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Abstract. The purpose of this study was to select the most suitable material to be used as solar still material. Materials compared in this study were plastic and stainless-steel because of their resistance to corrosion. The tested material was utilized as a container to accommodate sea water to be evaporated. The experiment carried out in Jakarta, Indonesia. Material temperature profile similar with the ambient temperature profile. When the sun is shining brightly, the material temperature is higher than the ambient temperature but in the afternoon and night the material temperature falls to ambient temperature. Therefore, it can be said that plastic and stainless-steel materials do not store heat. As a material for solar still, stainless-steel has higher evaporation rate than plastic, which is 7.66 ml/h for stainless-steel and 7.09 ml/h for plastics. So, based on this research, it can be concluded that stainless-steel is better to be used as a solar still material.

1. Introduction

Water is the decisive material in life. Humans, plants, and most animals will not survive without water. Along with the growing population in the world, water consumption is increasing. The addition of human population as much as 15% will reduce the water source and increase the water shortage by 40% [1], while the amount of fresh water on the earth surface, only available 2.8% and the rest is sea water [2]. Therefore, sea water is a potential source of water.

Because of its enormous potential, various methods and research have been done to convert sea water into fresh water. Distillation is one of the most widely used methods. Evaporation processes that occur slowly make the contaminants left behind, so that the resulting water becomes pure. The distillation process becomes cheaper by utilizing solar energy, although the production is not high. The direct heating method with solar heat is the most suitable way to produce fresh water up to 200 m^3/day [3].

The process of distillation by solar heating is generally done by using solar still. Various methods and materials are used to improve the performance of solar still. It seems that evaporation rate affected by its solar still. The use of Portland cement black-blackened, as heat storage, increase freshwater production by 39% [4]. Concave-shaped solar stills are used to increase evaporation by [5]. The perforated aluminum is mounted on the water's surface on the solar still to increase evaporation [6]. The use of plastics for easy cleaning of salt deposits is done by [7]. The tilted-wick was placed on the surface of the solar still spreading water to the entire surface of the wick through capillary fibers. So, the temperature becomes higher in the thin layer [8]. Five trays made of aluminum and stainless steel AISI 304 (polished, chrome plated, and non-polished) were tested to study its performance as a function of different tray materials. The result showed that the aluminum tray had the highest desalinated water production, while the polished steel tray had the lowest production [9].

The performance of a solar still is proportional to distillate output and indicated by the internal heat transfer coefficient. There are three parameters based on internal heat transfer coefficients: convective heat transfer coefficient, radiative heat transfer coefficient and evaporative heat transfer coefficient [10]. The material that holds sea water also receives heat from solar energy. Some of the heat in material flows into the water and some loss to ambient. Beside that some material able to store heat and release it when the heat source is not available. Then the material becomes a contributing factor in the evaporation of sea water.

Sea water is a very corrosive substance, the material used in desalination process must be corrosive resistance material. So, it is necessary to conduct research to do experiment with material which has beneficial effect on evaporation rate, but corrosion resistance. Nevertheless, still no related research has examined the effect of material on evaporation of seawater in solar-still. Then, this research examines the plastic and stainless steel container material to evaporate the sea water and their heat storage ability is compared.

2. Material and methods

The experiment uses a pan made of plastic and stainless steel (SUS 316). The pan of plastics and stainless-steel has same shape and size. Five pieces pan for each type of material, filled with 250 ml sea water which taken from Ujung Kulon, Indonesia.

3. Results and discussion

In figure 1, it shows that the material and water temperature have the same profile as the ambient temperature. When the temperature is about 31° – 33°C, temperature of material is almost equal to the ambient temperature but in higher temperatures, temperature ambient about 37°C, the temperature of materials rises above the ambient temperature. Plastic has the highest temperatures because the slow propagation and release of heat. Plastic is non-metallic materials that do not have free electrons. Therefore, the heat distribution occurs with lattice vibration [11] so the heat distribution becomes slow and the thermal conductivity becomes low. The slow distribution of heat from the plastic surface causes heat accumulation and the heat become higher than stainless steel. Even though temperature of plastic is higher than stainless steel, the temperature of water inside the stainless-steel pan is higher than the water inside plastic pan.

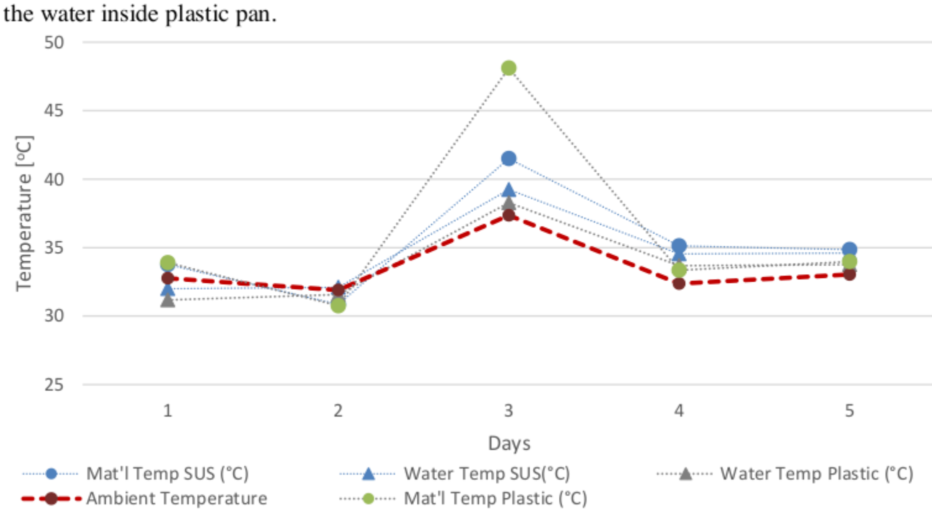

Figure 1. Temperature profile of material, water and ambient temperature during the experiment.

As the result, evaporation of seawater inside the plastic pan is lower than stainless steel pan, as shown in figure 2. In figure 2, the evaporation of sea water in plastic pan is 28.36 ml and stainless-steel pan is 35.22 ml. The conductivity of the stainless steel (16.95 W/m°C) is higher than plastics (0.15 W/m°C). This result along with the result of [12] that the heat transfer increases with decrease in thickness and increase in thermal conductivity and thermal conductivity of the material has a significant effect on the convective heat transfer coefficient [13]. The heat from solar radiation is absorbed and accumulated by the material. Some of the heat of material flows into water and some of it flows to the ambient. Heat in the water, which come from material and sun radiation, balance with evaporation energy [14]. Since the heat propagation in stainless-steel is better than plastic, heat in stainless-steel flows into water and elevate the evaporation. Furthermore, thermal conductivity of material plays important role in evaporation.

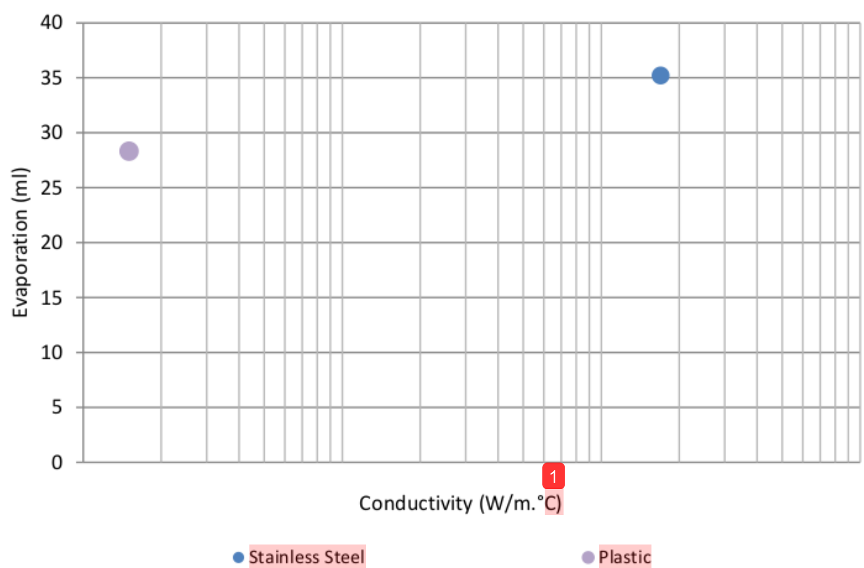

Figure 2. Effect of container material conductivity to evaporation.

In figure 3, as previously stated, the material temperature is higher than the ambient temperature in bright sunlight. In the afternoon, after 15:00, the material temperature falls below the ambient temperature. As the sun sets and the ambient temperature drops to 27°C, the temperature of stainless-steel and plastic, starts from 31°C, follow drops to about 27°C. When the ambient temperature is lower than material, heat flows from material to ambient. So that the material temperature drops to about ambient temperature. This proves that these materials do not have the ability to store heat. Nevertheless, through in the very small gap, temperature of stainless-steel is lower than temperature of plastic. Since conductivity of stainless steel is higher than plastics so the heat in stainless-steel release faster.

Figure 4 shows evaporation and evaporation rate in extended time. Horizontal axes show duration of evaporation. For example, 11-14 means that the time starts is at 11.00 AM and stop at 14.00 (2 PM). Evaporation is checked at 14.00 (2 PM). Evaporation of sea water in material stainless-steel and plastic in extended time shows that the evaporation in stainless steel is higher than in plastic. Even though evaporation increase as the time increase, evaporation rate decrease. Interestingly, rate of evaporation in plastic material decrease slower than evaporation rate of stainless-steel, though still lower.

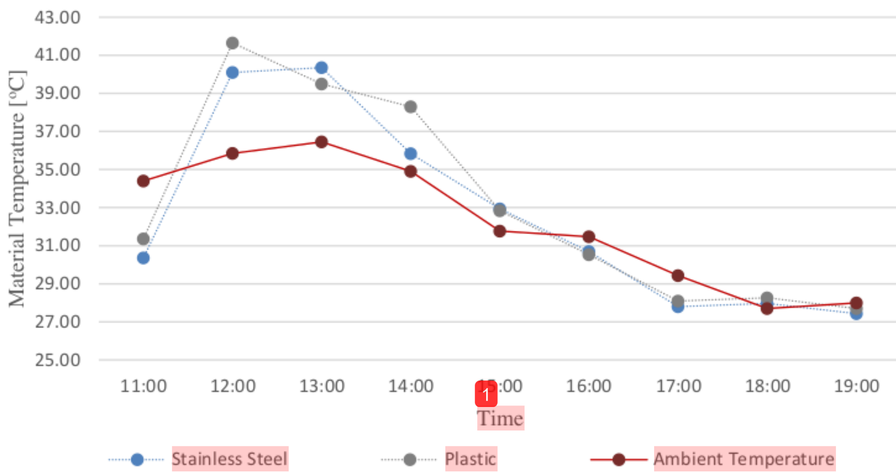

Figure 3. Ability of material to store the heat.

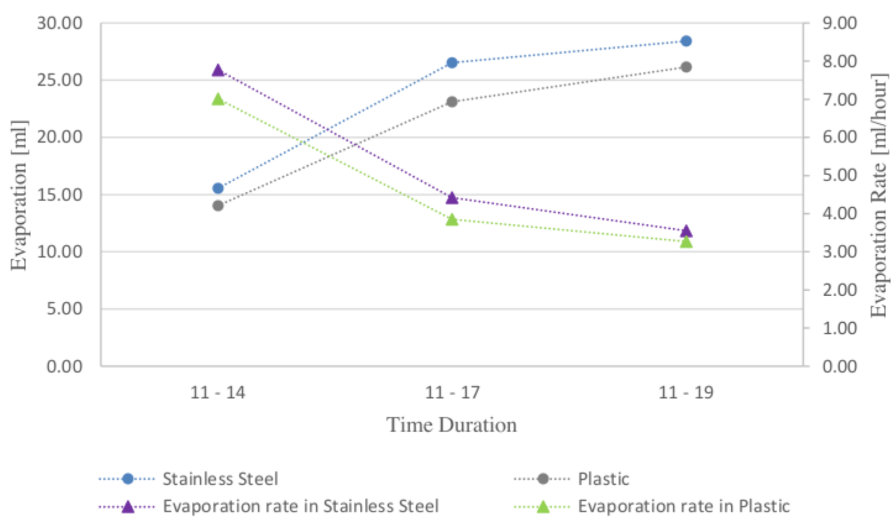

Figure 4. Evaporation and evaporation rate for extended time.

4. Conclusion

The experiment results show that the material affected the temperature of the water inside. Temperature of plastic is higher than the stainless steel but water temperature inside is lower. The temperature gap between water and its container affected by the conductivity of material. In the afternoon and night, the material temperature falls close to ambient temperature since the heat in materials flows into ambient. Therefore, it can be said that plastic and stainless-steel materials do not store heat. As a material for solar still, stainless-steel has higher evaporation rate than plastic, which is

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7.66 ml/h for stainless-steel and 7.09 ml/h for plastics. It can be concluded that stainless-steel is better to be used as a solar still material than plastic, since ability of plastics to store heat can be neglected.

References

[1] Schewe J, Heinke J, Gerten D, Haddeland I and Arnell N W 2014 Multimodel assessment of water scarcity under climate change *Proceedings of the National Academy of Sciences of the United States of America* vol 111 no 9 pp 3245-50
[2] Belessiotis V, Kalogirou S and Delyannis E 2016 *Thermal solar desalinisation - methods and systems, 1st ed*. Academic Press Elsevier
[3] García-Rodríguez L 2002 Seawater desalination driven by renewable energies: a review *Desalination* vol 143 issue 2 pp 103-113
[4] Sellami M H, Guemari S, Touahir R and Loudiyi K 2016 Solar distillation using a blackened mixture of Portland cement and alluvial sand as a heat storage medium *Desalination* vol 394 pp 155–61
[5] Kabeel A E 2008 Performance of solar still with a wick concave evaporation surface *Twelfth Int. Water Technol. Conference, IWTC12 2008* Alexandria, Egypt pp 1137–46
[6] Valsaraj P 2002 An experimental study on solar distillation in a single slope basin still by surface heating the water mass *Renew. Energy* vol 25 issue 4 pp 607–12
[7] Tarawneh M S K 2007 Effect of water depth on the performance evaluation of solar still *Jordan Journal of Mechanical and Industrial Engineering (JJMIE)* vol 1 no 1 pp 23–29
[8] Al-Karaghouli A, Renne D and Kazmerski L L 2009 Solar and wind opportunities for water desalination in the Arab regions *Renew. Sustain. Energy Rev.* vol 13 issue 9 pp 2397–407
[9] Da Silva M E V, Schwarzer K, Pinheiro F N, Rocha P A C and De Andrade C F 2015 Experimental study of tray materials in a thermal desalination tower with controlled heat source *Desalination* vol 374 pp 38–46
[10] Panchal H N and Shah P K 2011 Modelling and verification of single slope solar still using ANSYS-CFX *Int. J. Energy & Environ.* vol 2 issue 6 pp 985–98
[11] Hahn D W and Özişik M N 2012 *Heat conduction*, 3rd ed. (John Wiley & Sons, Inc.)
[12] Aboul-Enein S, El-Sebaii A A and El-Bialy E 1998 Investigation of a single-basin solar still with deep basins *Renew. Energy* vol 14 issue 1–4 pp 299–305
[13] Tiwari A K and Tiwari G N 2005 Effect of the condensing cover's slope on internal heat and mass transfer in distillation: an indoor simulation *Desalination* vol 180 issue 1-3 pp 73–88
[14] Qiblawey H M and Banat F 2008 Solar thermal desalination technologies *Desalination* vol 220 issue 1–3 pp 633–44

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