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Development of Engineered Water Reservoirs for Aedes Mosquito Breeding Control

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ABSTRACT

The presence of water reservoirs as mosquito breeding sites is a major factor in the transmission of dengue hemorrhagic fever (DHF). This study developed an engineering-based tool to manage larval density and prevent mosquito proliferation. Experiments were conducted using 18 water reservoirs made of fiber, concrete, metal, and plastic, both with and without larval traps, with 900 Aedes aegypti larvae as samples. Data were analyzed using univariate and bivariate methods (T-test) at a 95% confidence level. Results showed no significant difference among container materials in supporting mosquito breeding, allowing flexibility in designing water containers for vector control. A light sensor was later integrated to detect larval presence, and a model for community-based application was introduced. The findings confirm that all types of water storage, regardless of material or size, can support mosquito breeding. Incorporating technologies such as light or motion sensors can enhance larval control efforts. This model also serves as a tool for public education on environmental health, emphasizing the importance of household conditions in preventing mosquito proliferation. Further research will refine and implement the model in real-world settings.

Keywords: *Engineered Tubs, Nests, Flies Density*

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INTRODUCTION

Dengue hemorrhagic fever (DHF) remains a major public health concern in Indonesia. The disease is transmitted through the bites of Aedes aegypti and Aedes albopictus mosquitoes, which breed in various domestic water containers. High population mobility, environmental changes, and suboptimal urban management contribute significantly to the spread of this disease. The social and economic impacts of DHF, such as the loss of productive time and high medical costs, further burden communities, especially in densely populated urban areas (Sulistyawati et al., 2019). Indonesia currently faces a double burden of disease: the continued rise of infectious diseases like DHF and the increasing prevalence of non-communicable diseases. Poorly managed urban environments often provide ideal breeding grounds for mosquito vectors. This highlights the critical need for vector control strategies that are not only effective but also feasible and sustainable across different community contexts (Pascawati et al., 2024).

Previous research has explored various mosquito control methods, such as ovitraps for monitoring larval density and community-based environmental management approaches. However, the effectiveness of these methods is often limited due to insufficient public awareness and lack of resources for consistent implementation (Kesumawati et al., 2022). Additionally, studies indicate that the success of vector control programs heavily depends on the conditions of water storage containers, which are the primary breeding habitats for Aedes mosquitoes (Daswito & Samosir, 2020).

Recent cost-effectiveness analyses show that innovative technology-based interventions may offer substantial savings and improved control outcomes. For instance, new approaches such as mechanical-electric devices for larval control have shown promise in suppressing mosquito populations, though they remain largely limited to laboratory settings and pilot-scale trials (Pascawati et al., 2024). Importantly, these efforts often lack integration with active community participation, which is a key factor in ensuring sustainable success.

The primary gap identified in current literature is the absence of an integrated approach combining vector control with technology-driven environmental management. Many studies focus only on short-term effectiveness without evaluating long-term impacts on dengue incidence. Furthermore, there is limited research on the influence of water container materials—such as cement, glass, and fiber—on mosquito breeding success and larval survival (Sutriyawan & Lolan, 2023).

In this context, research focused on engineering water reservoirs using different materials becomes highly relevant. This innovation not only aims to reduce mosquito populations but also offers a practical and sustainable solution to dengue control. Moreover, by empowering communities to participate in the management of vector breeding sites, this approach holds significant promise for scalable and lasting impact.

This study aims to investigate the effectiveness of various water container materials in controlling Aedes larvae. Its novelty lies in the integration of technological innovation with community-based environmental interventions. The outcomes are expected to make a meaningful contribution to national efforts in reducing DHF incidence through evidence-based and community-inclusive strategies.

METHODS

This study used a laboratory experimental method with a manipulation and engineering approach of water storage containers. The study focused on the effect of variations in container material (cement, glass, fiber) and depth (50 cm, 75 cm, 100 cm) on the population and density of Aedes aegypti mosquito larvae. The research was conducted in the laboratory of Insectarium and workshop of Poltekkes Kemenkes Padang. The object of research was Aedes aegypti mosquito eggs obtained from Lokalitbang Baturaja. The eggs were hatched using the rearing method under room temperature conditions of 25-27°C. Samples consisted of 50 mosquitoes per container, with a total of 6 containers for each treatment variation, and were repeated three times, resulting in a total of 900 mosquito larvae per repetition.

The study began with the preparation of materials and equipment, including water containers made of cement, glass, and fiber with depths of 50 cm, 75 cm, and 100 cm. The depths of 50 cm, 75 cm, and 100 cm were chosen based on standard container sizes commonly found in communities endemic to dengue fever (DBD) and to evaluate the impact of varying water volumes on larval population dynamics. The variation in water container materials—cement, glass, and fiber—was selected because they represent common materials used for water storage in endemic areas and have different physical characteristics, allowing for an evaluation of how material affects the habitat of Aedes aegypti larvae. Mosquito eggs were immersed in fresh water mixed with Abate solution (5 mg/liter) for each treatment container. Observations were conducted for 14 days to record hatching time and mosquito larvae density. The research instruments included water storage containers: (Variations of cement, glass, and fiber materials with dimensions of 50 cm, 75 cm, 100 cm), Rearing Equipment (Flashlights, larval pipettes, plastic clips, larval killers, and mosquito cages), Supporting Tools (Thermometer, hygrometer, camera, and stationery).

Data were collected through direct observation of the number of larvae that hatched in each treatment container. Data were counted and recorded every 24 hours until 14 days of observation. All measurements were carried out with the applicable protocol standards to maintain the validity of the results. Data were analyzed using descriptive and inferential statistical tests. Trend and trend data were analyzed by percentage based on three container materials (cement, glass, fiber) and three dimensions (50 cm, 75 cm, 100 cm). The t-test was used to determine the significance of differences in mean larval density with a 95% confidence level.

RESULTS

The results of the research began the preparation and treatment for the first year of the experiment and treatment of the Engineering of Water Storage Tubs for Potential Brooding into Mosquito Nests *Aedes Sp*. is to design the shape and capacity of the tub as a treatment tub and in the second year the presence of larvae sensors will be installed as shown in the following sketch.

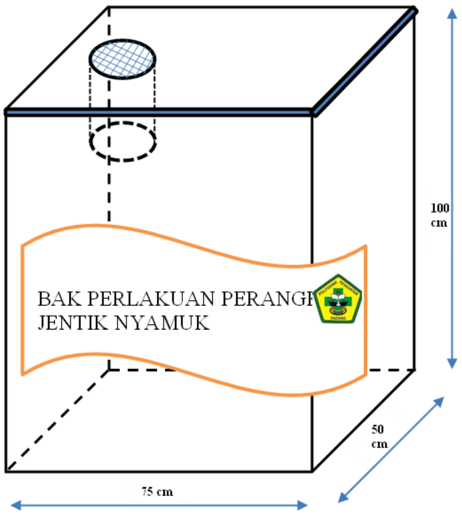

Fig.1 Sketch of the Engineered Basin in the Treatment for Potential Breeding Sites Mosquitoes *Aedes aegypti*

Researchers selected experimental containers and materials that were appropriate for the procedure to control mosquito larval density, using tubs with rough and slippery surfaces, namely cement, fiber, and plastic tubs, with dimensions of 50 cm^3, 75 cm^3, and 100 cm^3. The Aedes sp. mosquitoes used were obtained from Lokalitbang Baturaja, with a number of about 3,000-6,000 eggs and a success rate of 72%. Observations of larval growth, from the egg phase to larval instar 1 to instar 4, lasted for 2 to 3 weeks, with each treatment involving 25 larvae. Observations showed that in cement container 1, the developmental phase of larvae was late, with 19 larvae, while in containers 2 and 3, the last phase showed 21 Aedes sp. larvae.

Table 1. Distribution Frequency Average days of Larval Development *Aedes aegypti* on Cement-based Containers

Average number of days of larval development	Cement container 1	Cement container 2	Cement container 3
0-3 days	25	25	25
2-5 days	22	24	22
5-7 days	18	16	14
7-14 days	12	10	10
>14 days	6	4	4
Total larvae developed (0-14 days)	19	21	21

Based on Table 1, it can be explained that the development of the larvae phase in cement container 1 experienced a delay, calculated in the age range of 0–14 days.

Table 2. Distribution of Frequency of Average days of Larval Development *Aedes egypti* in Fiber Containers

Average days of larval development	Containers fiber 1	Fiber container 2	Fiber container 3
0-3 days	25	25	25
2-5 days	20	20	18
5-7 days	14	16	14
7-14 days	12	12	12
>14 days	3	5	6
Total larvae developed (0-14 days)	22	20	19

From Table 2, it is described that the development of the late larval phase is in fiber container 3, which is 19 larvae, while containers 2 and 3 until the last phase have become 23 and 20 larvae, respectively *Aedes aegypti.*

Table 3. Distribution of Frequency of Average Days of Larval Development *Aedes aegypti* in Glass Containers

Average number of days of larval development	Containers glass 1	Glass container 2	Glass container 3
0-3 days	25	25	25
2-5 days	18	22	20
5-7 days	15	16	15
7-14 days	8	10	9
>14 days	3	3	3
Total larvae developed (0-14 days)	22	22	22

From Table 3, it is described that the development of the larval phase is the same for glass as much as 22 *Aedes Sp. larvae.* To determine the ability of the water tub as a potential breeding ground for Aedes sp. mosquito nests, the results of data analysis from the test of differences in the ability of engineered water tubs with experiments on breeding in water containers as follows.

Table 4. Mean Distribution of the Ability of Water Tanks in the Development of *Aedes aegypti*

Observation	N	Mean	Std. Deviation	Std. Error Mean
Number of larvae_Bak_SemenFiber1	5	16.6000	7.66812	3.42929
	5	14.8000	8.34865	3.73363
Number of larvae_Bak_SemenFiber2	5	15.8000	9.01110	4.02989
	5	15.6000	7.63544	3.41467
Number of larvae_Bak_SemenFiber3	5	15.0000	8.60233	3.84708
	5	15.0000	7.07107	3.16228

Based on table 4. The distribution of observation results obtained information during the five stages of observation in the span of 0 to 14 days the average growth varied between 14.8 - 16.6 of the number of larvae tested.

Table 5. Statistical Test Results with T-test Based on the Ability of Water Tubs by Type of Container Material in the development of *Aedes aegypti*

Observation	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI of the Difference Lower	Upper
Number of larvae_Bak_Sem enFiber1	.001	.977	.355	8	.732	1.80000	5.06952	-9.89033	13.49033
			.355	7.943	.732	1.80000	5.06952	-9.90498	13.50498
Number of larvae_Bak_Sem enFiber2	.248	.632	.038	8	.971	.20000	5.28205	-11.98042	12.38042
			.038	7.790	.971	.20000	5.28205	-12.03779	12.43779
Number of larvae_Bak_Sem enFiber3	.395	.547	.000	8	1.000	.00000	4.97996	-11.48381	11.48381
			.000	7.711	1.000	.00000	4.97996	-11.55912	11.55912

Table 5 above explains that there is no effect of the type of container material on the development of *Aedes Sp.* both made from fiber and cement because the p value> 0.05 (95% confidence), but based on the observation of the average development there is a difference in growth speed. Based on the day of observation, the growth of larvae is described in Table 6 below

Table 6. Statistical Test Results with T-test Based on the Ability of Water Tubs based on the length of days (0-14) of development*Aedes aegypti*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI of the Difference Lower	Upper
Number of Flies_ Day_rata2	.106	.754	.131	8	.899	.66667	5.08287	-11.0544	12.3878
			.131	7.933	.899	.66667	5.08287	-11.0717	12.4059

Table 6 above explains that there is no effect of the type of container material on the development of *Aedes aegypti.* both made from fiber and cement because the p value> 0.05 (95% confidence). Furthermore, as a comparison, testing is carried out as *oneway analysis of variance* (Anova) follows:

Table 7.

Table 7. Mean distribution of the ability of Fiber Tubs in the development of *Aedes aegypti*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bd	Upper Bd		
Fiber Tub 1	5	14.8000	8.34865	3.73363	4.4338	25.1662	3.00	25.00
Fiber Tub 2	5	15.6000	7.63544	3.41467	6.1193	25.0807	5.00	25.00
3` Fiber Tub	5	15.0000	7.07107	3.16228	6.2201	23.7799	6.00	25.00
Total	15	15.1333	7.14009	1.84356	11.1793	19.0874	3.00	25.00

From table 7 above, it is explained that there is an average difference in the ability of fiber basins in the growth of larvae, especially the 2nd basin with the 1st and 3rd basins. To see the ability of the three fiber basins, continue with the Anova test in table 8.

Table 8. Statistical Test of *Oneway Anova* the Ability of Fiber Tubs in the development of *Aedes aegypti*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.733	2	.867	.015	.986
Within Groups	712.000	12	59.333		
Total	713.733	14			

From table 8 above, it is explained that there is no effect of the type of fiber material on the development of *Aedes Sp.* The p value> 0.05 (95% confidence) is followed by multiple Comparisons further test with Bonferoni.

Table 9. Multiple comparison results of the ability of Fiber Water Tubs in the development of *Aedes Sp.*

(I) Group	(J) Group	Mean Diff. (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bd	Upper Bd
Fiber Tub 1	Fiber Tub 2	-.80000	4.87169	1.000	-14.3407	12.7407
	Fiber Tub 3`	-.20000	4.87169	1.000	-13.7407	13.3407
Fiber Tub 2	Fiber Tub 1	.80000	4.87169	1.000	-12.7407	14.3407
	Fiber Tub 3`	.60000	4.87169	1.000	-12.9407	14.1407
Fiber Tub 3`	Fiber Tub 1	.20000	4.87169	1.000	-13.3407	13.7407
	Fiber Tub 2	-.60000	4.87169	1.000	-14.1407	12.9407

Table 9 shows that the 3rd fiber basin is significantly different from the 1st and 2nd basins.

For cement tanks, the results of the analysis can be explained in the following table.

Table 10. Mean distribution of the ability of cement tanks in the development of *Aedes sp.*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bd	Upper Bd		
Cement Tub 1	5	16.6000	7.66812	3.42929	7.0788	26.1212	6.00	25.00
Cement Tub 2	5	15.8000	9.01110	4.02989	4.6112	26.9888	4.00	25.00
Cement Tub 3	5	15.0000	8.60233	3.84708	4.3188	25.6812	4.00	25.00
Total	15	15.8000	7.84857	2.02649	11.4536	20.1464	4.00	25.00

From table 10 above, it is explained that there is an average difference in the ability of cement tanks in the growth of larvae, especially the 2nd tub with the 1st and 3rd tubs. As much as 15.8. To see the ability of the three cement tanks, continue with the Anova test in table 11.

Tabel 11. *Oneway Anova* Statistical Test of the Ability of Cement Tubs in the development of *Aedes Sp*

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.400	2	3.200	.045	.956
Within Groups	856.000	12	71.333		
Total	862.400	14			

From table 11 above, it is explained that there is no effect of the type of cement material on the development of *Aedes Sp*. The p value> 0.05 (95% confidence) is followed by further test multiple Comparisons with Bonferoni.

Table 12. Multiple Comparison Results of the Ability of Cemented Water Tanks in the development of *Aedes Sp.*

(I) Group	(J) Group	Mean Diff. (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bd	Upper Bd
Cement Tub 1	Cement Tub 2	.80000	5.34166	1.000	-14.0470	15.6470
	Cement Tub 3	1.60000	5.34166	1.000	-13.2470	16.4470
Cement Tub 2	Cement Tub 1	-.80000	5.34166	1.000	-15.6470	14.0470
	Cement Tub 3	.80000	5.34166	1.000	-14.0470	15.6470
Cement Tub 3	Cement Tub 1	-1.60000	5.34166	1.000	-16.4470	13.2470
	Cement Tub 2	-.80000	5.34166	1.000	-15.6470	14.0470

Table 12 shows that the 3rd cement tub is significantly different from the 1st and 2nd tubs

Observations show that stagnant water plays an important role in the development and life phase changes of mosquitoes, from eggs to larvae. Eggs can be laid by adult mosquitoes in various places and will hatch into first instar larvae in 1-3 days, depending on the condition of the container and stagnant water (Adifian, Ishak, and Ane, 2019; Adrianto, 2021). Engineered tanks made of cement, fiber, and glass had no significant effect on mosquito breeding potential. However, the average time required for the growth of eggs to larvae, and from larvae instar I to IV, before becoming pupae and adult mosquitoes, is about 2 to 3 weeks.

(a)  **(b)** 

Figure 2. (a) Engineered basin treatment container; (b) basin treatment container surface

Clear and stagnant water reservoirs, with optimal light and temperature conditions (24 - 28°C), facilitate the development of Aedes sp. larvae (Alto et al., 2014; Aryanti et al., 2013). The characteristics of water containers, including material, dimensions, color, and placement in dark and humid places, greatly influence the development potential of Aedes sp. mosquitoes (Aryanti et al., 2013; Baharuddin & Rahman, 2015; Kinansi & Pujiyanti, 2020). Water reservoirs in the community become breeding grounds for mosquitoes, and the more water containers there are, the greater the risk of increasing the number of mosquito nests, which can be measured by the larval density index (Achee et al., 2015; Tri et al., 2020).

This phenomenon is associated with increased population mobility and the spread of dengue virus. Integrated control efforts with various techniques, such as trap modification and changes in the color and volume of containers, can improve the ability to trap Aedes sp. eggs (Barrera, Amador & MacKay, 2011; Household and Water, 2009; Sugiarto et al., 2018). This study shows that household water reservoirs are at risk of becoming potential mosquito nests, and it is hoped that this research product can provide solutions to detect the presence of mosquitoes in the aquatic phase, including eggs, larvae, and pupae.

People's habit of collecting water without supervision leads to the risk of mosquito breeding, especially in containers left for days without monitoring (Boewono, 2012; Laroche et al., 2017; Baharuddin & Rahman, 2015). This study aims to develop a water storage container with modified Aedes sp. egg and larvae traps, which can be used as a tool in integrated vector control. Further experimental tests with a controlled experimental approach and valid statistical analysis will be conducted to ensure the potential of Aedes sp. mosquito nests can be scientifically measured.

DISCUSSION

The observations recorded in Table 1 to Table 3 show that different types of modified water containers can harbor Aedes aegypti mosquitoes. Each container showed differences in larval development time. In cement container 1, the larval phase developed more slowly with 19 larvae, while containers 2 and 3 produced 21 larvae. In fiber container 3, there was also a delay in larval development with 19 larvae, while containers 2 and 3 developed 23 and 20 larvae, respectively. In the glass container, larval development was uniform, with 22 larvae. This observation indicates that the type of container influences the length of time it takes for eggs to develop into adult mosquitoes within 14 days, which is consistent with the life cycle of Aedes aegypti. Stagnant water that is often found around us provides opportunities for mosquitoes to breed, especially due to the habit of people holding water without a lid that allows larvae to develop. Therefore, this study aims to identify breeding sites, larval density, and larval growth of Aedes aegypti. (Baharuddin and Rahman, 2015)

Previous research showed that mosquito breeding density based on containers in Nanggalo was lower (18.18%) compared to Pauh (30.70%). New habit interventions, such as PSN (Drain, Cover, Remove), were practiced by 69% of families in Nanggalo and 97% in Pauh. The types of containers in the two areas differed, with landfill containers in Nanggalo being used for daily purposes, while in Pauh, non-landfill containers were more prevalent. Non-landfill containers such as dispensers, refrigerators, old tires, and used cans were found most (222 containers, 49.6%) in the Padang Pasir Health Center working area in 2022, while landfill containers such as buckets and drums totaled 214 containers (47.8%), and natural landfill only 12 containers (2.6%). Factors that influence the density of DHF vectors, including community behavior, climate change, economic growth, and availability of clean water, also play an important role. Although DHF cases decreased in 2020, it is estimated that these cases will still increase and spread more widely because the vector is still spread in settlements and public places (Kinansi and Pujiyanti, 2020).

During the five stages of observation from 0 to 14 days, the average larval growth varied from 14.8 to 16.6. There were differences in the ability of larval growth between the 1st, 2nd, and 3rd fiber tanks, especially the 2nd tank which showed different results. Lestari's (2014) research in Semarang showed CI rates in Sendangmulyo and Terboyo Wetan villages of 15.37% and 30.77%, respectively, indicating high and moderate larval density. In Purus urban village, most mosquito breeding sites were found in Non-TPA containers (104 containers, 54.8%), landfill (101 containers, 53.1%), and natural landfill (5 containers, 2.6%). Kelurahan Rimbo Kaluang has more landfill containers (66 containers, 50.3%) than Non-landfill (59 containers, 45.0%) and natural landfill (6 containers, 4.6%). Kelurahan Flamboyan Baru has the highest number of Non-TPA containers (64 containers, 50.4%) and 62 landfill containers (48.8%), with only 1 natural landfill container (0.7%). This difference is likely influenced by people's habit of using water containers, which differs from region to region, as well as the condition of water supply in the area. Areas with limited water supply tend to have more water storage containers, providing greater opportunities for the presence of Aedes aegypti larvae (Tanjung, 2015; Latifa et al., 2013).

The results of the test for the effect of engineered water basins showed that all materials and container dimensions had the potential to harbor Aedes mosquitoes, but there was no significant effect of material type (fiber or cement) on the development of Aedes sp., as the p value was > 0.05. Based on observations, stagnant water has been shown to be a determining factor in mosquito breeding, with mosquito eggs able to be laid in almost all containers and hatch into larvae within 1-3 days, depending on container conditions and stagnant water (Adifian, Ishak, and Ane, 2019; Adrianto, 2021). In contrast to the research of Hodijah et al (2015), which found that bathtubs are the most widely used containers for Aedes aegypti breeding because the water in them lasts longer and is rarely replaced. Other studies by Hasyimi and Soekirno in Tanjung Priok, as well as Tri (2010) in

Denpasar, also revealed that bathtubs were the most common places where mosquito larvae were found. Meanwhile, Anif Budiyanto showed that most containers were found inside the house, and Milana Salim's study stated that the dark atmosphere indoors made it difficult to see and clean mosquito larvae. Budiyanto's (2003) study also noted that dark colors are more often found in mosquito breeding sites.

Arda's research (2012) showed that in sub-districts with high, medium, and low endemicity levels, there are differences in physical environmental conditions that affect house density and the presence of containers. Each house usually has a water storage container that has the potential to become a mosquito breeding ground. Karyadi's (2015) research in Kutai stated that vector control efforts through fogging and abatement have not been effective in reducing vector populations, so DHF cases still occur. The pattern of DHF spread tends to be concentrated in densely populated areas, with the distance between the most frequent cases ranging from 101- 200 meters. The survey showed that the density of larvae (HI 39.83% and BI 54.2%) indicates a potential threat of dengue transmission.

Containers or landfills, water reservoirs used by the community, especially those that are large and difficult to clean, such as bathtubs, are ideal breeding grounds for Aedes aegypti. Dark-colored containers located outside the house also need to be taken seriously to prevent them from becoming mosquito nests. Based on Minister of Health Regulation No. 50 of 2017, a larva-free rate lower than 95% indicates that larval control still poses a risk of dengue transmission, especially in endemic areas.

Salim's research shows that a high number of larvae in an area makes the area more prone to dengue fever (DHF) and increases the chance of dengue virus transmission. The presence of containers plays an important role in increasing the density of Aedes aegypti mosquito vectors, because the more containers in an area, the more places that can be used as mosquito nests.

Data from studies conducted through November 2021 and 2022 processed information on potential water storage risks and family interactions in nest controlmosquito . These data were used to determine interaction and risk models based on mosquito breeding characteristics, as well as to analyze trends and compare results with previous vector research and relevant theory.

Research by Ramadhani (2017) showed that the presence of containers plays a significant role in the population of Aedes aegypti larvae. The more water reservoirs, the more breeding grounds for mosquitoes, leading to mosquito population density. Widia Sari et al. also observed that A. aegypti larvae were found in more landfill and non-landfill containers than A. albopictus, as A. aegypti is better able to adapt to the human environment. Therefore, mosquito breeding sites need more attention as they affect the increase in mosquito population.

In Kelurahan Purus, with a CI of 22.1%, many larvae were found in various types of containers, including landfill, non-landfill, and natural landfill. The spread of DHF cases is usually triggered by high population mobility, urban development, climate change, and other epidemiological factors. Climate change affects rainfall, temperature, humidity, and wind, which impacts ecosystems and health, including the proliferation of disease vectors. The main factors for the spread of DHF are climate change and human behavior, such as low community participation in Mosquito Nest Eradication (PSN), and an increase in the number and mobility of the population which facilitates the spread of the DHF virus (Powell & Tabachnick, 2013; Baharuddin & Rahman, 2015; Kinansi & Pujiyanti, 2020).

According to the Minister of Health Regulation No. 02 of 2023, if the larva-free rate in an area is still below 95%, the risk of DHF transmission remains. This shows that monitoring and control measures have not fully reduced the risk of DHF transmission, especially in endemic areas with a high larval index. Salim's research revealed that the high number of larvae in an area increases its vulnerability to DHF and increases the chance of virus transmission. The presence of containers as water reservoirs plays a role in increasing the density of Aedes aegypti vectors, because the more containers, the more breeding places for these mosquitoes.

The increased population of Aedes aegypti increases the risk of infection with the DHF virus, leading to an increase in DHF cases. This is supported by research showing that water containers strongly influence the incidence of DHF (Duma, 2017). The 2021 research will be continued in 2022 with analysis and models to determine relevant variables. The environmental data used in this study, such as spatial data on population density, ABJ, and case coordinates, provide an overview of the risk of DHF transmission based on the location of water containers, mosquito nests, and 3M intervention efforts. The results showed that the Nanggalo Health Center area has a higher risk of DHF transmission.

Research by Arsin et al. (2013) revealed that environmental factors such as container type, temperature, humidity, and pH affect the presence of Aedes aegypti larvae, and there was an increase in the larva-free rate (ABJ) after the intervention of PSN DBD (3M Movement and Abatization). Research by Susanna et al. (2019) also showed that Sismantik training increased ABJ, with the highest results in the fourth larval monitoring. Research by Ibrahim et al. (2019) found a significant difference in larval presence before and after counseling. PSN 3M activities target water reservoirs, both for daily use (TPA), non-TPA, and natural water reservoirs (Ministry of Health RI, 2017).

The integrated control model developed is expected to become an integrated control concept based on community participation, especially in Padang City, to reduce the population of Aedes aegypti mosquitoes as the vector of DHF. This model can be applied ecologically at regional and national levels, with further research on mosquito nest control approaches and engineering at various mosquito life stages.

CONCLUSIONS

This study demonstrates that various types of modified water containers, whether made from cement, fiber, or glass, can serve as breeding sites for *Aedes aegypti* mosquitoes. The development of larvae varied across container types, with slower larval growth observed particularly in Cement Container 1 (19 larvae) and Fiber Container 3 (19 larvae), compared to other containers. The type and condition of water containers significantly influenced the larval development period within 14 days, consistent with the life cycle characteristics of *Aedes aegypti*.

The observations further confirm that stagnant water, often found in uncovered water containers, provides favorable conditions for mosquito breeding. Although material type (fiber or cement) showed no significant effect on larval development statistically ($p > 0.05$), the presence and management of stagnant water remain critical factors. These findings align with previous studies indicating that water storage habits, container type, and environmental factors such as climate, household behavior, and water availability significantly affect larval density and DHF (Dengue Hemorrhagic Fever) risk.

Additionally, previous studies show that regions with higher container density and lower community participation in mosquito control programs have a higher incidence of DHF. The high larval densities found in both landfill and non-landfill containers emphasize the need for continuous monitoring and public health interventions. Effective container management, community participation in the 3M Program (Drain, Cover, Remove), and environmental engineering are essential to reducing mosquito breeding sites and, consequently, the transmission risk of DHF.
Therefore, an integrated control approach involving community engagement and continuous monitoring is crucial for sustainable vector control efforts. Future interventions should focus on container management, education on water storage practices, and regular larval surveys to mitigate the spread of dengue vectors.

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