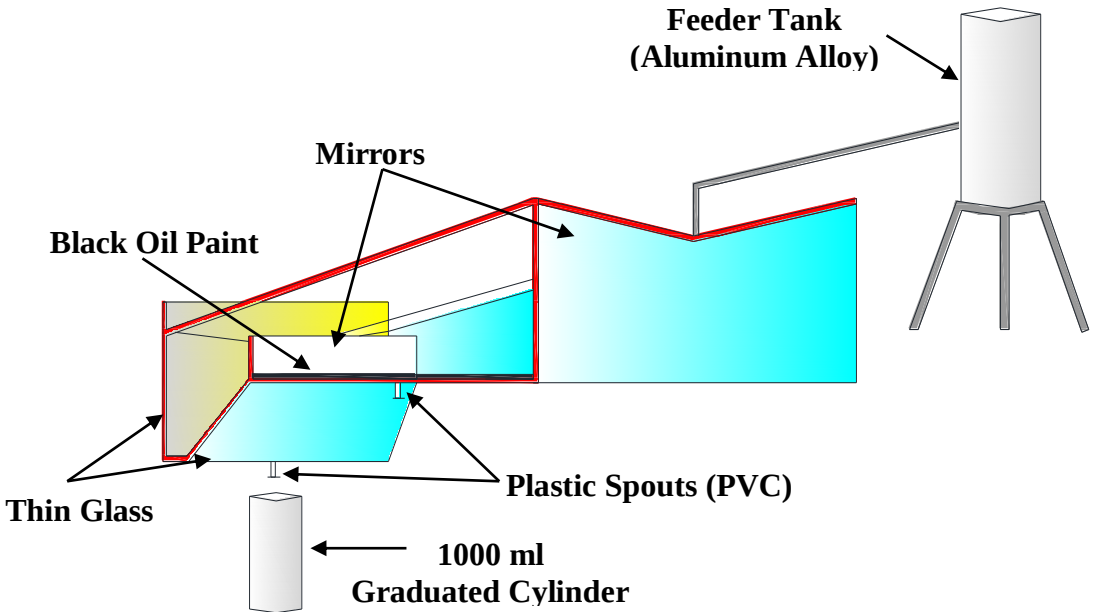

Fig. (1): The Designed Still (3D View).

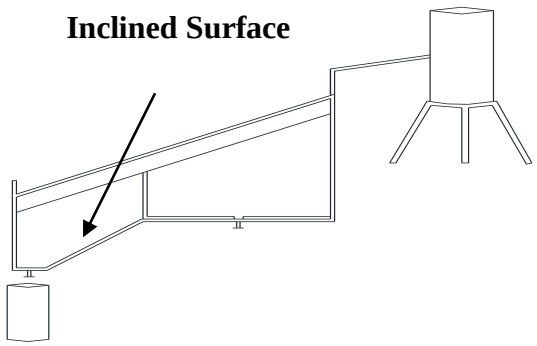

Fig. (2): The Designed Still (Front View).

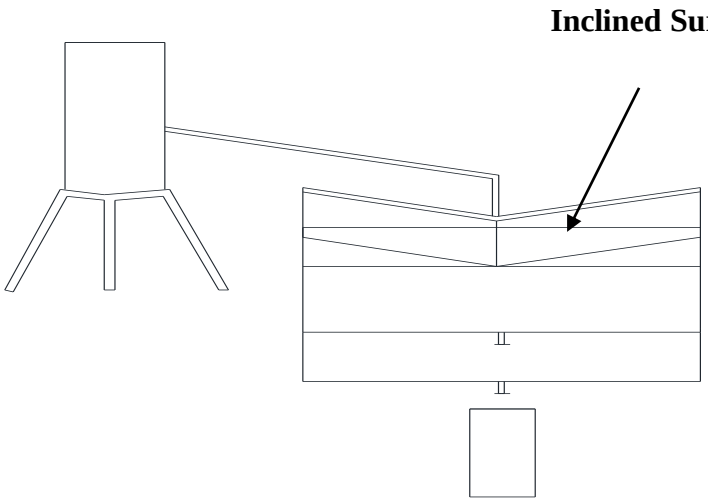

Fig. (3): The Designed Still (Left Side View).

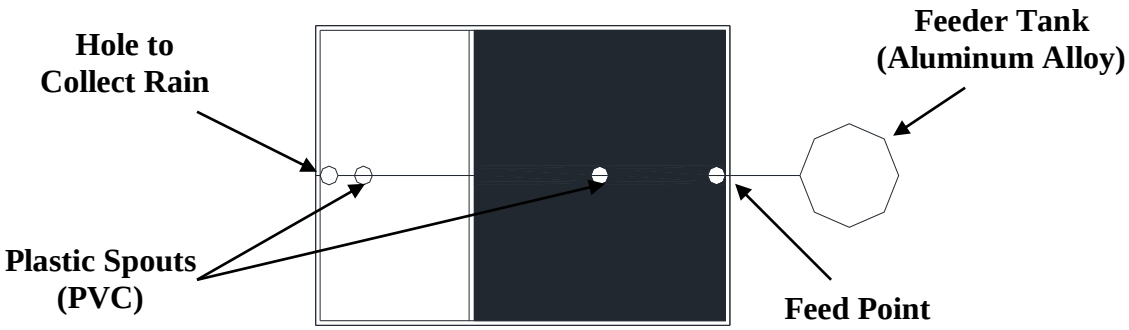

Fig. (4): The Designed Still (Top View).

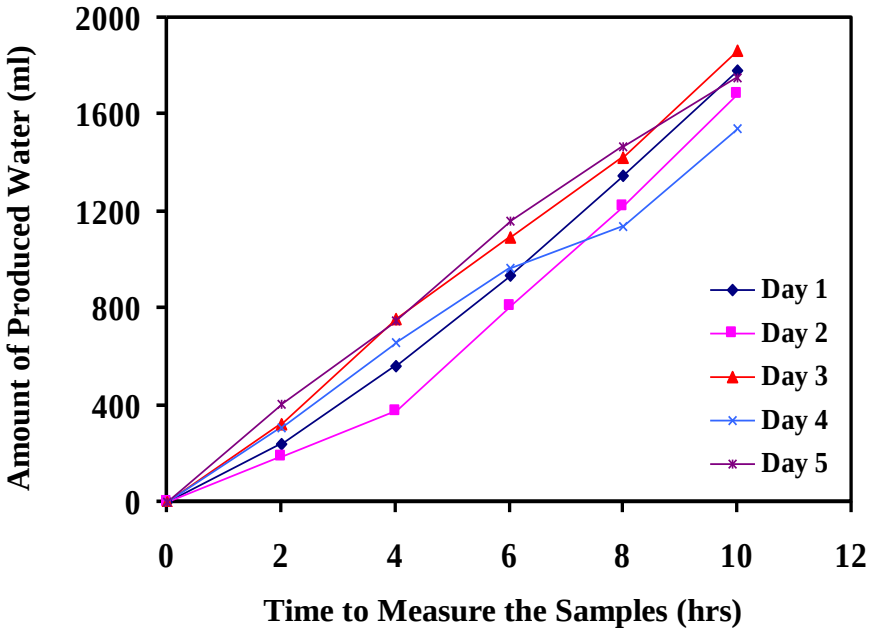

Fig. (5): The Amounts of Produced River Water (ml) during Five Days.

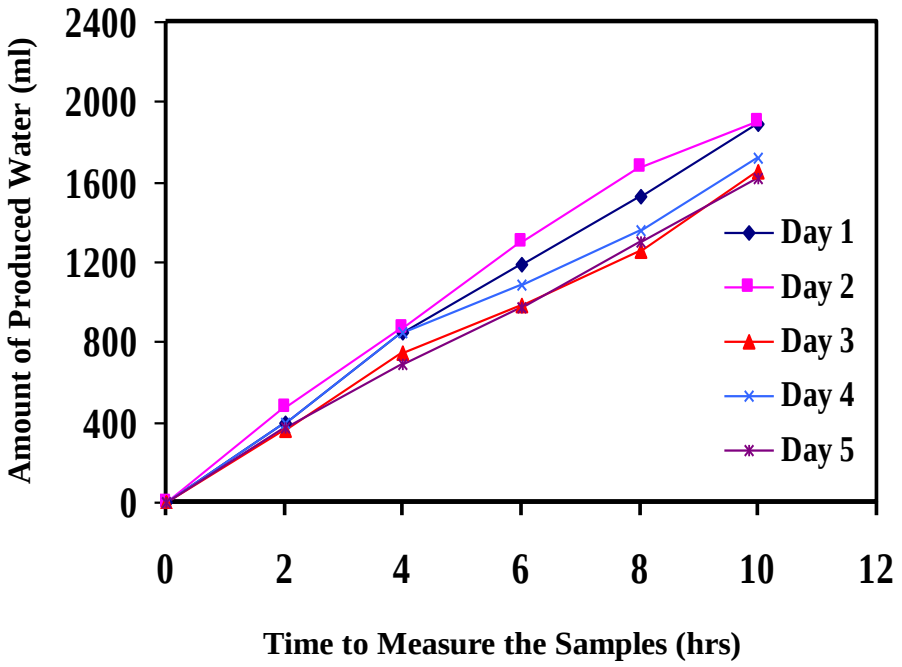

Fig. (6): The Amounts of Produced Well Water (ml) during Five Days.

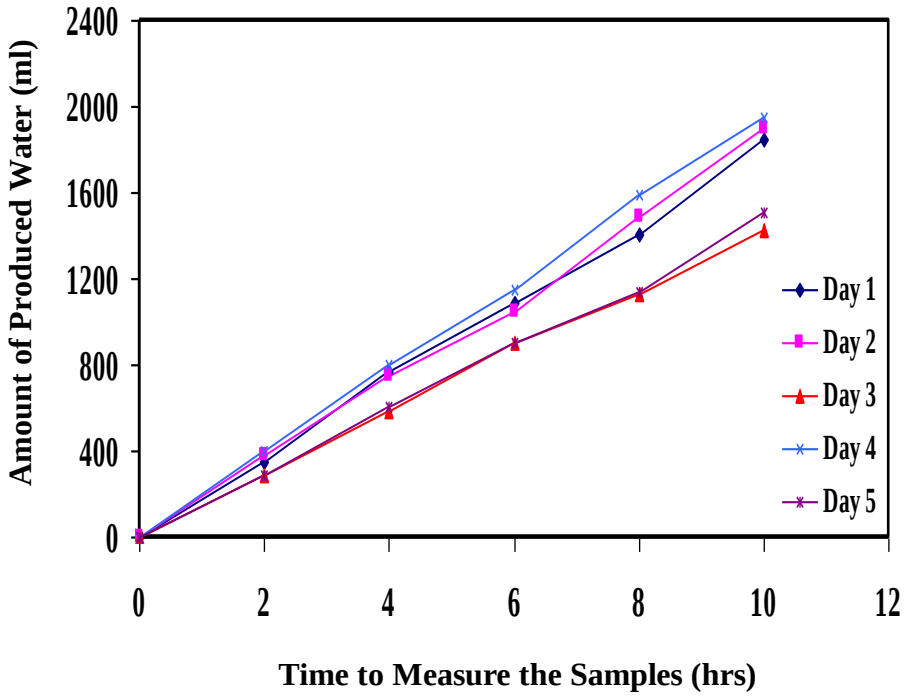

Fig. (7): The Amounts of Produced Bilge Water (ml) during Five Days.

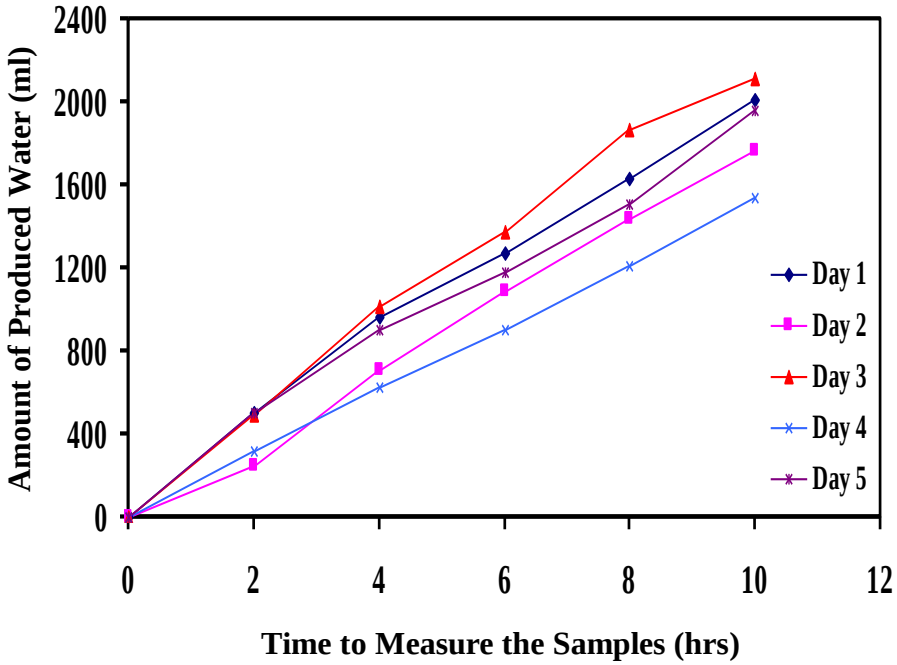

Fig. (8): The Amounts of Produced Pool Water (ml) during Five Days.

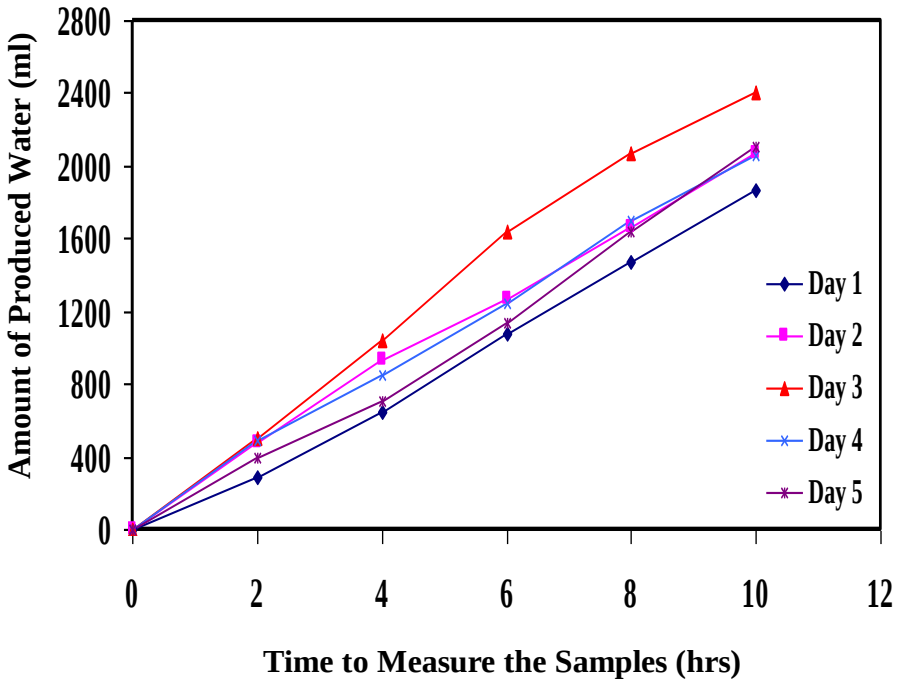

Fig. (9): The Amounts of Produced Lake Water (ml) during Five Days.

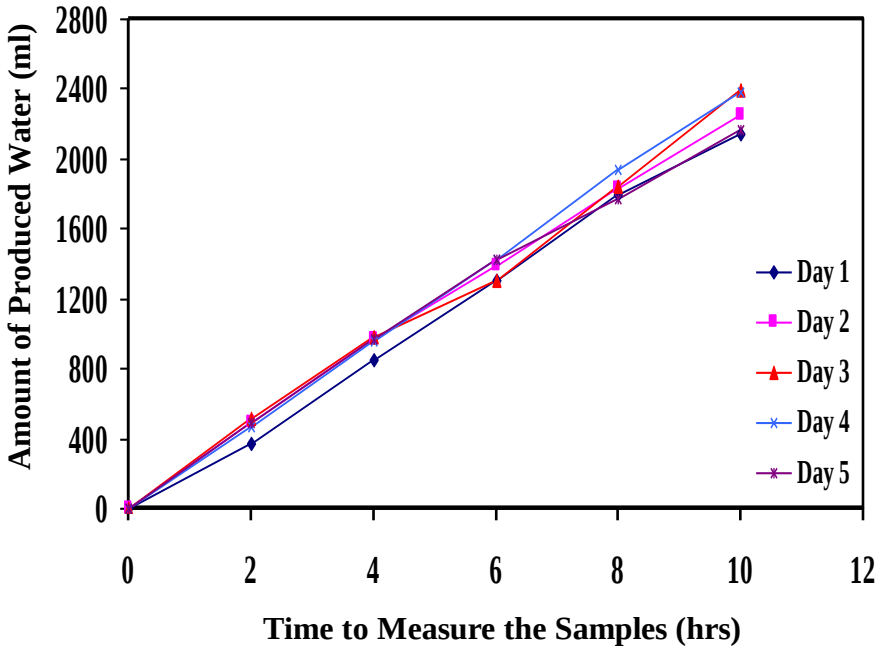

Fig. (10): The Amounts of Produced NaCl Water (ml) during Five Days.

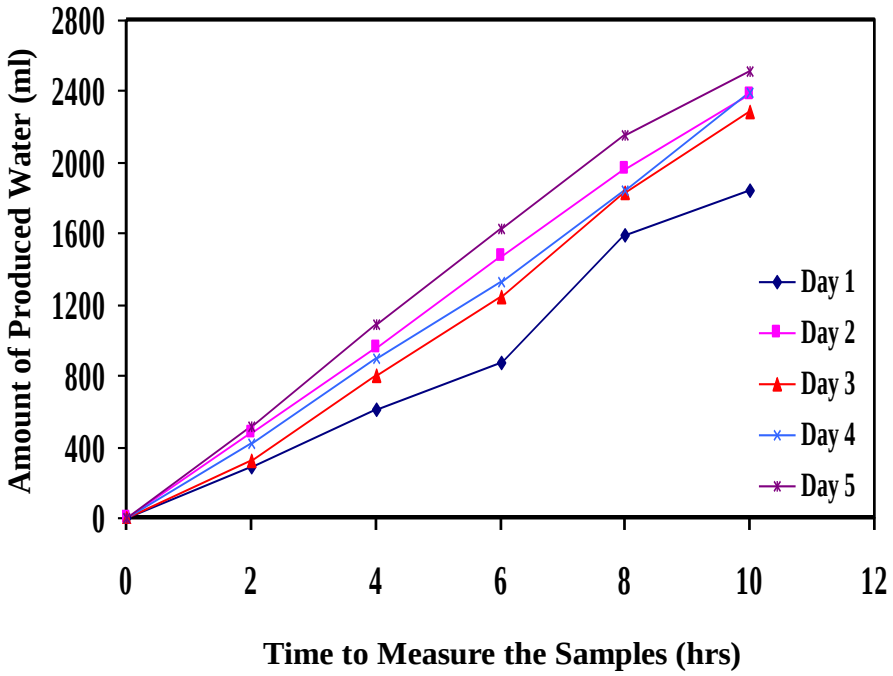

Fig. (11): The Amounts of Produced Sugar Water (ml) during Five Days.

تقطير المياه بالطاقة الشمسية
(إعادة إنتاج المياه العذبة من المياه الأسنة)

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الخلاصة

يتناول هذا البحث تصميم جهاز التقطير الشمسي لإعادة إنتاج المياه العذبة، الصالحة للشرب دون أي شوائب عالقة، من عينات مختلفة من المياه الآسنة المأخوذة من 5 مصادر (النهر، البئر، الماء الآسن من قعر البرميل، حوض السباحة والبحيرة)، بالإضافة إلى عينتين من المياه التي تم أعدادها بإضافة ملح الطعام (NaCl) والسكر إلى ماء الحنفية، وذلك لإظهار تأثيرها على الماء المقطر. ويستخدم جهاز التقطير الشمسي المصمم كجامع لمياه الأمطار كذلك، عندما يتم العمل عليه في الأيام الممطرة.

تم تنفيذ التجارب في غضون 10 ساعة لكل عينة من العينات المذكورة أعلاه. وكانت كمية كل عينة من المياه المأخوذة من المصادر تعادل 20 لتر كمعيار للمقارنة بين العينات ونتائجها، بعد التقطير. تم اعتماد عينات المقطر كل 2 ساعة لكل عينة. وتباينت النتائج من العينة الواحدة إلى الأخرى، ولكن العينات التي نجحت كانت بالتدرج التالي المياه الحلوة (السكر المضاف إلى ماء الحنفية)، النهر، البئر، حوض السباحة، والبحيرة، على التوالي. بينما عينات المياه التي فشلت هي المياه المالحة والمياه الآسنة، غير ملائمة للشرب.

أعتمد هذا الإجراء لإعادة إنتاج المياه الصالحة للشرب في المناطق شبه القاحلة أو الصحارى، حيث لا يوجد مصدر مياه شرب واحد سوى احد المصادر المذكورة أعلاه. تم تحليل النتائج وأظهرت ان 98.4٪ مياه نقية ناتجة من المياه الحلوة، و86٪ من النهر، 84.5٪ من البئر، 78٪ من حوض السباحة، 76.7٪ من البحيرة، 57.6٪ من المياه المملحة و53.8٪ من المياه الآسنة. والنسب المئوية المتبقية، كما أظهرت التحاليل، كانت الشوائب العالقة، الطين، الملوحة، والسمية. وأخيراً، يمكن استخدام مياه حوض السباحة والبحيرة كمصدر امن لمياه الشرب في المدن، إلى جانب المياه الحلوة، والنهر، والبئر.

الكلمات الدالة: التقطير الشمسي، إعادة إنتاج المياه، الماء الآسن، الماء العذب، جامع المطر.