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Modified Rainwater Harvesting to Prevent the Breeding of Aedes Aegypti Mosquitoes

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Abstract

Clean water is a basic need for every human being, aligning with the sixth goal of Sustainable Development, which ensures that all communities have access to clean water. Early Childhood Education (PAUD) Pelita Hati in Sumber, Kramat, Kranggan, Temanggung Regency, needs 920 liters of clean water per day. Still, during the dry season, the need for clean water is not met. One solution is to utilize a rainwater harvesting (RWH) system, but it leads to mosquito breeding, especially Aedes aegypti. A simple prototype modified RWH by integrating it with the Prevent Aedes Pump (PAP) technology with an internal aquarium filter pump was designed to prevent mosquito breeding. The observation was conducted for 10 days, and the results showed that installing the internal filter pump reduced the number of Aedes aegypti larvae from 4 to 0. The system also reduced the levels of dissolved iron from 0.2 mg/L to 0.02 mg/L and coliform bacteria from 560 MPN/100 ml to 15 MPN/100 ml.

Keywords*: Aedes aegypti, aquarium filter, Prevent Aedes Pump, rainwater harvesting*

1. Introduction

Clean water and adequate sanitation are an essential part of sustainable development, especially in ensuring universal access to clean water for the community. In Indonesia, population growth and the expanding economy have led to an increased demand for clean water and land use changes, impacting water availability. One solution to address this issue is rainwater harvesting (RWH), which can serve as an alternative water source for daily needs and help reduce runoff and groundwater depletion [1]. However, rainwater management also needs to consider potential issues such as the breeding of *Aedes aegypti* mosquitoes, which can cause dengue fever.

In Temanggung, Central Java, a tropical region with two seasons, dry and rainy, some areas experience drought despite typically high annual rainfall. RWH can be an effective solution to address the scarcity of clean water during the dry season. However, potential issues such as the breeding of *Aedes aegypti* mosquitoes due to water storage containers need to be considered. Therefore, modifying RWH by integrating it with the Prevent Aedes Pump (PAP) technology can be a holistic solution to prevent the breeding of *Aedes aegypti* mosquitoes while efficiently utilizing rainwater.

PAP is a modified tool that is effective for producing water currents so that it can prevent mosquitoes from breeding in residential bathtubs as one of the Aedes Aegypti breeding places. Research conducted by Febriantoro et al [2], regarding ways to break the breeding cycle of mosquitoes as well as increase the efficiency of cleaning bath water on a home scale using PAP (Prevent Aedes Pump) technology. the results of this research is decrease in the number of larvae from 4 larvae on the fourth day to 1 tail on the eighth day.

This is because some mosquito larvae are sucked in by the filter tool from the PAP technology.

Aedes aegypti is a type of mosquito that can carry the dengue virus, yellow fever virus, and chikungunya virus. This mosquito is the main vector or carrier of dengue fever, and its distribution is very wide, covering almost all tropical regions worldwide. *Aedes aegypti* undergoes complete metamorphosis, which includes stages from eggs, then larvae, pupae, and finally becoming adult mosquitoes. The larval phase occurs within 6-8 days. The pupal or cocoon phase occurs within 2- 4 days. The growth of eggs to adulthood takes place over 9-10 days. With such a life cycle, mosquitoes can live for 2-3 months [3].

Figure 1. The PAUD Pelita Hati in Kramat, Temanggung

Early Childhood Education (PAUD) Pelita Hati, located in Kramat, Kranggan, Temanggung Regency, in coordinates of -7.31218 and 110.25849. They have 20 students and 3 educators, with two water tanks containing water from the PDAM source with capacities of 1000 liters and 800 liters. However, during the dry season, the school's need for clean water is not adequately met. The school's proximity to community fields adds complexity to meeting the need for clean water. Therefore, the author is interested in designing a modified rainwater harvesting system that combines Rainwater Harvesting (RWH) with Prevent Aedes Pump (PAP) technology to prevent the breeding of *Aedes aegypti* mosquitoes at PAUD Pelita Hati. This modification is expected to be a holistic solution that not only meets the need for clean water but also prevents the breeding of mosquitoes that can cause dengue fever.

According to the Meteorology, Climatology, and Geophysics Agency (BMKG), rain is defined as precipitation or deposits that come from liquid or solid substances produced by the condensation process that falls from the clouds to the ground. Meanwhile, the height of rainwater collected in an area of 1 m^2 on a flat surface, which does not flow, seep, or evaporate, is defined as rainfall [4]. At November 2023, when this research occurred, the rainfall in Temanggung Regency was 152 mmHg [5].

The standard quality benchmark for environmental health for water media for hygiene and sanitation purposes is by the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023. This quality standard includes physical, biological, and chemical parameters, as seen in Table 1, Table 2, and Table 3. Water for hygiene and sanitation purposes is used to maintain personal hygiene such as bathing and brushing teeth, as well as washing food, eating utensils, and clothes. In addition, water for hygiene and sanitation purposes can be used as raw water for drinking water [6].

Table 1 Physical Parameters in the Environmental Health Quality Standard for Water Media for Hygiene and Sanitation Purposes

No.	Parameter Types	Maximum Allowable Level	Unit
1	Temperature	Air temperature ± 3	ºC
2	Total Dissolved Solid	< 300	mg/L
3	Turbidity	<3	NTU
4	Color	10	TCU
5	Smell	Odorless	-

Table 2 Biological Parameters in the Environmental Health Quality Standard for Water Media for Hygiene and Sanitation Purposes

No.	Parameter Types	Maximum Allowable Level	Unit
1	*Escherichia coli*	0	CFU / 100 ml
2	*Total Coliform*	0	CFU / 100 ml

Table 3 Chemical Parameters in the Environmental Health Quality Standard for Water Media for Hygiene and Sanitation Purposes

No.	Parameter Types	Maximum Allowable Level	Unit
1	Ph	6.5 – 8.5	-
2	Nitrate (as NO^{3-})	20	mg/L
3	Nitrite (as NO^{2-})	3	mg/L
4	Chromium valence 6 (Cr^{6+})	0.01	mg/L
5	Iron (Fe)	0.2	mg/L
6	Manganese (Mn)	0.1	mg/L

In this research, the discussion revolves around the influence of installing an internal pump on the prototype. Therefore, the purpose of this research is to determine the influence of reducing the number of mosquito larvae and parameters such as pH, temperature, TDS, dissolved iron, and coliform bacteria.

2. Materials and Methods

According to the Directorate General of Climate Change Control of the Ministry of Environment, Rainwater Harvesting (RWH) is a method of collecting and storing rainwater in tanks or reservoirs. Rainwater is collected by the roof surface of the house and channeled through pipes connected to the gutter to the storage area below. Before reaching the storage tank, rainwater is filtered through a filter tube to remove impurities. The three main components that must be present in a rainwater harvesting system are the roof as a rainwater collector, the gutter as a rainwater channel to the storage area, and the tank or pond as a rainwater reservoir, as well as supporting components [7]. A centrifugal pump operates on the principle of centrifugal force to flow water. The centrifugal system is a system that uses the principle of centrifugal force to flow fluids or liquids from one place to another. A centrifugal pump is an example of a centrifugal system used to accelerate the flow rate of water or fluid by utilizing the centrifugal force generated by the impeller.

In this study, the effect of RWH using a pump and without a pump has been compared on the growth of *Aedes aegypti* larvae. Observations were carried out for 10 days by looking at the development of the number of larvae in each variable. Apart from that, water quality testing is carried out in the laboratory so that the effectiveness of the RWH system can be determined.

3. Result and Discussion

3.1 Quality of Rainwater

The quality of rainwater harvested from the top of PAUD Pelita Hati was analyzed in the laboratory, with the result as seen in Tables 4 and 5.

Table 4 Rainwater Quality of Fresh Rainwater

No.	Parameter	Test Results	Quality Standard
1	pH	6	6,5 - 8,5
2	Temperature	28,3 ºC	Air temperature 3 ºC
3	TDS	0,17 ppm	<300 ppm
4	Dissolved iron	0,2 mg/L	0,2 mg/L
5	Total coliform	560 MPN/100ml	0 CFU/100ml

Source: Laboratory test result (2023)

Table 5 Quality of Rainwater in Sample 1 and 2

No	Parameter	Test Results		Quality Standard
		Sample 1 (With pump)	Sample 2 (Without Pump)	
1	pH	6	6	6,5 - 8,5
2	Temperature	28,54 ºC	28,33 ºC	Air temperature 3 ºC
3	TDS	0,169 ppm	0,091 ppm	<300 ppm
4	Dissolved iron	0,02 mg/L	0,02 mg/L	0,2 mg/L
5	Total coliform	15 MPN/100ml	94 MPN/100ml	0 CFU/100ml

Source: Laboratory test result (2023)

The pH level affects the effectiveness of water chlorination. Monitoring and maintaining the pH level is crucial to ensure water quality and suitability for various purposes. pH measurements are conducted concurrently with temperature and TDS measurements using litmus paper. The pH testing results for sample 1 and sample 2 indicate a stable pH value of 6, which falls within the ideal rainwater pH range according to the Meteorology, Climatology, and Geophysics Agency. The ideal rainwater pH is within the range of 5.6 – 6. The mosquito population did not proliferate significantly due to the acidic pH of the water. Mosquitoes will proliferate optimally within a pH range of 7-8 [8].

The results of the temperature measurements for samples 1 and 2 indicate that the average temperature values for both samples are in the range of 28-29 ºC, which is conducive to the breeding of *Aedes aegypti* mosquitoes. The highest temperature for both samples occurred on the seventh day, reaching 31-32 ºC, which can accelerate the life cycle of *Aedes aegypti* mosquitoes and increase their biting activity. This is in line with the Minister of Health Regulation No. 35 of 2012 on Guidelines for Identifying Health Risk Factors Due to Climate Change, which states that the ideal temperature for the breeding of *Aedes aegypti* mosquitoes is between 25-27 ºC. However, if the temperature rises above 32-35 ºC, it can increase the risk of disease transmission carried by vector mosquitoes up to three times higher [9].

The results of the TDS measurements for samples 1 and 2 show that the average TDS value for sample 1 (0.169 ppm) is higher than sample 2 (0.091 ppm). This is due to the treatment of installing an internal pump filter in sample 1, which causes the rotation of water currents in the prototype bucket and the transport of ions in the water, while sample 2 without the internal pump filter treatment does not experience water current rotation [10]. However, the TDS content in both samples is still far below the environmental health quality standard for water media for hygiene and sanitation purposes, which limits the maximum TDS content to <300 mg/L. Therefore, the rainwater can still be used for hygiene and sanitation purposes.

The soluble iron content in rainwater has decreased due to the filtration and oxidation processes. The installation of an internal aquarium filter pump in sample 1 caused the rotation of water currents and the transport of iron ions, while in sample 2, the reduction in soluble iron content was due to the oxidation reaction caused by air exposure [11]. However, the soluble iron content in both samples still complies with the environmental health quality standard for rainwater, which limits the maximum soluble iron content to 0.2 mg/L. Therefore, the rainwater can still be used for hygiene and sanitation purposes.

The total coliform bacteria content in rainwater undergoes a significant decrease after filtration and oxidation. The greatest decrease in coliform bacteria content occurs in sample 1, which undergoes filtration through an internal pump filter [12]. The decrease is from 560 MPN/100ml to 15 MPN/100ml. Sample 2, which does not undergo treatment, also experiences a decrease but not as much as sample 1, from 560 MPN/100ml to 94 MPN/100ml.

3.2 Breeding of *Aedes aegypti* Mosquito Larvae

The observations of the number of *Aedes aegypti* Mosquito Larvae in the tank for 10 days, with or without pump, gave the result as seen in Table 6.

Table 6 Breeding of *Aedes aegypti* Mosquito Larvae

Day	**Amount of *Aedes aegypti* Larvae (With pump)**	**Amount of *Aedes aegypti* Larvae (Without pump)**
1	0	0
2	0	0
3	2	0
4	0	2
5	0	2
6	1	3
7	0	4
8	0	3
9	0	0
10	0	0

Source: Primary data (2023)

Based on the observations over 10 days, there was a difference in the growth of mosquito larvae between sample 1, which used an internal pump filter, and sample 2, which did not use a filter. In sample 1, the growth of mosquito larvae was more limited, with a total of 3 larvae appearing on the third and sixth days. On the other hand, in sample 2, the growth of mosquito larvae was greater, with the highest number of larvae, 4, appearing on the seventh day. This indicates that the use of an internal pump filter can restrict the growth of mosquito larvae. According to Febriantoro et.al [2], PAP can cause flow and current in the bathtub, so mosquitoes don't want to lay eggs in the tub and if there are larvae it will inhibit the growth rate of the larvae into adult mosquitoes.

4. Conclusion

Based on the research conducted at PAUD Pelita Hati, it can be concluded that the rainwater quality was affected by the treatments, with sample 1 showing better results in terms of TDS and total coliform bacteria content due to the installation of an internal pump filter. The specific numerical results are pH: 6 for both samples; average temperature: 28.54 ºC for sample 1, 28.33 ºC for sample 2; TDS: 0.169 ppm for sample 1, 0.091 ppm for sample 2; soluble iron: 0.02 mg/L for both samples; total coliform bacteria: 15 MPN/100 ml for sample 1, 94 MPN/100 ml for sample 2 (without pump). The proliferation of mosquito larvae is higher in sample 2, which is without the installation of an internal pump filter, with the highest number being 4. In contrast, in sample 1 with the installation of an internal pump filter, the highest number is only 2. This means that the installation of an internal pump can significantly prevent the proliferation of *Aedes aegypti* mosquitoes.

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