Desalination 344 (2014) 383–390

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Factors affecting the performance of triangular pyramid solar still

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HIGHLIGHTS

- A low cost triangular pyramid solar still was designed, fabricated and tested.
- Water quality agrees with the WHO guidelines.
- Least water depth produced maximum productivity.
- Water productivity and water temperature were nearly proportional to solar intensity.

ARTICLE INFO

Article history:
Received 25 November 2013
Received in revised form 3 April 2014
Accepted 4 April 2014
Available online 3 May 2014

Keywords:
Evaporation
Condensation
Water depth
Wind velocity
Parameters

ABSTRACT

This work presents a few important factors that affect the performance of a triangular pyramid solar still. An experimental work has been conducted to find the effect of water depth on the performance of the triangular pyramid solar still. From the present study, it is concluded that the convective and evaporative heat transfer coefficients are important for designing solar distillation systems and the effect of temperature difference between the evaporative and condensing surfaces is also important to optimize the operating temperature range. The condensing area of the solar still is more than that of evaporating area. Thus the experimental results showed that the effect of depth of water in the solar still affects the fresh water production. Nevertheless, outdoor experimental tests were conducted to study the effect of wind speed variations to cool down the glass cover. It was found that increasing the wind speed from 1.5 to 3 m/s and to 4.5 m/s has the effect of increasing the still productivity by 8 and 15.5% respectively.

1. Introduction

Many countries around the universe, particularly developing countries and countries in the Middle East region, suffer from a shortage of fresh water. Environment programmers from the United Nation (UN) stated that one-third of the world's population lives in countries with insufficient fresh water to support the population [1]. Solar desalination is one of the best methods in converting backrush water to fresh water using solar energy [2]. Various research have been investigated in order to increase the productivity of fresh water from solar still in remote and rural areas. Solar desalination is categorized into (i) active solar still and (ii) passive solar still.

Bharadwaj et al. [3] investigated the effect of condensation area on solar still. Nevertheless, he concluded that the contact angle should be lowered for glass material so that it allows more solar irradiance through them. Materials of hydrophilic will have more condensation than that of hydrophobic for fresh water production. The other phenomena such as inclination and condensation had no effect on the fresh water production. Thus, it has been concluded as the contact angle is an important parameter for choosing the inside material for condensation of solar still.

Nematollahi et al. [4] experimentally investigated the energy and exergy analyses. Water is flowed through the packed bed and the air from the solar collector is passed through the opposite direction. From the exergy analysis of solar distiller the humidification tower is an important component. The model which was proposed by him well predicted the temperature of air and water from the collector. The exergy efficiency of the system increases when the temperature of air at the inlet decreases with an increase in tower diameter. Also with an increase in the humidification tower length there is a decrease in the exergy efficiency. And at a particular length of the bed, there is no decrease in the exergy efficiency when the tower length is too long. This is due to the saturation condition which achieved soon in the still.

Abdenacer et al. [5] set up a model to simulate the performance of solar still with simple greenhouse effect. He proposed that the temperature difference between glass and water will improve the evaporation rate. Since temperature difference is the driving force for the solar still, it

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http://dx.doi.org/10.1016/j.desal.2014.04.005
0011-9164/

has a great impact on fresh water production. Also it has been concluded that the inclination angle must be equal to the latitude of the area to get a better performance. The effect on wind velocity has also been studied where higher wind velocity over the cover decreases the temperature of cover. This improves the temperature difference. Also the effect of cover cooling has been studied. The effect of inlet water temperature with external heating will improve the efficiency of solar still.

Omara et al. [6] presents a new design of solar concentrator, simple solar collector, a boiler for salt water desalination. He concluded that the productivity of fresh water from solar still with and without preheating on a solar dish was 6.7 and 5.5 l/m^2/day. While it is compared to a conventional still it is 1.7 l/m^2/day. So there is an increase in efficiency of 244 and 347% with and without preheating respectively. The average daily efficiency of solar dish collector and conventional still was 68 and 34% respectively.

Tiwari et al. [7] investigated the effect of condensing material on an active solar still. He has chosen copper, glass and plastic materials for the condensation area. The yield of active solar still is more than that of a passive solar still. Furthermore, he observed that the yield of copper material (3.6 kg/m^2) as a condensing material for an active solar still is more when compared to glass (3.3 kg/m^2) and plastic (3 kg/m^2). The effect of wind velocity on the solar still is also experimentally investigated and results showed that higher wind velocity over the cover higher yield is achieved in an active solar still.

Tiwari et al. [8] investigated the effect of cover inclination and depth of water on the performance of passive solar still. The inclination of cover varied from 15, 30 and 45°. For different inclination angles, the convective heat transfer coefficient significantly varies. The heat transfer coefficient between the cover and atmosphere is larger for 15° inclination of cover. This higher variation increases the yield of solar still also with a least depth of water hence the performance of the still is higher when compared to higher water masses.

Mahian et al. [9] carried out the experimental exergy and economic analyses of a pyramid type solar still. It has been concluded that the exergy efficiency is higher for least water masses. The exergy efficiency of the solar still is more than that of the passive solar still; as well it is more during summer than winter seasons. The cost of solar still is 8–9% lower than that of a passive solar still.

Ahsan et al. [10] investigated the performance of low cost solar still and the parameters affecting the productivity of fresh water from the still. Thus, it has been concluded that a low cost triangular solar still is well suited for summer conditions than winter conditions. Nevertheless, the productivity is inversely proportional to the depth of water and directly proportional to the solar radiation.

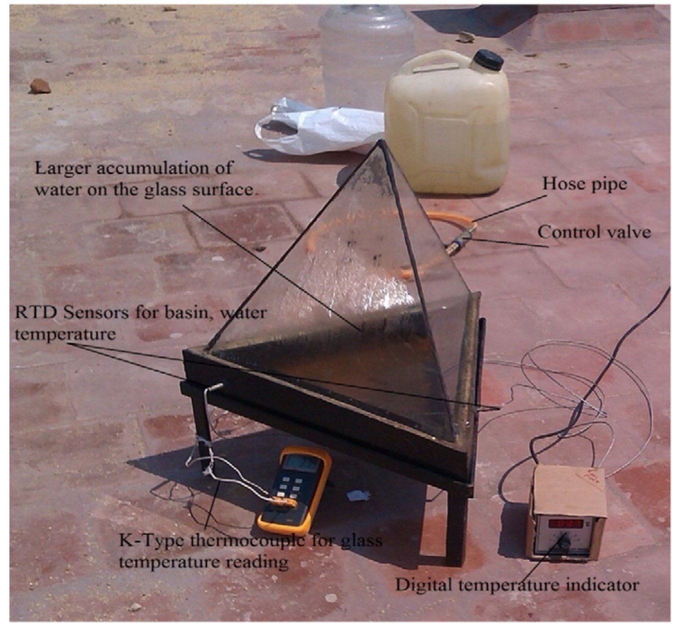

Fig. 2. Triangular pyramid solar still.

El-Sebaii [11–14] investigated the effect of wind velocity on different solar still and found that the wind velocity is varied from 10 to 14 m/s on the solar still, an increase in temperature difference between glass and water. Furthermore, investigations made on different solar still and the daily productivity showed an increase with higher wind velocity on a hot and humid day.

Ravishankar et al. [15] experimentally investigated the performance of the triangular pyramid solar still. Nevertheless, the results showed that the maximum distillate output of the still of about 4.3 l/m^2 day was achieved with a constant depth of water ($d_w = 0.02$ m). The accumulated yield of solar still showed the maximum with natural convection where it has been studied that for an hourly variation of wind velocity over the surface. Similarly various authors search for different configurations of solar still such as tubular solar still [19–27] triangular solar still [28,29], hemispherical cover [30], hemispherical absorber

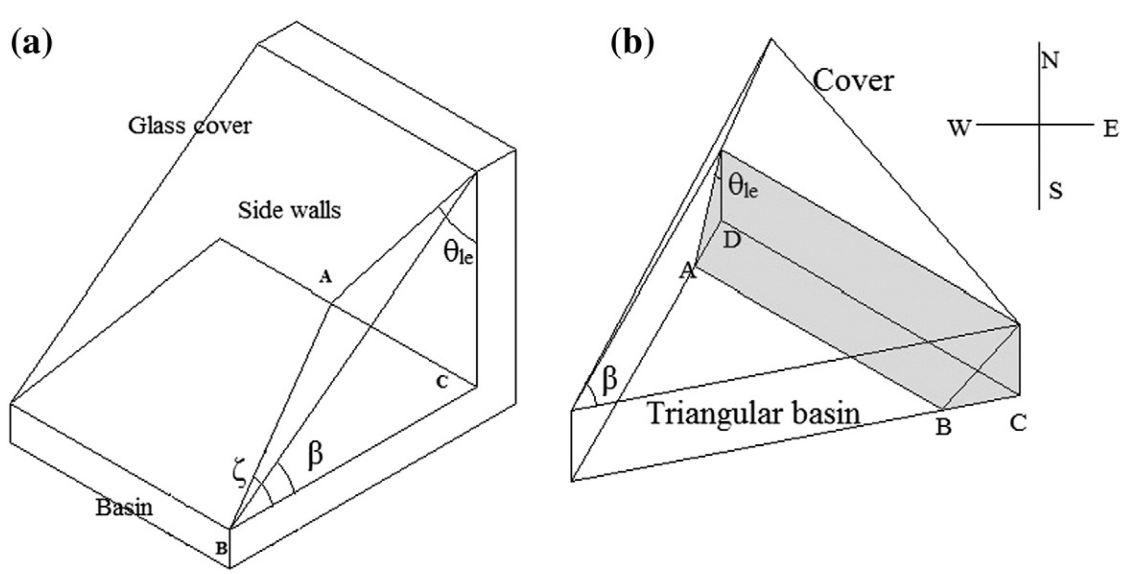

Fig. 1. Shadow effect on (a) Conventional (b) Triangular pyramid solar still.