Effect of Material ConductivityThermalto Sea Water Evaporation in Solar Desalination

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Abstract - Sea desalination technology with solar energy is very suitable to be utilized in Indonesia to produce fresh water with low production costs. In order to speed up the evaporation process, a suitable material is needed to be used as a seawater pan. Therefore, the purpose of this study is to determine the appropriate material to be used as a place of sea water. This research uses trapezium bowl with aluminium, copper, rubber, and glass material with surface area of 31.5 cm^2 and 250 ml of water. Data collection from 10:00 am until 14:00 pm for five days. Environmental, material, and water temperatures are measured hourly. In high material conductivity such as copper (319.25 W/m.°C) and aluminium (16.95 W/m°C), the evaporation was 33.96 and 30.48 ml. While rubber (0.13 W/m°C) and glass (0.15 W/m°C) which had lower conductivity, also have lower evaporation, that was 27,68 and 27,83 ml. Thus, in desalination process by using solar heat, conductivity of container material affected the amount of water that evaporates. The higher the thermal conductivity value of the material then the volume of evaporated water would also be greater.

Keywords: keywords desalination, evaporation, sea, water, solar

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%(Schewe et al. 2014), while the amount of fresh water on the surface of the earth, only available 2.8%, the rest is sea water(Belessiotis, Kalogirou, and Delyannis 2016). 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 m3/day(Garcia-Rodriguez 2002).

The material that holds sea water also receives heat coming from solar energy.Thus, many researchers run experiments to see the effect of material. Comparison betweenglass-coated solar stills as heat storage and regular solar still to see the effectiveness of material was run by Zeinab S. Abdel-Rehim and A. Lasheen(Abdel-Rehim and Lasheen 2005). The use of Portland cement black-blackened, as heat storage, increases freshwater production by 39% (Sellami et al. 2016).To examine effect of shape of the solar still, A.E. Kabeelcompare concave-shaped solar stills are used to increase evaporation (Kabeel 2008). The perforated Aluminium is mounted on the water's surface on the solar still to increase evaporation (Valsaraj 2002). The use of plastics for easy cleaning of salt deposits is done by Muafag Suleiman K (Tarawneh 2007). Dan Mugisidi et al, used copper, stainless steel, plastic, and rubber to examine effect of material to the sea water evaporation rate (Mugisidi et al. 2017). The heat will flow and be transferred to water and to the ambient. The conductivity of the material affects the heat transfer occurring in the material or the transfer of heat to the water so that the conductivity becomes a contributing factor in the evaporation of sea water. Therefore, this study was conducted to determine the effect of thermal conductivity of aluminium, copper, rubber, and glasson sea water evaporation.

2. Material and Methods

The experiment was conducted in University of Muhamadiyah Prof Dr HAMKA, Jakarta. 250 ml of sea water, which was taken from Ancol seashore, was filled into container, which was made from aluminium, copper, rubber, and glass. Shape and size of the container was the same. Evaporation measured from initial volume of water, 250 ml, subtracted by remaining volume. Data collection was taken from 10.00 am to 14.00 am for five consecutive days. Each material consists of five containers.Material, water, and ambient temperature were measured hourly.

3. Resuls and Discussions

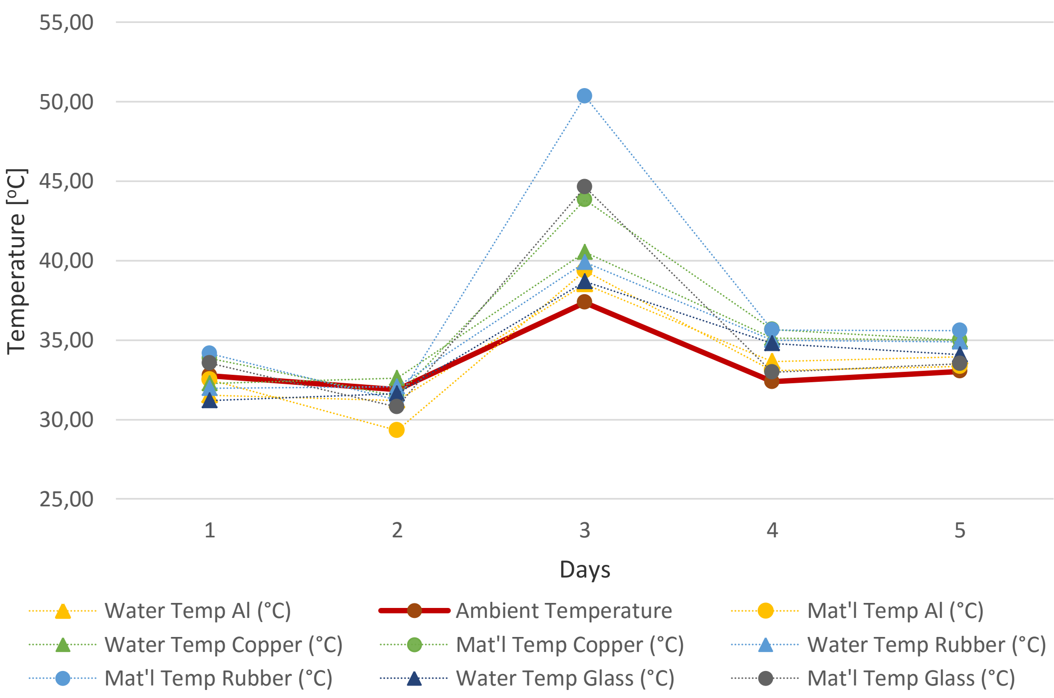

Fig.1. The Result of Temperature of Material, Water, and Ambient

The sea water was filled into container which was made from conductor and isolator material.The conductor was aluminium and copper, the isolator was rubber and glass. Twenty containers were exposed to the solar for four hours. The result of temperatur of material, water, and ambient showed in fig. 1.

In figure 1, it appears that the average temperature not same in every single day. The highest temperature was captured in third day because the day was clear. The ambient temperature was about 37oC and the water and material temperature were higher. Interestingly, when the ambient temperature was about 33oC, material and water temperature were not far from the ambient. But, when temperature was higher than 35oC, all material temperature was elevated. The highest was temperature of rubber then followed by temperature of glass, copper and lastly aluminium. One can see that the temperature different between conductor material and water inside were about 1 up to 2oC. Different things happened on rubber and glass. Temperature gap between glass and water inside was about 8oC. Bigger gap happened on rubber. The temperature different between rubber and water contained was 10oC. Even tough the rubber temperature was 50oC, water temperature was only 39.9oC. It was obvious that the heat from solar was retained on the surface of rubber.As illustrated in fig 2, solar heat up water and container. The sun heats the bowl and the water in it. The heat on the surface of the material will flow to all parts of the material and flow into the water and wasted to ambient. The heat that accumulated in the water was released by evaporation.

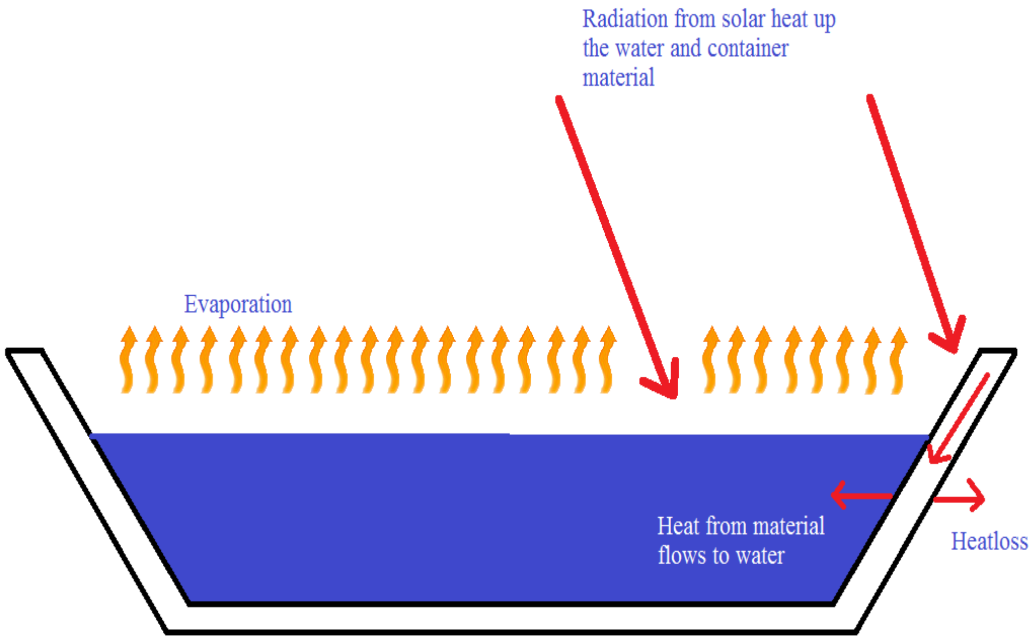

Fig. 2. Ilustration of heat flows from solar to material and water.

The elevated temperatures present in materials with low conductivity such as rubber, was caused by slow propagation of heat. Rubber was non-metalic materials that did not had free electrons. Therefore, the heat distribution occurs with lattice vibration (Hahn and M. Necati Ozosik 2012) so that the heat distribution becomes slow and the thermal conductivity becomes low. The slow flow of heat in the material caused a temperature difference between rubber and water. It happened also on the glass. The water in the glass bowl has a temperature difference with the container because the glass also has a low thermal conductivity.Different situations occured in copper and Aluminium. The difference of heat between copper and Aluminiumwithwater in it was only 1-2 degrees celcius. It happened because the heat from the sun flow quickly into the water and the environment.

The heat flow from the container material to water affects the evaporation that occurs as shown in Fig. 3

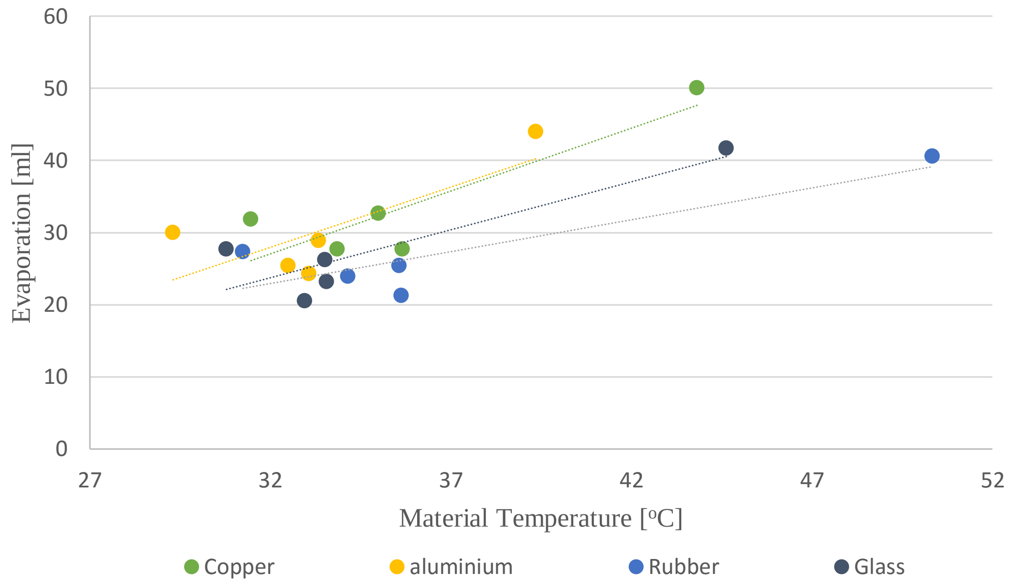

Fig.3. Effect of material temperature on water evaporation

In Fig. 3, it appeared that material temperature was not affected volume of evaporation. Rubber, even though the material temperature higher than other material, 50°C, its evaporation was lowest, only 40 *ml*. As explained before, material temperature of rubber and glass were retained on the surface and flowed slowly to other part of material and lastly to water. Thus, the heat contribution of the nonconductive materialwasnotvery influential in the evaporation processes.

Table 1. Thermal conductivity of container material

Container Material	Thermal Conductivity (W/m.°C)
Rubber	0.13
Glass	0.15
Aluminium	16.95
Copper	319.25

In contrast with rubber and glass,copper and Aluminium which were the material of the conductor, the material temperature was below the temperature of the non-conducting material but the evaporation was higher. Since the heat from solar that heat up Aluminium and copper flowed to water through material, evaporation heat of water in Aluminium and copper were higher than rubber and glass. Thus, it was obvious that the conductivity thermal of material plays significant role in evaporation process.

Evaporation process of water inside the container was affected by thermal conductivity material of container. In Table1.,thermal conductivity of rubber was 0.13 *W/m°C*, glass was 0.15 *W/m°C*, Aluminium was 16.95 *W/m°C* and copper was 319.25 *W/m°C*. Relationship between thermal conductivity of container with water evaporation could be seen in Fig. 4.

In Fig. 4, it appeared that evaporation increased as the conductivity increased. This result showed that volume of evaporation strongly influenced thermal conductivity of the container.

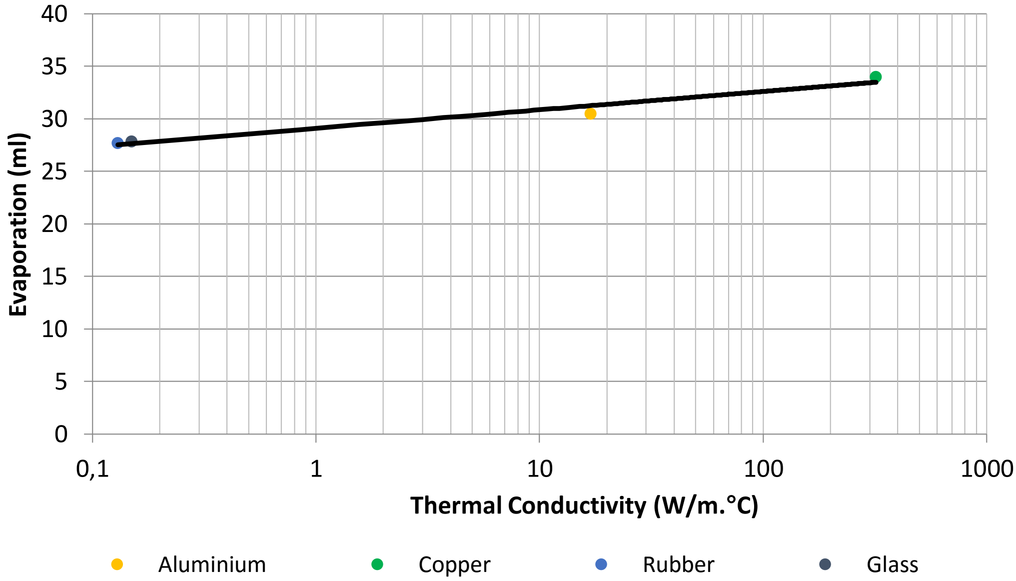

Fig.4. Effect of conductivity thermal material on water evaporation

4. Conclusion

The experimental results show that the thermal conductivity of the container material affects the evaporation of the seawater contained therein. In high material conductivity such as copper(319.25*W/m.°C*) and aluminium (16.95 *W/m°C*), the evaporation was 33.96 and 30.48 ml. While rubber (0.13 *W/m°C*) and glass (0.15 *W/m°C*)which had lower conductivity, also have lower evaporation, that was 27,68 and 27,83 *ml*. Thus, in desalination process by using solar heat, conductivity of container material affected the amount of water that evaporates. The higher the thermal conductivity value of the material then the volume of evaporated water would also be greater.

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