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Effects of Interfacing and Nanocarbon on the Performance of Basin-type Solar Still

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Abstract. Drinking water is a basic daily need of the community. The existing drinking water sources are often polluted by substances that may be harmful to health. Basin-type solar still is a cheap alternative to convert polluted water into clean water. The problem with basin-type solar still is that the efficiency is low. This study aims to increase the efficiency of basin-type solar still using interfacing and nanoparticles from coconut and bamboo charcoal. This research experiment was conducted in a laboratory using heating lamps to simulate solar energy. The distillation basin has a dimension of 33 cm x 30 cm. The interfacing used is made of wood with an aluminum plate as an absorber. Temperature and water yields sensors are controlled and recorded every 10 seconds using an Arduino microcontroller. The results were compared with a conventional basin-type solar still. The research showed that the yield of distilled water using interfacing and nanoparticles of coconut and bamboo charcoal has increased by 125% and 108% compared to the yield of conventional basin-type solar still. The results of the study can be applied in remote areas where the existing water sources are mostly polluted.

INTRODUCTION

Drinking water is a basic daily need of everyone. Water is an important human need to support daily activities. Without water, people's activities will be disrupted. Dirty water is caused by pollution and harmful substances. Solar still distillation is one solution to overcome the problem of clean water [1]. The water distillation process starts from heating the absorber so that it can heat the water to become steam. This evaporation process can separate water from impurities. The water vapor then condenses and is collected in a reservoir as clean water [2].

The problem that exists in solar energy water distillation is the low efficiency. This study, using basin type solar still where this type has low efficiency. This distillation uses wood and aluminum interfacing and uses nanoparticles from bamboo and coconut charcoal. The addition of nanoparticles aims to increase the heat absorptivity of the basin-type solar still to speed up the evaporation process.

The performance of solar still energy is determined by the amount of clean water produced. Many factors affect the amount of distilled water that can be produced including the effectiveness of the absorber in absorbing solar energy, the effectiveness of the glass in condensing water vapor, the level of water in the distillation, the amount of solar energy that comes, and the amount of water in the tub [3]. The absorber must be made of a material with good absorption of solar energy, for that the absorber is coated with black paint [1]. This study aims to increase the efficiency of basin-type solar still by using wood and aluminum absorber interfacing and the addition of bamboo charcoal and coconut charcoal nanoparticles on the surface of the absorber plate.

METHODS

The research began with the manufacture of basin-type solar still with wood and aluminum interfacing. This experiment was conducted in a laboratory using heating lamps to simulate solar energy. Data collection experimentally using solar energy water distillation equipment, there are several variables that are measured and analyzed. These

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variables are: absorber temperature (TW), glass temperature (TC), ambient temperature (TS), amount of water produced (ml), heat energy (G), and area of distillation apparatus (AC). in detail, the steps of this research experimentally are:

1. Prepare a distillation device, namely a basin-type solar still device (Figure 1 and 2)
2. Prepare the measuring tools used to include temperature sensors, level water sensors, solar meters, Arduino microcontrollers, stopwatches, measuring cups.
3. Adding variations in the amount of nano-particles of bamboo charcoal and coconut charcoal in the amount of 0 grams, 1 gram, and 3 grams.
4. Data is recorded every 10 seconds for 2 hours for each variation tested, the data recorded include: absorber temperature (T_W), glass temperature (T_C), ambient temperature (T_S), amount of water produced (ml), lamp heat energy (G).
5. Repeat steps 3 and 5 according to a predetermined variation.
6. Perform data processing and analysis using equation (1).

Figure 1 is a schematic drawing of a conventional basin-type distillation unit. Figure 2 shows a schematic drawing of a modified type distillation unit with an interface absorber and nanocarbon.

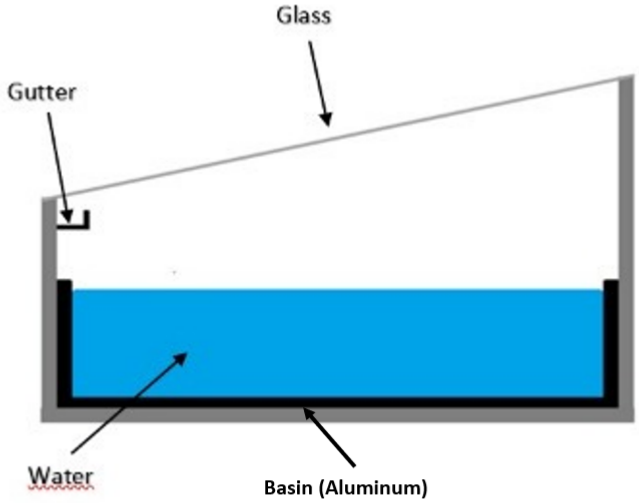

FIGURE 1. Schematic of a conventional basin-type solar still

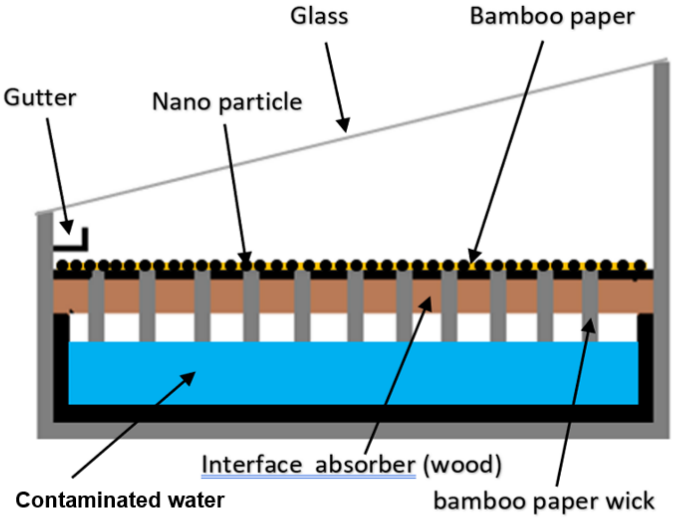

FIGURE 2. Schematic of a basin-type solar still with an absorber and nanoparticle interface

Table 1 shows the specifications of the basin-type solar still unit and its size.

TABLE 1. Design Parameters for the absorber basin-type solar still setup

Parameters	Dimension
Length of absorber	330 mm
Width of absorber	300 mm
Height of absorber	20 mm
Inclination angles	15°
Length of the glass cover	350 mm
Width of the glass cover	320 mm
The thickness of the glass cover	3 mm

Data Retrieval System

Before retrieving the data, the sensor is checked and monitored with the Arduinno Microcontroller. Data were taken on the study included:

1. Cover glass temperature, T_c (°C)
2. Absorber temperature, T_a (°C)
3. Volume of distillation water, m (liter)
4. Length of data retrieval time, t (seconds)
5. Amount of light energy coming, G (watt/m2)

The value of the efficiency of solar energy water distillation can be determined based on the comparison between the energy required for the evaporation process of the distillation unit. The efficiency of the distillation unit (ηL) can be calculated by the following equation with M_{vapor} is the result of distilled water (kg), hfg is the latent heat of vaporization (kJ/kg), Ac is the distillation area (m^2), G is the incoming solar energy (Watt/m^2), dt is heating time (seconds).

$$\eta_L = \frac{M_{vapor} \,.\, h_{fg}}{A_c . G . \Delta T} \tag{1}$$

RESULT AND DISCUSSION

The results of the research can be seen in Figure 3 to Figure 5.

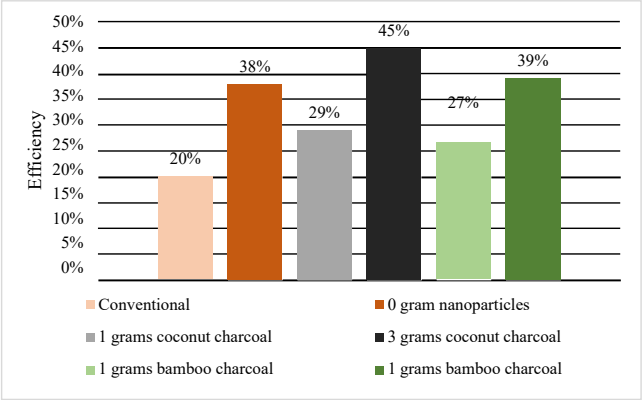

FIGURE 3. Comparison of efficiency using variations of nanoparticles

The highest efficiency obtained used from nanoparticles of bamboo and coconut charcoal is 39% and 45%, respectively. Then followed by the results of distillation without nanoparticles of 38%. The lowest efficiencies were 29% and 27% from nanoparticles of bamboo and coconut charcoal, respectively. A good evaporation process balanced with good condensation can increase efficiency [4]. The condensation process is influenced by the difference between the absorber position and the glass temperature. In the variation of 3 grams of nanoparticles, the average temperature difference is 24℃ and the variation of 1 gram of nanoparticles is 17℃.

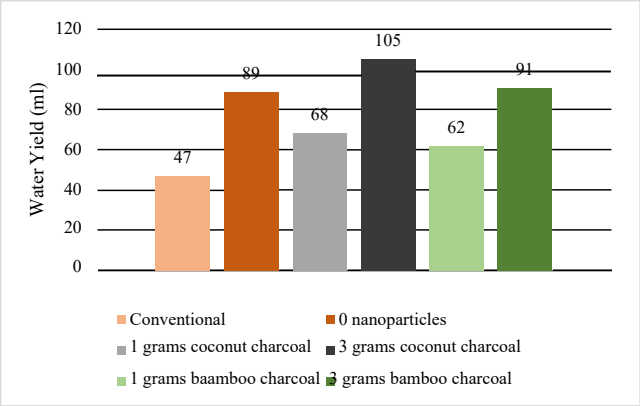

FIGURE 4. Comparison of the results of distilled water using variations of nanoparticles

The highest produce is 91 ml and 105 ml from 3 grams nanoparticles bamboo charcoal and coconut charcoal. This is because the black concentration on the absorber can increase the heat absorptivity so that the evaporation rate is faster than the other variation [5]. The use of nanoparticles of 1 gram was not effective enough in increasing the heat absorptivity and inhibiting the capillarity of water in the tissue.

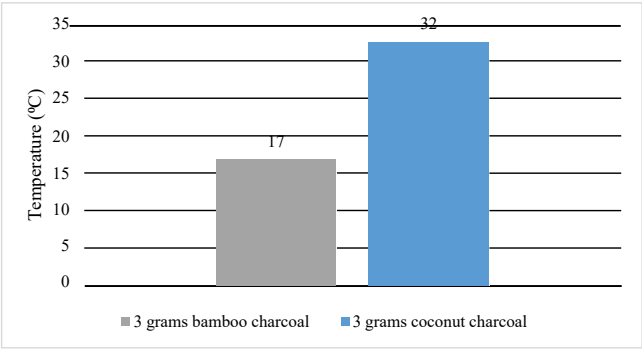

FIGURE 5. Comparison of ΔT

Absorber temperature higher than the glass temperature will help increase the evaporation rate [6]. However, the very low glass temperature indicates that no dew has formed, so the efficiency and yield of the distillation apparatus are low. In this study, the value of ΔT of 4 variations of 0 gram nanoparticles, coconut charcoal nanoparticles 1 gram and 3 grams, and 1 gram bamboo charcoal are relatively the same. However, ΔT the results from the use of 3 grams of bamboo charcoal occupy the highest position, but the distilled water obtained is 91 ml lower than the use of 3 grams of coconut which is 105 ml.

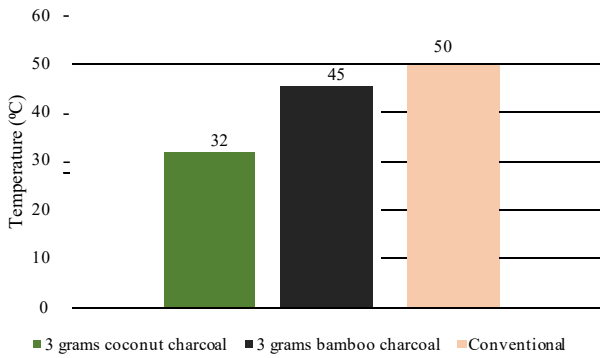

FIGURE 6. Large comparison of water temperature

Conventional basin-type solar still water temperature is relatively high because radiant heat is directly received by all water in the tub. Effect on the evaporation process is very long and low efficiency because it requires a lot of heat energy to carry out the evaporation process. Not like the use of absorber interfacing, which only holds a small amount of water in the absorber so that it can maximize the available heat for the evaporation process.

CONCLUSION

Based on the results of research that has been carried out regarding the effect of adding nano carbon concentration on the performance of basin-type solar still, obtained (1) the use of an interfacing absorber causes not all water in the basin to receive heat, so heat is more effective in evaporating water on the surface of the absorber, (2) efficiency increases by using an interfacing absorber with additional nanoparticles, (3) the use of nanoparticlesis quite effective in increasing the efficiency of solar energy water distillation equipment. Coconut charcoal nanoparticles are the best choice than bamboo charcoal nanoparticles with the same carbon content, and (4) the difference intemperature of absorber and glass cover affects the increase in efficiency in the distillation unit. However, a high-temperature difference does not always produce high distilled water.

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