MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 5 No. 1 (2024) 155-162
https://publisher.uthm.edu.my/periodicals/index.php/mari

Dual-Functional Rainwater Harvesting System

Muhammad Naufal Zaid, Muhammad Azhar Amdan, Norakhmal Hafiz Norafandi, Nor Baizura Hamid*

Department of Civil Engineering, Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author: norbaizura@uthm.edu.my
DOI: https://doi.org/10.30880/mari.2024.05.01.023

Article Info

Received: 1 September 2023
Accepted: 10 December 2023
Available online: 31 January 2024

Keywords

Rainwater Harvesting System, global Warming, Small-scale, Temperature, Digital Multimeter

Abstract

Water harvesting has become a common practice in modern metropolitan settings. As a result of the paving and building of various metropolitan regions, natural catchment areas have reduced. Not only that, but our country is not immune to the global warming wave, which requires serious consideration. This is demonstrated by the fact that the earth's temperature is rising day by day. The goal of this project is to create innovative, environmentally sustainable building systems. The overall goal of this study is to create a small-scale cooling system that produces direct power from rainwater. Additionally, a digital multimeter is used to test the electrical current generated in this dual-purpose rainwater harvesting system, and an environmental meter was used to test the temperature in the cooling system. This experiment aims to demonstrate that the created model functioned well in the tests carried out. The average reading voltage test findings for the first, second, and third readings are 0.020 volts, 0.122 volts, and 0.133 volts, respectively. According to the turbine test results, that is the voltage value, the third reading value is greater than the first and second readings. Based on temperature tests, the average temperatures before and after 10 am were 31.5 °C and 30.5 °C, respectively. But at noon, the temperature was 34.6 °C and 33.0 °C; the value was decreasing. The average value at 2 pm before was 32.3 °C and 31.3 °C after the system was applied. This temperature value is obtained by using an environmental meter that shows the temperature difference between before and after. The reading value for before and after 12 pm shows a higher temperature difference value of 1.6 °C compared to the difference for 10 pm and 2 pm, which is 1.0 °C.

1. Introduction

Malaysia is a country located in an equatorial climate that is hot and humid all year round. This is because the position of Malaysia is located between lines 0 to 10 on the equator. Malaysia is a country located in an equatorial climate which is hot and humid all year round. This is because Malaysia's position is located between the lines 0 to 10 on the equator [1]. Without us realizing it, the economic progress we get from day to day has many benefits and disadvantages for the environment. One of the most significant consequences is global warming. Global warming occurs due to the natural rotation of the sun which changes the intensity of sunlight and moves closer to the earth. Another cause of global warming is greenhouse gases. Greenhouse gases are carbon monoxide and sulfur dioxide that trap solar heat radiation and prevent it from escaping from the surface earth [2]. This occurs because of human activities like open burning and the usage of petrol that contains lead raising the earth's temperature [3].

This study aims to produce a small-scale rainwater harvest model. The rainwater that falls will be collected for the use of this system and help in the sustainability of nature. According to Er and Catherine, the scope of environmental management needs to be expanded to include all available resources to preserve current and future generations. It shows that cooperation needs to be done by various parties in playing a role to make this mission of preservation and conservation a success [4].

The rainwater harvesting concept developed is using a hydroelectric system. the use of turbines helps to flow electricity. According to Osman Affandi, the flow of water pushes the turbine (just like the wind will turn the windmill) which turns the turbine and the shaft. The shaft is part of the electrical generator components and its movement acts as a motor that generates power [5].

The development of home cooling systems has undergone significant advancements over the years, providing increased comfort and convenience to households worldwide. Initially, traditional methods such as natural ventilation and shade were utilized to combat heat. However, with the advent of technology, the concept of mechanical cooling systems emerged, revolutionizing the way we control indoor temperatures [6].

In general, the goal of this study is to create an environment-friendly rainwater harvesting system that is used as a roof cooler and can directly generate small-scale electricity supply. The objective of this study is to produce a rainwater harvesting system and natural electricity generation. The findings from tests demonstrate that the system developed is functioning.

2. Method

The methodology of this study shows the flow of work required to meet the study's objectives. It had been carried out in accordance with the flowchart shown in Fig. 1.

2.1 Materials

The materials used in this study for the dual-functional rainwater harvesting system are turbines and connecting wires, water storage tanks and filter nets, water pumps, and water sprinklers. The turbine used is a crossflow type with 12 V DC output, which can be directly used as an Arduino power supply. The maximum output current is up to 150 mA, which is sufficient for most light applications. In this experiment, a 40 V water pump was used to pump water up to the roof as far as 2.2 meters. Fig. 2 shows the development process for the rainwater harvesting system model. The model was then evaluated for the model's roof before and after water spraying, as well as the turbine's performance in flowing voltage current.

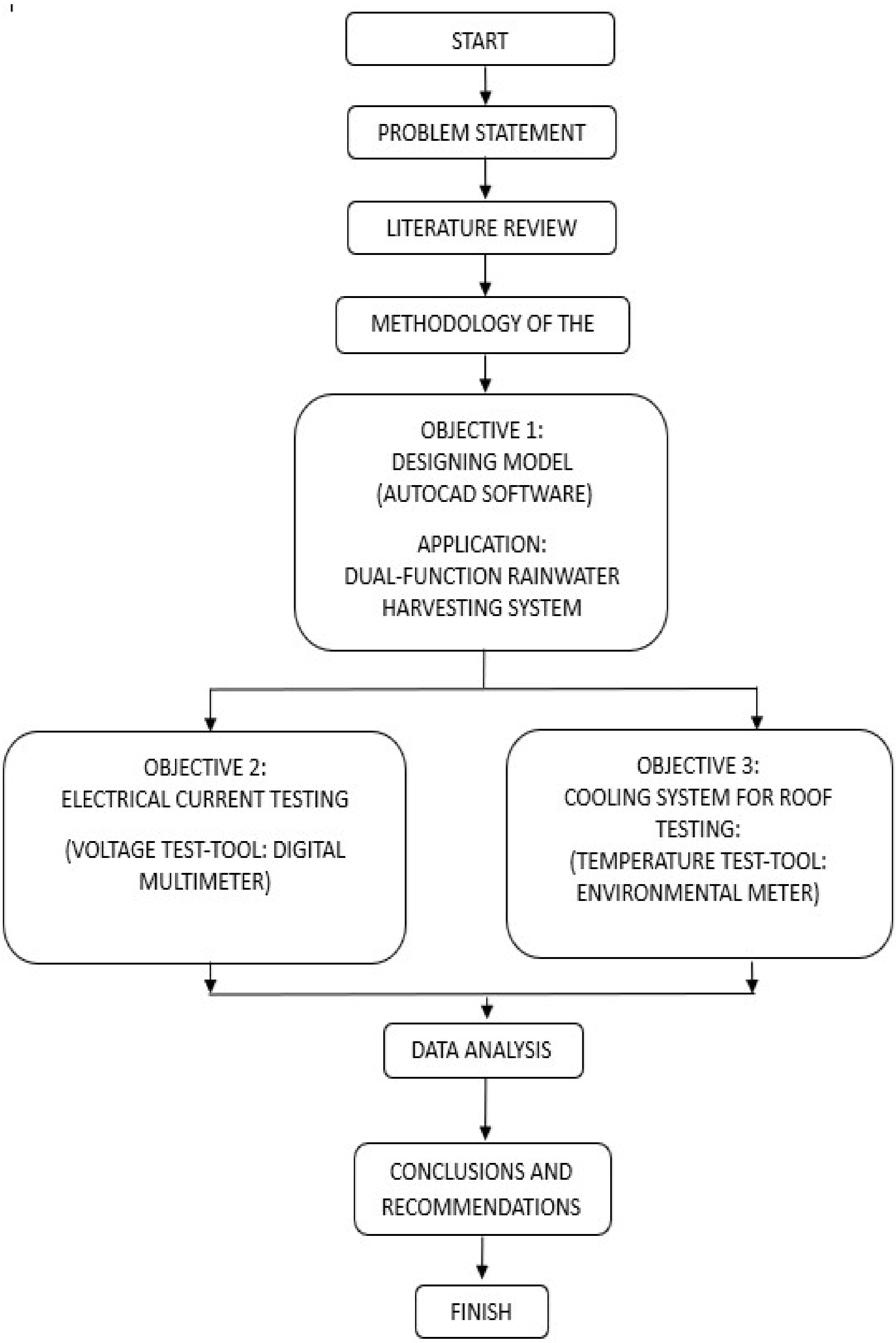


Fig. 1 Flowchart of the study

Fig. 2 Process of Development for the Rainwater Harvesting System Model

2.2 Methods

2.2.1 Design of Dual-Functional Rainwater Harvesting System

The design concept for the system of models is depicted in Fig. 3. This model was designed using engineering software, which is AutoCAD 2023. It was designed to collect rainwater, produce hydroelectric power, and cool the roof of the house when the weather is hot. The rainwater that falls will flow through the turbine into the storage tank. When the weather is hot, the stored water will be pumped up and sprayed on the roof. The current generated through the rotation of the turbine will flow to the battery before producing an electric current for the light bulb flame.

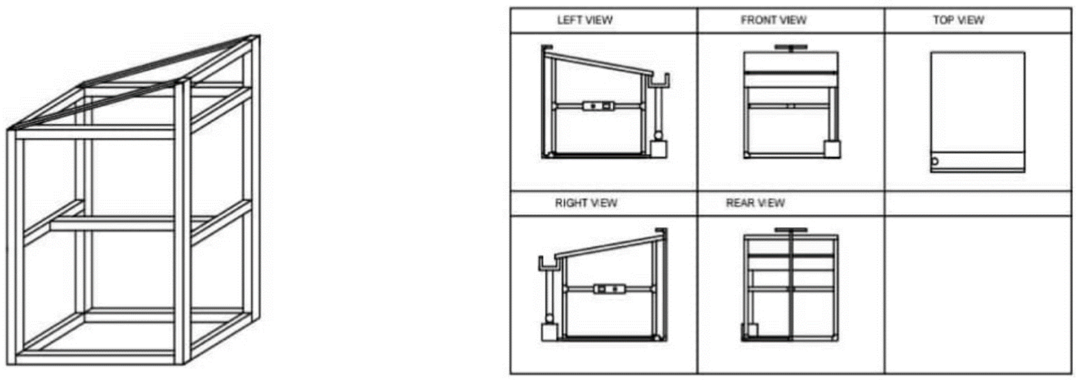


Fig. 3 Schematic Diagram of the proposed Model

2.2.2 Electrical Current Testing

Fig. 4 displays voltmeter readings that were taken three times, with the average measurement being recorded. The resulting current flows through the flow of water to the turbine, where the production of magnetic flux occurs. The turbine used is a cross-flow turbine suitable for small-scale electricity generation in addition to being environmentally friendly. In addition, this turbine is suitable for use at home because it does not use a strong current of water to produce electrical energy. The resulting electrical energy is between 5 to 10 kW. A typical turbine's operational flow ranges from 40 to 5000 liters per second.

Fig. 4 Electrical Current Test

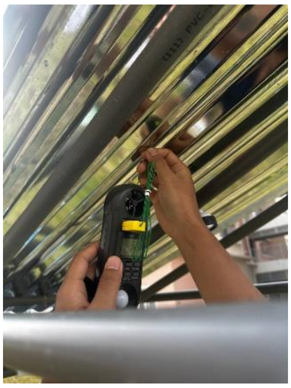
2.2.3 Temperature Testing of Cooling System for Roof

Fig. 5 shows an environmental meter being used to test the cooling system for the roof's temperature. The average reading value is calculated by taking three readings. The test was taken three times, at 10 AM, 12 PM, and 2 PM, respectively. Water from the storage tank will be pumped up to be cured on the roof. Water is sprayed for 2 to 3 minutes before the reading is taken. This is intended to cool the roof first.

Fig. 5 Temperature Testing of Cooling System

This test was carried out by detecting the temperature on the roof of the dual-functional rainwater harvesting system model that has been built. This test is carried out by using a temperature detector, which is an environmental meter. The main objective of this test is to use catchment water as a roof cooler during hot weather. Temperature measurements are obtained at several intervals throughout the day, including the morning, noon, and evening (Table 1). The reading took three times to obtain an average and a more precise reading. This test was carried out by getting comparison readings before and after the system was used.

Table 1 *Temperature values for different times*

Reading at 10.00 am	Reading at 12.00 am	Reading at 2.00 pm
		

3. Result and Discussion

3.1 Voltage Test

Referring to Table 2, the average reading for the voltage test has been taken over three readings. The average values were 0.020, 0.122, and 0.133 volts. On the other hand, the average value for the voltage test is categorized into a single kind because it only utilizes a single type of water turbine, a cross flow turbine. The average reading of the voltage test for the third reading was the highest of all the values obtained**.**

Table 2 *Electrical Current Testing*

Reading	**Dc (V)**	**Dc (V)**	**Dc (V)**	**Average Reading (V)**
First	0.017	0.021	0.023	0.020
Second	0.063	0.107	0.196	0.122
Third	0.126	0.130	0.144	0.133

3.2 Temperature Test

Fig. 6 shows the value of the temperature reading before and after the system was applied. This test is carried out by using a temperature detector, which is an environmental meter. The reading has been taken three times, at 10 am, 12 pm, and 2 pm. The average value for the temperature testing is divided into two conditions, before and after the system was applied. The average value reading before and after 10 am is 31.5 °C and 30.5 °C, respectively. Next, at 12 pm it is 34.6 °C and 33.0 °C. Meanwhile, at 2 pm the average reading before and after is 32.3 °C and

31.3 °C, respectively. From the average values obtained, it shows that the rainwater harvesting system functioned well and could reduce the temperature.

CALCULATION

$5ft \times 3ft = 15ft^2$

$15ft^2 \times \frac{144in^2}{1ft^2} = 2160in^2$

$moderate\ rain\ fall = 0.2\ in/hr$

$\frac{GALLONS}{hr} = 2160in^2 \times \frac{0.2in}{hr} \times \frac{1\ GAL}{2.31in^2} = 2\ \frac{GAL}{min}$

$\frac{GALLONS}{min} = 2\frac{GAL}{hr} \times \frac{1hr}{60min} = 0.03\ GAL/min$

$Flow = \frac{0.03\ GAL}{min} \times \frac{3785L}{GAL} \times \frac{1min}{60sec} = 2 \times 10^{-3} L/s\ or\ 0.002L/s$

$Height = 1.5\ meter$

$Desnsity = 997kg/L$

$Gravity = 9.8m/s^2$

$\frac{0.002L}{s} \times 1.5m \times \frac{9.8m}{s^2} = 3 \times 10^{-5} N.\frac{m}{s}\ or\ 3 \times WATTS\ or\ 0.00003\ WATTS$

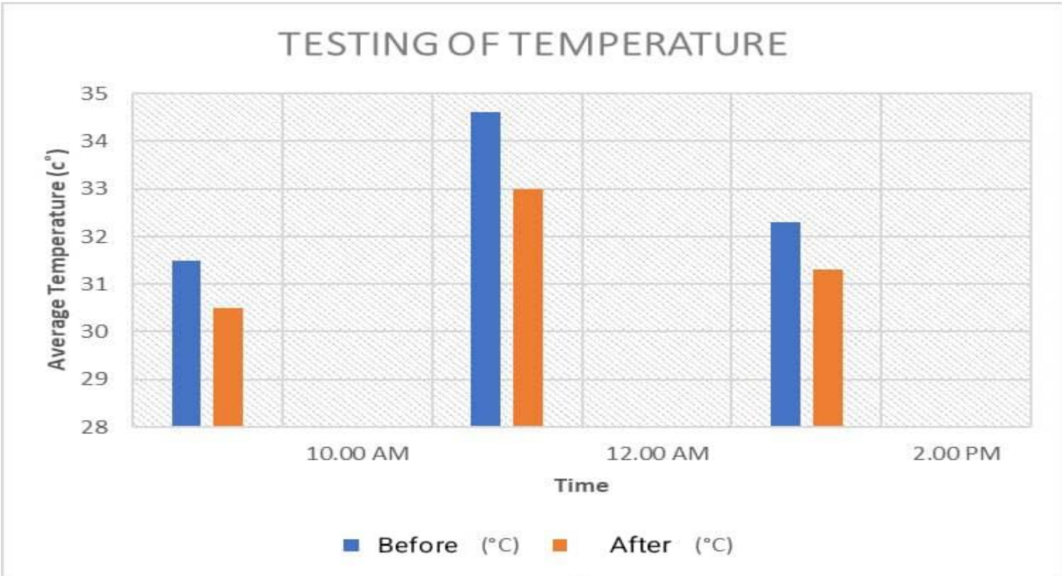


Fig. 6 Comparison of the Temperature Reading

4. Conclusion

Overall, the conclusion that can be drawn is that the objective was successfully achieved. Two types of tests were performed to ensure that the targeted goals were achieved. For each test performed, readings were taken three times to obtain consistent data. The data from each test is taken using the average value. The first test is a test to determine the turbine voltage rate. The results for the turbine test were done, the first reading was 0.020 V, the second reading was 0.122 V, and the final reading was 0.133 V. The results show that the value of the third reading is higher than the average reading of the first and second. Next is the temperature of the roof, using the environmental meter. The temperature value before the turbine is opened at 10 am is 31.5 °C, at 12 pm it is 34.6 °C, and at 2 pm it is 32.3 °C. The temperature reading value after the turbine is opened at 10 s 30.5 °C, at 12 pm it is 33.0 °C, and at 2 pm it is 31.3 °C. Based on the temperature difference before and after, the reading value for 12 pm shows a higher difference value, which is 1.6 °C, compared to 10 pm and 2 pm, which are 1.0 °C, respectively. The results show that the value of the voltage reading is dependent on the speed of the turbine rotation and is related to the temperature conditions, i.e., peak hours in the morning have cooler temperatures than in the afternoon and evening. The observation that can be made from this test is that the value obtained is relatively small because the size of the built model is small. The use of a dual-functional rainwater harvesting system is an innovation. Rainwater that is brought down to produce small-scale electricity and catchment water that is used as a cool roof prove that all the goals of the project have been achieved.

Acknowledgement

The authors would like to thank the Centre for Diploma Studies (CeDS), Universiti Tun Hussein Onn Malaysia for their support. In addition, a heartfelt thank you to all team members for their dedication to the project and mutual support in making it a success.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

References

[1] Salahuddin, A., & Curtis, S. (2011) Climate extremes in Malaysia and the equatorial South China Sea, *Global and Planetary Change, 78(3-4),* 83-91.

[2] Wai, N. M., Camerlengo, A., & Wahab, A. K. A. (2005) A study of global warming in Malaysia, *Jurnal Teknologi, 42(F), 1*-10.

[3] Shaffril, H. A. M., Samah, B. A., Uli, J., & D'Silva, J. L. (2011) The potential impact of climate change environmental hazards on quality of life of fishermen community in Malaysia, *Australian Journal of Basic and Applied Sciences, 5(7),* 507-515.

[4] Yusoff, A. H., Zulkifli, S. Z., Ismail, A., & Mohamed, C. A. R. (2015) Vertical trend of trace metals deposition in sediment core off Tanjung Pelepas Harbour, Malaysia, *Procedia Environmental Sciences, 30,* 211-216.

[5] Hussein, P., Adnan, M. D., & Siarap, K. (2003) Alam Sekitar, Kontroversi Awam Dan Teori Artikulasi: Satu Analisis Kontroversi Projek Hidro Bakun.

[6] Mokarram, N. H., & Wang, H. (2022) Design and modeling of novel two-phase heat exchangers for a home cooling system with ice energy storage, *Applied Thermal Engineering, 207,* 118175.