Analysis of Water Acidity Levels on the Presence of Aedes aegypti Larvae in Pampang Village, Panakkukang District, Makassar City

Ronny[1*], Arini Puspitasari[2], Nurfitriani Azizah[3]

[1] *Country Occupational Safety and Health Study Program, Universitas Sulawesi Barat, Prof. Dr. Baharuddin Lopa, S.H. Street, Talumung, Baurung, Banggae Timur District, Majene Regency, West Sulawesi 91412, Indonesia*

[2] *Environmental Sanitation Study Program, Poltekkes Kemenkes Makassar, Wijaya Kusuma Raya Street No. 46, Banta-Bantaeng, Makassar City, South Sulawesi 90222, Indonesia*

[3]*Environmental Management Study Program, Universitas Hasanuddin, Perintis Kemerdekaan Street No. 10, Tamalanrea Indah, Tamalanrea District, Makassar City, South Sulawesi 90245, Indonesia*

Corresponding Author.

**Email*: ronnyunsulbar@gmail.com

Abstract: *Water pH is an important chemical parameter that indicates the acidity or alkalinity of water and can influence biological processes in aquatic environments, including mosquito breeding. This study aimed to analyze the relationship between water pH levels and the presence of Aedes aegypti larvae in household water storage containers. This research employed a quantitative observational design with a descriptive-analytic approach. A total of 99 households in Pampang Village, Panakkukang District, Makassar City were selected using simple random sampling. Data collection included direct observation of larvae presence and measurement of water pH using a calibrated pH meter. The results showed that 45 houses (45.5%) were positive for Aedes aegypti larvae, while 54 houses (54.5%) were negative. Most water storage containers had alkaline pH (77.8%), while 22.2% were acidic. Larvae were predominantly found in alkaline water (88.9%). Statistical analysis using the Chi-square test showed a significant relationship between water pH and larval presence (p = 0.015). The odds ratio (OR) indicated that alkaline water increased the risk of larval presence. In conclusion, water pH is significantly associated with the presence of Aedes aegypti larvae. Community-based interventions focusing on water quality monitoring and regular cleaning of water storage containers are recommended.*

Keywords: *Aedes aegypti larvae, Water pH, Water Storage Container, Dengue Vector Control*

1. INTRODUCTION

The pH value of water is an important chemical parameter that describes the degree of acidity or alkalinity of a solution, which is theoretically defined as the logarithm of the activity of dissolved hydrogen ions (H^+). Although it does not have an absolute scale, water pH plays a major role in determining the physical and chemical stability of water [1]. Water with a pH below neutral (pH < 7) tends to undergo changes in color, odor, and taste, and may affect the acid base balance and electrolyte equilibrium in the human body [2]. Therefore, controlling water pH is a crucial aspect in both environmental health and public health contexts. In various studies, water pH is often used as an initial indicator of chemical changes occurring in a medium, including raw water sources and water stored in containers [3]. An unsuitable level of acidity can alter material properties and environmental conditions, thereby affecting organisms living within it [2]. In general, substances with a pH below 7 are categorized as acidic because they release hydrogen ions, whereas substances with a pH above 7 are alkaline due to the release of hydroxide ions when dissolved in water [4]. These conditions directly influence the biological processes of various aquatic organisms, including disease vectors.

One environmentally based disease that remains a global public health problem is Dengue Hemorrhagic Fever (DHF) [5]. The World Health Organization (WHO) reports that approximately 2.5 billion people worldwide, or about 40% of the global population living in tropical and subtropical regions, are at high risk of contracting DHF. In Indonesia, control of Aedes aegypti as the primary vector of DHF is carried out through various Mosquito Breeding Site Eradication (PSN) strategies, including routine larval surveillance, maintenance

of larva-eating fish, and implementation of the 4M program (draining, covering, burying, and monitoring). The success of these efforts is generally measured using the Larvae-Free Index (ABJ) [6].

Aquatic environments, particularly water pH, are known to play an important role in the growth and development of Aedes aegypti. Larval development to the adult stage is strongly influenced by the pH conditions of their habitat [7]. Acidic environments have been reported to inhibit larval development into adult mosquitoes. This phenomenon is related to the activity of cytochrome oxidase enzymes in larval metabolism [8]. Dissolved oxygen levels in water, which are influenced by pH, also determine the effectiveness of these enzymes. At lower pH levels, dissolved oxygen content tends to be higher, whereas in alkaline conditions dissolved oxygen levels are lower, potentially inhibiting larval metabolic processes [9]. Thus, water pH may serve as an environmental factor influencing the survival and life cycle of Aedes aegypti.

Water storage containers (WSCs) such as drums, buckets, and other household water containers constitute the primary breeding sites for Aedes aegypti [10]. Numerous studies have reported high larval density in WSCs within residential environments. Reported that out of 3,343 WSCs examined, 2,953 were positive for Aedes aegypti larvae. This condition indicates that the characteristics of water in WSCs, including pH, significantly contribute to the risk of DHF transmission [11]. Therefore, larval control through PSN activities and the use of larvicides remain the main strategies for preventing this disease, with the ABJ serving as an indicator of program effectiveness [12].

Regionally, South Sulawesi Province continues to experience a relatively high burden of DHF. Data from the 2020 South Sulawesi Health Profile recorded 2,714 DHF cases with an incidence rate of 29.6 per 100,000 population. During the period from January to May 2020, 2,166 DHF cases with 19 deaths were reported. At the local level, the working area of Pampang Health Center, Panakkukang District, Makassar City, showed fluctuating DHF cases, with 79 cases in 2021, 53 cases in 2022, and 42 cases in 2023. In addition, the condition of water storage facilities in this area still indicates the presence of WSCs that do not meet health standards, totaling 1,595 out of 10,680 existing facilities [2].

The persistently high incidence of DHF, particularly in urban areas such as Panakkukang District, indicates that existing vector control efforts have not yet been fully optimal. Most PSN programs continue to focus on physical and behavioral aspects, while the chemical characteristics of water, especially the pH of water in storage containers, have not been widely studied as environmental risk factors [13]. In fact, water pH has the potential to influence the survival and development of Aedes aegypti larvae. Therefore, research on the role of water pH in storage containers as an environmental factor in DHF vector control is highly important. The findings of this study are expected to provide a scientific basis for developing more effective, sustainable, and environmentally based DHF control strategies.

2. METHOD

The research was conducted in two stages: the preparation stage from December 2023 to January 2024 and the data collection stage from March to April 2024. The study population consisted of all household heads in Pampang Subdistrict, totaling 10,379 households. The sample size was determined using the Slovin formula with a simple random sampling technique, resulting in 99 houses selected as samples. The independent variable in this study was water pH, while the dependent variable was the presence of *Aedes aegypti* larvae in water storage containers. Primary data were collected through direct observation using observation sheets to identify the presence of larvae and through measurement of water pH, while secondary data were obtained from books, journals, scientific articles, and relevant health facility records. To ensure measurement accuracy, the pH meter was calibrated daily using standard buffer solutions (pH 4, 7, and 10) prior to field measurements. Larval identification was conducted through direct visual inspection using standard larval survey procedures. Potential confounding variables such as water temperature, type of container, and container cleanliness were also recorded during observation. However, these variables were not included in the final statistical model and are acknowledged as study limitations. The collected data were then processed and analyzed using the Chi-square test with a significance level of $p < 0.05$ with the assistance of SPSS software, and the results were presented in tabular form to facilitate interpretation.

3. RESULTS AND DISCUSSION

Based on the results of the study conducted in Pampang Subdistrict, Panakkukang District, Makassar City, from April 24 to April 26, 2024, a survey of *Aedes aegypti* larvae was carried out in household water storage containers. A total of 99 household samples were examined during morning to afternoon hours through direct

surveys using observation sheets and a pH meter. The pH values obtained during the study ranged from 6 to 8. The types of water storage containers identified included 22 basins, 70 buckets, and 7 bathtubs. The collected data were subsequently presented in tabular form as follows:

Table 1. Types of Water Storage Containers Identified in Pampang Subdistrict, Panakkukang District, Makassar City, 2024

No	Types of Shelters	Frequency (n)	Percentage (%)
1	Basin	22	22,2%
2	Bucket	70	70,7%
3	Bathtub	7	7,7%
	Total	**99**	**100%**

Source : Primary Data

Table 1 shows that among the 99 sampled houses, the most commonly found type of water storage container was buckets, with 70 units (70.7%), followed by basins with 22 units (22.2%), and bathtubs with 7 units (7.1%). This finding indicates that buckets are the dominant type of water storage container used by the community in Pampang Subdistrict.

Table 2. Water pH Levels in Water Storage Containers in Pampang Subdistrict, Panakkukang District, Makassar City, 2024

NO	pH	Frequency (n)	Percentage (%)
1	Acid	22	22,2%
2	Neutral	0	0%
3	Base	77	77,7%
	Total	**99**	**100%**

Source : Primary Data

Table 2 shows that the majority of water storage containers at the study site had alkaline pH levels, with 77 houses (77.8%). Acidic pH levels were found in 22 houses (22.2%), while no water storage containers with neutral pH were identified. This condition indicates that the chemical characteristics of water in Pampang Subdistrict tend to be alkaline.

Table 3. Presence of *Aedes aegypti* Larvae in Water Storage Containers in Pampang Subdistrict, Panakkukang District, Makassar City, 2024

NO	The presence of Aedes aegypti larvae	Frequency (n)	Percentage (%)
1	Positive (+)	45	45,4%
2	Negative (-)	54	54,5%
	Total	**99**	**100%**

Source : Primary Data

Table 3 shows that out of 99 houses examined, 45 houses (45.5%) were positive for the presence of *Aedes aegypti* larvae in water storage containers, while 54 houses (54.5%) were negative. These results indicate that nearly half of the surveyed households still have the potential to serve as breeding sites for dengue vector mosquitoes.

Table 4. Presence of *Aedes aegypti* Larvae in Water Storage Containers Based on Acidic, Neutral, and Alkaline pH in Pampang Subdistrict, Panakkukang District, Makassar City, 2024

NO	pH	Frequency (n)	Percentage (%)
1	Acid	5	11,1 %
2	Neutral	0	0 %
3	Base	40	88,8 %
	Total	**45**	**100%**

Source : Primary Data

Table 4 shows that among the 45 water storage containers that were positive for *Aedes aegypti* larvae, the majority were found in alkaline conditions, with 40 containers (88.9%). Meanwhile, only 5 containers (11.1%) with acidic pH were positive for larvae, and no larvae were found in containers with neutral pH.

Table 5. Relationship Between Water pH and the Presence of *Aedes aegypti* Larvae in Pampang Subdistrict, Panakkukang District, Makassar City, 2024

Acidity Level		The Existence of Mosquito Larvae				p-value
		Positive		Negative		
		n	%	n	%	
1	Acid	5	11,1%	17	31,4%	0,015
2	Base	40	88,8%	37	68,5%	
	Total	**45**	**100%**	**54**	**100%**	

Source : Primary Data

Table 5 shows that the presence of *Aedes aegypti* larvae was most frequently observed in water storage containers with alkaline pH, accounting for 40 containers (88.9%), whereas only 5 containers (11.1%) with acidic pH were positive. The statistical analysis using the Pearson Chi-square test yielded a p-value of 0.015 ($p < 0.05$), indicating a statistically significant relationship between water pH and the presence of *Aedes aegypti* larvae in water storage containers in Pampang Subdistrict.

The findings of this study conducted in Pampang Subdistrict, Panakkukang District, Makassar City, demonstrate that both the physical characteristics of household water storage containers and the chemical properties of stored water are closely associated with the presence of *Aedes aegypti* larvae. The distribution of water storage container types revealed that buckets were the most commonly used containers, accounting for 70 units (70.7%) out of the 99 houses surveyed, followed by basins with 22 units (22.2%) and bathtubs with only 7 units (7.7%). The predominance of buckets reflects common household practices in urban residential areas, where buckets are frequently used as secondary or backup water storage due to irregular water supply. However, this practice inadvertently increases the risk of mosquito breeding, as buckets tend to be left filled with water for extended periods without regular draining or cleaning. Such stagnant and stable water conditions are highly favorable for *Aedes aegypti*, a mosquito species that prefers clean, stagnant water in artificial containers for oviposition [14].

Field observations further indicated that the presence of larvae was more frequently detected in buckets compared to bathtubs. This difference can be explained by variations in container usage and maintenance. Bathtubs are typically used daily for bathing activities, resulting in frequent water replacement and cleaning, which disrupts the mosquito life cycle by removing eggs and larvae attached to container walls [15]. In contrast, buckets are often used intermittently, rarely scrubbed, and sometimes only partially covered, allowing mosquito eggs to remain attached to the inner surfaces and hatch undisturbed [16]. Additionally, the physical attributes of buckets such as their relatively small size, darker color, and more turbid water compared to bathtub water create microenvironments that are more attractive to female mosquitoes for laying eggs [17]. Limited community awareness regarding the importance of routine inspection and cleaning of water storage containers further exacerbates this condition, allowing containers to function as persistent breeding habitats and increasing the risk of Dengue Hemorrhagic Fever (DHF) transmission within residential areas [18].

In terms of chemical characteristics, water pH measurements showed that the majority of water storage containers contained alkaline water. Of the 99 houses examined, 77 houses (77.7%) had alkaline water, while 22

houses (22.2%) had acidic water, and no containers were found to have neutral pH. This distribution indicates that the water stored in household containers in the study area tends to be alkaline in nature. From an environmental health perspective, water pH is an important parameter because it influences water stability, dissolved oxygen levels, microbial growth, and overall biological activity within aquatic environments [19]. Chemically, acidic water (pH < 7) is characterized by higher concentrations of hydrogen ions (H^+), whereas alkaline water (pH > 7) contains higher concentrations of hydroxide ions (OH^-). These chemical conditions can directly or indirectly affect the survival and development of aquatic organisms, including mosquito larvae [20].

The survey of larval presence revealed that 45 houses (45.4%) were positive for *Aedes aegypti* larvae, while 54 houses (54.5%) were negative. This finding indicates that nearly half of the surveyed households still serve as potential mosquito breeding sites, suggesting that vector control efforts in the study area have not yet been fully effective. The relatively high proportion of positive containers reflects a substantial Container Index (CI), which is commonly used as an indicator of dengue transmission risk [21]. Previous studies have consistently reported that household water storage containers are the primary breeding sites for *Aedes aegypti*, particularly in areas where water storage practices are common [22]. Behaviors such as leaving containers uncovered, infrequent draining, and failure to scrub container walls allow mosquito eggs to remain viable for long periods and hatch when favorable conditions arise [23].

Further analysis of larval presence based on water pH showed a clear pattern. Among the 45 containers that were positive for larvae, 40 containers (88.8%) had alkaline water, while only 5 containers (11.1%) had acidic water, and none had neutral pH. This distribution suggests that *Aedes aegypti* larvae were more frequently found in alkaline water conditions than in acidic environments. Alkaline water is believed to provide a more suitable environment for larval development because it supports the growth of microorganisms, algae, and organic matter that serve as essential food sources for mosquito larvae. In contrast, acidic water conditions may cause physiological stress, disrupt metabolic and enzymatic processes, and increase larval mortality [24]. Acidic environments may also enhance the solubility of certain toxic compounds, such as heavy metals, which can further inhibit larval survival [25]. In addition to these chemical effects, behavioral factors play a role, as female mosquitoes tend to select oviposition sites that maximize the likelihood of offspring survival.

Statistical analysis using the Chi-square test confirmed a significant relationship between water pH and the presence of *Aedes aegypti* larvae, with a p-value of 0.015, which is lower than the established significance level of 0.05. This result indicates that water pH is one of the environmental factors influencing larval presence in household water storage containers. The findings of this study are consistent with previous research, including studies which reported a significant association between water pH and the presence of *Aedes aegypti* larvae. Although female mosquitoes are not entirely selective with respect to water pH during oviposition, the acidity or alkalinity of water has a substantial impact on egg hatching success and larval development into adult mosquitoes [26]. Extremely acidic conditions can inhibit plankton growth, thereby reducing the availability of food for larvae and ultimately decreasing their survival rates [27]. Despite the significant association observed, this study may be subject to several potential biases. Measurement bias may occur due to environmental fluctuations affecting pH readings. Observation bias is also possible, as larval identification relied on visual inspection without laboratory confirmation. In addition, confounding factors such as temperature, organic matter content, and container maintenance practices may influence larval presence but were not fully controlled in this study. Therefore, the results should be interpreted with caution.

Overall, the results of this study emphasize that the persistence of *Aedes aegypti* breeding sites is influenced by a combination of physical and chemical environmental factors, particularly the type of water storage container and the pH of stored water. Therefore, dengue prevention and control efforts should not only focus on modifying community behavior through routine draining, covering, and cleaning of water storage containers but also consider water quality management as an integral component of sustainable environmental health interventions. Integrating these approaches is essential to reduce mosquito breeding potential and ultimately lower the risk of dengue transmission in residential settings.

4. CONCLUSION

Based on the Chi-square test results, a p-value of 0.015 was obtained, which is lower than the significance level of $\alpha = 0.05$. Therefore, it can be concluded that there is a relationship between water acidity (pH) and the presence of Aedes aegypti mosquito larvae in water storage containers. The study results showed that among the 22 houses with acidic water pH, larvae were found in 5 houses, while no water storage containers with neutral pH were identified. In addition, among the 77 houses with alkaline water pH, 40 water storage

containers were positive for the presence of Aedes aegypti larvae. These findings indicate that variations in water pH play a role in the presence of mosquito larvae in water storage containers within residential environments. Based on these results, it is recommended that communities routinely monitor the acidity level (pH) of water in household water storage containers, such as bathtubs, buckets, and other storage vessels, to prevent the formation of breeding sites for Aedes aegypti larvae [28]. Furthermore, future researchers are encouraged to include additional environmental variables, such as water temperature, and to conduct more specific identification of mosquito larvae using microscopic examination to obtain more comprehensive research findings. The odds ratio analysis further indicates that alkaline water conditions increase the likelihood of larval presence by approximately 3.68 times compared to acidic conditions. These findings highlight the importance of considering water quality, particularly pH, as part of integrated dengue vector control strategies.

Overall, the results of this study emphasize that the presence of Aedes aegypti larvae in residential environments does not occur in isolation but is influenced by a combination of environmental factors, particularly the characteristics of water storage containers and the chemical condition of the water in terms of acidity (pH). The dominant use of buckets as water storage containers, which are typically infrequently drained and contain stagnant water, provides substantial opportunities for Aedes aegypti mosquitoes to breed. This condition is further reinforced by the finding that most larvae were detected in water storage containers with alkaline pH, which biologically supports greater food availability and larval survival.

LIMITATIONS

This study has several limitations. First, confounding variables such as water temperature, organic content, and container hygiene were not controlled analytically. Second, larval identification was conducted without laboratory confirmation, which may introduce classification bias. Third, the cross-sectional design limits the ability to establish causality between water pH and larval presence. Future studies are recommended to use experimental or longitudinal designs and include more comprehensive environmental variables.

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