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Temperature stabilization based on passive cooling technology in the initial design of an eco-friendly mini greenhouse

Zulkarnain[1,2], Nurfi Hikma[1,*], Ramy Fitrah Izzah[3], Nandita Devira[1]
[1]Department of Physics, Universitas Riau, Pekanbaru 28293, Indonesia
[2]Department of Physics, Universitas Indonesia, Depok 16424, Indonesia
[3]Department of Physics, Institut Teknologi Bandung, Bandung 40132, Indonesia

ABSTRACT

Greenhouses become one of the buildings where the cultivation of plants. The concept of environmentally friendly greenhouses is included in the current model of urban agriculture. The design of the greenhouse building concept is environmentally friendly by utilizing passive cooling technology. Passive cooling technology is used in this design to balance the temperature and humidity of the greenhouse through natural energy flow. The purpose of the research and design of this building is to investigate the temperature differences inside and outside the greenhouse space. The results of this study know that passive cooling with and without water greatly affects the temperature in the room. Passive cooling without water will produce hot temperatures in the room compared to passive cooling using water.

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* **Corresponding Author**
E-mail address: nurfihikma9998@gmail.com

1. INTRODUCTION

The trend of cultivation in greenhouses has become a model for today's urban agriculture. Greenhouse design should carry the concept of environmentally friendly buildings (green buildings) so that they can be sustainable [1-4]. So the construction must be planned carefully. Greenhouses are usually covered on all sides of the building with transparent covers to get enough sunlight. Sunlight functions to emit light to plants to help plants carry out the photosynthesis process. Without sufficient sunlight, plants will not grow well [5-10].

The roof receives radiation and convection from the sun. Then the roof releases heat by radiation and convection into the room. This is what causes the high temperature in the room. Houses generally use ceilings to overcome this problem. So the air in the house is cooler [11-14]. To reduce the high air temperature inside the greenhouse, passive cooling is needed. Passive cooling is a design that focuses on managing heat gain and heat release [15-19]. The passive cooling that will be designed is passive cooling using water and without water. Water is placed on the roof of the building above the container that has been prepared. The final goal of this research is to develop an environmentally friendly greenhouse with passive cooling technology [11, 20-23]. Investigating temperature differences inside and outside the greenhouse is very important. This research was conducted as a form of lab-scale greenhouse. As a first step, the walls are made of styrofoam and the roof is made of transparent acrylic. This transparent roof aims to allow sunlight to penetrate into the room. Therefore, this study will investigate changes in room temperature in a miniature greenhouse.

2. RESEARCH METHODS

Related research was carried out at the Plasma and Photonics Laboratory, FMIPA, Riau University for 2 weeks. The equipment and materials used in this research include acrylic, styrofoam, pipes, hot glue, Inaco jelly cups, sandpaper, lamp pitting, plugs, cables, saw blades, lights, plugs, aquarium machines, and thermometers. The research procedure consists of 4 stages. The first stage is the building design stage, the building is designed in 3D Drawing computer software where the building image can be seen in 3 dimensions. The building design is shown in Figure 1.

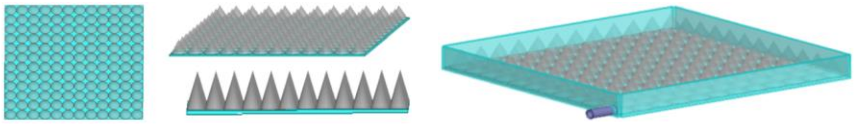

Figure 1. Building roof design.

The second stage is the preparation stage for the tools and materials that will be used to construct the building in this research. In the next stage of building construction, the first step is to make a rectangular box from styrofoam with a width of 50 cm and a height of 50 cm, and a hole is made in one side as a place to see the temperature on the thermometer. The second step is to cut the acrylic with a length and width of 50 cm and make 4 parts to be attached to the top of the previous acrylic with a height of 5 cm. This functions as the top of the building to be created. Next, attach the top of the Inaco jelly cup to the acrylic that has been made using devil's glue and wait until it dries. Fourth step: Make a thermometer support to measure the outside temperature/environmental temperature. The support is made of 2 left and right pipes and the top is connected to another pipe. Make an inner support by attaching a cable from the top of the styrofoam to the left and right which functions as a place to place the inner thermometer to measure the temperature in the room.

After completing the building construction stage, the final stage is the testing stage of the building system by measuring the temperature using a thermometer, where the thermometer is placed inside a box with a hole in it. After that, water flows to the top of the box which flows from the tank through a pipe using a small pump. After a few minutes after the water is supplied, the temperature is checked on the thermometer that was placed in the box previously. The target temperature in this building is 25°C, which is a good temperature for the growth of plants that usually grow in the highlands, such as strawberries.

3. RESULTS AND DISCUSSIONS

Research on greenhouses with passive cooling technology that has been carried out shows significant results between indoor temperatures and outdoor temperatures. Apart from that, water placed on the roof of a building in the form of an acrylic container filled with water without water also influences what happens. This is caused by the presence of an intermediary/barrier when the covering wall receives heat from solar radiation using an acrylic container with and without water. The aim of this research is to test whether passive cooling can inhibit the rate of heat received by the roof from entering the building space, causing the indoor temperature to be lower than the outdoor temperature/environmental temperature.

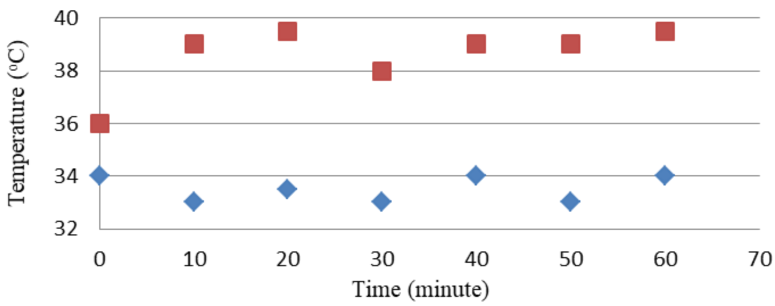

Figure 2. The blue is ambient temperature and the red is room temperature (temperature changes without water).

Figure 2 shows the temperature in a building with passive cooling without water, where the longer the observation time, the room temperature will increase even though the environmental temperature drops at one time. Likewise, Figure 3 also shows the same result, namely that the temperature will increase with the length of observation time. The temperature will also rise, although with slight changes. The difference between the two lies in the difference in outdoor and indoor temperatures. In observations of passive cooling with water, the temperature increase from outside the environment is not too large compared to passive cooling without water. This proves that the water is used as observation material has a great influence on the incoming solar radiation and temperature.

Differences in temperature can also cause air to move. This is because air with a higher temperature has lower air pressure than air with a lower temperature. For example, if the air inside a building is hotter than outside, then the air will escape into high openings. Hot air tends to move upwards. Cooler outside air will enter the building to replace the space left by the hot air. This technique is usually called stack effect ventilation [24].

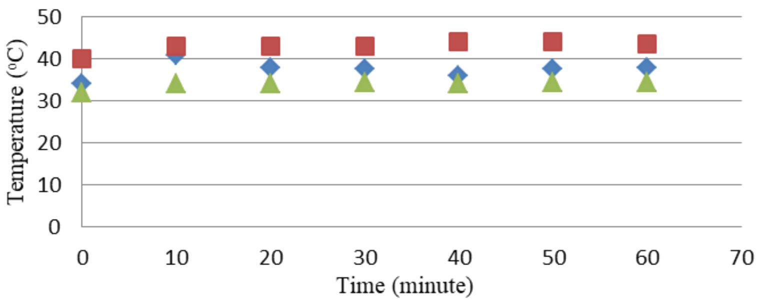

Figure 3. The blue line is time, the red line is environmental temperature, the purple line is water temperature and the green line is room temperature (temperature changes with water).

Another principle with the Bernoulli effect which results in a decrease in pressure when air movement is accelerated (accelerated) to cover a longer distance than the opposite side. Meanwhile, air moving through a smaller volume of space will experience acceleration. This is called the venturi tube effect. Buildings should be able to provide comfortable activity space (including thermal comfort) for humans as users so that they are protected from unfavorable external climates so that activities in the building can run optimally [24, 25]. Air infiltration with a natural ventilation system can be used to increase thermal comfort in spaces within a building.

4. CONCLUSION

The results of this research show that passive cooling with and without water greatly influences the temperature in the room. Passive cooling without water will produce a hotter temperature in the room compared to passive cooling using water. This proves that sunlight entering through the roof of the building is in the form of passive cooling with water and is not completely radiated into the room. Apart from that, without passive cooling with the right model, it will make the room in the greenhouse even hotter. From the results mentioned previously, it can be concluded that passive cooling with water on the roof of the building is an effective step that can be taken to create a cooler temperature. So passive cooling is suitable as it is suitable for installation in greenhouses. Further research is needed that compares the shape and size of the wall covering with the increase in room temperature obtained.

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