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EXPERIMENTAL EVALUATION OF A SINGLE-BASIN SOLAR STILL USING DIFFERENT ABSORBING MATERIALS

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ABSTRACT

Single-basin solar stills can be used for water desalination. Probably, they are considered the best solution for water production in remote, arid to semi-arid, small communities, where fresh water is unavailable. However, the amount of distilled water produced per unit area is somewhat low which makes the single-basin solar still unacceptable in some instances. The purpose of this paper is to study the effect of using different absorbing materials in a solar still, and thus enhance the productivity of water. Experimental results show that the productivity of distilled water was enhanced for some materials. For example, using an absorbing black rubber mat increased the daily water productivity by 38%. Using black ink increased it by 45%. Black dye was the best absorbing material used in terms of water productivity. It resulted in an enhancement of about 60%. The still used in the study was a single-basin solar still with double slopes and an effective insolation area of 3 m^2.

KEY WORDS

Solar distillation; single-basin solar still; absorbing materials.

INTRODUCTION

Solar distillation can be used in the production of fresh potable water. Its application is not restricted to remote and arid regions, but also may be used for small communities. According to Howe (1986), at an average of water consumption of about 400 liter / person-per-day, a small community with a total population of 200 can benefit more from solar desalination than transporting water at distances of 16 km or longer with lower costs. For example, a community that is located at about 100 km from a fresh water source can save about 33% in total cost if solar distillation was selected instead of transporting of fresh water. During hot season, solar insolation is high, and water is at its peak rate of consumption. A convenient method widely used is the utilization of solar energy using solar stills.

There are various designs of solar stills (Malik *et al.*, 1982, Tiwari, *et al.*, 1986). Usually they have single-or double-slope solar collectors. In either case, they operate on absorbing solar radiation through transparent cover, usually made of glass, which is then transmitted to water. Production rate of water can vary with design of solar still and location. Many attempts have been made to design and study the performance of the basin-type solar stills (Kamal, 1988, Maalej, 1991, Onyegegbu, 1986, Sharma and Mullick, 1993, Tiwari *et al.*, 1997). Water productivity was a major concern in most studies. Numerous efforts were made in order to enhance the productivity. For example, studies were made on solar stills operating at reduced pressure (Alsaad, 1987, Yeh *et al.*, 1985), others reported enhancement in the performance when air was forced to move inside the solar still (Ali, 1991, Yeh, 1993). Some studies were interested in using black dye as the absorbing material (Dutt *et al.*, 1989, Pandey, 1983, Tamimi, 1987). In this paper the effect of using different absorbing materials was investigated experimentally in a single-basin solar still.

EXPERIMENTAL

The experimental set up used in the study is shown in Fig. 1. It consists of a single-basin solar still with an effective area of 3 m^2, made of stainless steel. A glass cover was placed on a galvanized iron frame, in a tilted angle of 25°. The entire assembly was made air tight with the help of a rubber gasket. 120 L of water was used for each run. Mainly, three types of different materials were considered. These materials were black absorbing rubber mat, black ink-in-water solution, and black dye-in-water solution. They were compared to the condition where solar distillation was carried out when no absorbing material was used with water.

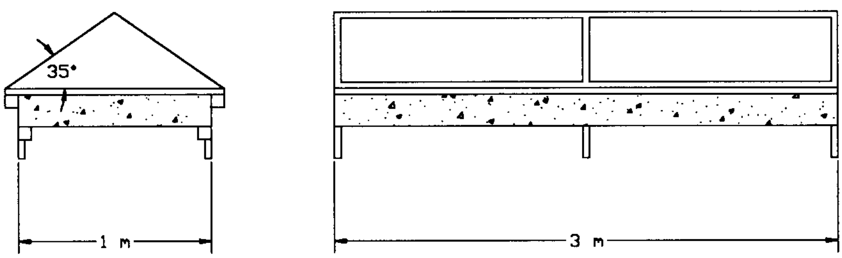

Fig. 1. Schematic diagram of experimental setup

RESULTS AND DISCUSSION

Volumetric production rates are obtained and presented in Fig. 2. It shown that the maximum amount of production rate occurred, for all materials used, at around 2:30 p.m. The production rate was highest when black dye was used. The lowest production rate occurred when water alone was used and there was not any other absorbing material inside the still. This observation was noticeable throughout the day. However, it was clearer during the morning hours than later in the day. This indicates that black dye can absorb solar radiation at higher rates than other materials considered in this study.

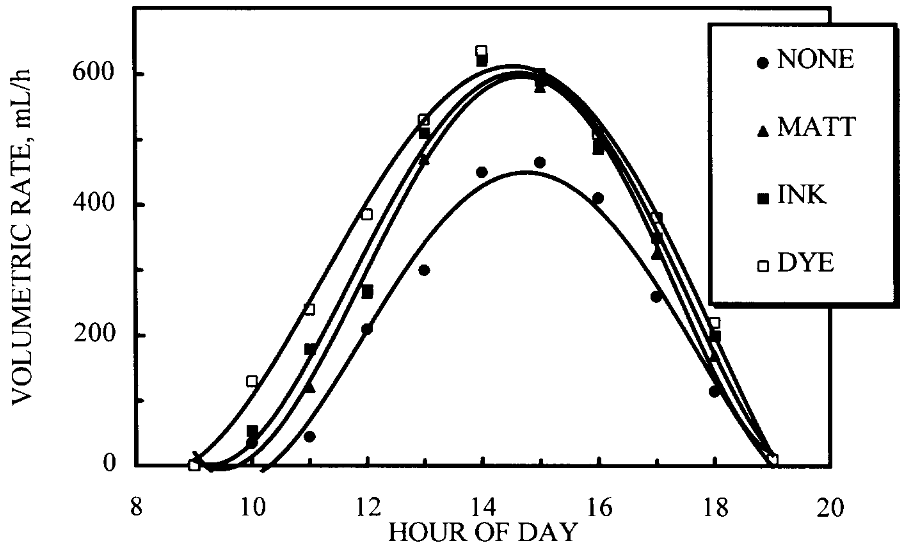

Fig. 2. Water collected as a function of the hour of day

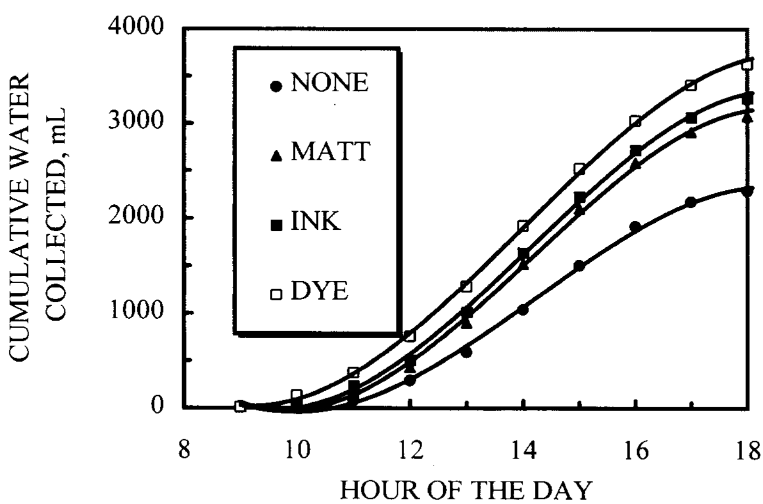

Fig. 3. Hourly cumulative water collected

The cumulative volume of water collected is presented in Fig. 3. As expected from previous observations that black dye showed the highest water productivity when used in the solar still. The water productivity was enhanced by 60% when black dye was used. It based on comparison of cumulative quantity obtained to that when no absorbing material was used. Black ink was also good but not as well, obtaining an enhancement of about 45%. When an absorbing black rubber mat was used, its enhancement was 38%. For future considerations other materials can be used such as shredded metals, activated carbons, salts, and many more. In a recent study by Jamal *et al* (1991), it was found that some salts increase solar energy absorption. For example, $CuSO_4$ and $KMnO_4$ increased the solution temperature when dissolved in water, separately. Mixing the two solutions together would even increase it more.

CONCLUSION

Water productivity in a solar still can be increased with the presence of some absorbing materials such as dyes, ink, and rubber mat. Increasing the productivity of water would reduce the effective insolation area of a solar still, which has been considered a major disadvantage in solar distillation.

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