

Community-Based Monitoring and Education on Household Water Quality in a Rural Area of Karawang

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Abstract

Surface water serves as the primary source of water for many communities but is highly vulnerable to contamination, which poses significant health risks. Telukambulu Village, located in Karawang, West Java, faces persistent challenges in maintaining the quality of household water. This community service initiative aimed to assess household water quality by analyzing physical parameters and using test strips to screen for key chemical indicators. The findings indicate that the water is not fully suitable for daily use, such as drinking and cooking, due to inconsistencies in parameters including pH, alkalinity, and chlorine levels. To address these issues, educational sessions were conducted to increase residents' awareness of proper water management, alongside the introduction of simple, sustainable filtration technologies. This initiative successfully improved community understanding of water quality and offered practical solutions for enhancing household water safety. By promoting this approach, the program aims to empower the community to manage water more effectively and support improved public health and living standards.

1. INTRODUCTION

Water quality has a significant impact on nearly all aspects of human activity. However, factors such as urbanization, industrialization, climate change, population growth, and other human-induced activities have made both surface and groundwater increasingly vulnerable to contamination (Wang et al., 2023). According to the World Health Organization (WHO), approximately 80% of diseases in developing countries are attributed to biological contamination of water. Globally, the lack of adequate sanitation and access to clean drinking water places nearly 2.3 billion people at risk of contracting waterborne illnesses (Perveen & Amar-UI-Haque, 2023).

Surface water refers to all liquid water present on the Earth's surface. While the Earth's hydrosphere consists predominantly of liquid water, over 97% of it is saltwater from the oceans. Only 1.1% comprises fresh liquid water, and of that, 99% is stored as groundwater, leaving just 1% as surface freshwater. Freshwater is essential for sustaining

all living organisms, maintaining public health, supporting food production, and driving most industrial activities. However, anthropogenic pressures, including pollution, industrialization, climate change, and population growth, have increasingly degraded water quality and strained global water resources. These challenges underscore the urgent need for sustainable water management and robust environmental governance frameworks (Uddin et al., 2023). Given its broad utility, which includes for drinking and domestic purposes, industrial and scientific applications, irrigation and agriculture, horticulture, livestock production, and aquatic ecosystem management surface, water remains a vital and ubiquitous resource (Syed et al., 2023). Consequently, comprehensive monitoring and accurate assessment of surface water quality are essential to ensure safe and hygienic water use.

Karawang Regency faces ongoing challenges in ensuring adequate water supply, particularly during the dry

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season. These issues are evident in the region's inability to meet the community's basic water needs consistently throughout the year. Current challenges include the uneven distribution of water, insufficient raw water availability, poor flow continuity, and failure to meet clean water quality standards (Isyanto & Mulyadi, 2020). According to the Karawang Regency Medium-Term Regional Development Plan for 2021–2026, the region's water quality index declined significantly, from 60.00 in 2016 to 44.2 in 2020. In light of this decline, it is essential to strengthen water quality monitoring efforts, which includes improving sanitation infrastructure for both household and public restrooms.

Water quality assessment involves the analysis of various characteristics, including chemical, physical, and biological properties. Several models are commonly employed to evaluate water quality, such as the Water Quality Index (WQI), the Pollution Index (PI) (Syeed et al., 2023), and tools based on remote sensing and Geographic Information System (GIS) technologies (Ahmed et al., 2023). Among the available methods, the use of water test strips offers a rapid and cost-effective alternative for monitoring water quality. This approach allows for the quick assessment of water conditions, typically within seconds. Water test strips are user-friendly, safe, easy to interpret, and capable of measuring multiple parameters simultaneously. These parameters include total chlorine, hardness, alkalinity, iron, copper, nitrate, nitrite, pH, and chloride, among others (Kyei et al., 2023).

The objective of this study was to assess water quality for sanitation and hygiene purposes in Telukambulu Village, located in Batujaya District, Karawang, using water test strips. Telukambulu covers an area of approximately 635 hectares and is home to around 5,898 residents. Administratively, the village consists of three hamlets: Krajan I, Krajan II, and Jatimulya. The village is situated near an irrigation canal that is part of the Citarum River Irrigation System, a vital infrastructure that supports agriculture in the region. Although the canal is primarily intended for irrigation, its proximity to residential areas increases the risk of indirect contamination of local water sources. Agricultural pollutants such as fertilizers, pesticides, and other runoff may infiltrate groundwater or household wells, posing a potential threat to the quality of water used for daily household needs.

The village's socioeconomic conditions further amplify these risks. The majority of Telukambulu residents depend on agriculture as their primary source of income, particularly as rice farmers or laborers in nearby fields. Others are engaged in informal trading or low-income employment sectors. Educational attainment is generally low to moderate, and access to healthcare facilities remains limited. Many households lack sufficient access to clean water and proper sanitation infrastructure, which increases their vulnerability to waterborne diseases and hygiene-related health issues.

Given these circumstances, it is essential to evaluate the quality of water used by the community, particularly

groundwater from dug wells and bore wells, as well as water supplied by Perusahaan Daerah Air Minum (PDAM). Although most households do not use surface water from the irrigation canal directly, its proximity remains a significant environmental factor that may compromise the safety of local water sources. This study, therefore, aimed to provide a practical and cost-effective method for initial water quality screening using water test strips, to help inform public health efforts and promote improved sanitation practices in the community.

In addition, the program included community education and the introduction of simple water purification technologies to enhance overall water quality. Educational sessions were conducted to raise public awareness of the importance of water quality management for health and daily use. Alongside these efforts, simple and affordable water filtration methods were introduced, enabling households to adopt sustainable practices for clean water management. These initiatives aimed to equip the community with practical tools and knowledge to improve water quality and foster a healthier living environment.

2. METHOD

This study consisted of two main stages. The first stage involved screening household water quality in Telukambulu Village, while the second focused on disseminating the findings to residents and raising awareness about the importance of water quality for health.

Water samples were collected using a cluster random sampling technique from households in the three hamlets: Krajan I (36 samples from 120 households), Krajan II (36 samples from 110 households), and Jatimulya (24 samples from 90 households). The samples were tested using water quality test strips to evaluate physical characteristics, including color, odor, and the presence of lead, mercury, iron, and cyanuric acid.

In the second stage, the results of the water quality screening were presented to the community along with recommendations for addressing the identified concerns. The presentation included a detailed explanation of the potential health risks associated with poor water quality, supported by the data gathered during the screening. This stage aimed to enhance public awareness of the importance of maintaining water quality for daily use and overall health.

To support improvements in water quality, the program introduced a simple water filtration device based on an existing design widely implemented due to its low cost and ease of use. The filtration system was constructed using PVC pipes and a series of filter media, including cotton filter, silica sand, activated carbon, zeolite sand, and manganese sand, layered to remove contaminants effectively. The construction process involved three main steps:

1. assembling the main filtration tube using a 4-inch PVC pipe fitted with drilled holes and connectors,
2. building a Z-shaped water flow system using $\frac{3}{4}$ -inch

PVC pipes and elbow joints with a ball valve for water input, and

3. integrating all components into a functional filtration unit.

The filter media were arranged in the following sequence: cotton filter, silica sand, cotton filter, activated carbon, cotton filter, zeolite sand, and cotton filter. This device was not a novel invention, but rather an adaptation of a simple, proven design tailored to local conditions. Practical demonstrations were held in the village to show how the filtration system operated and to highlight its ability to reduce contaminants and improve access to safe drinking water. The initiative aimed to empower the local community with accessible tools and knowledge to support sustained clean water access.

3. RESULT AND DISCUSSION

Clean water is defined as water that meets the health and quality standards established by governmental regulatory bodies. It can be categorized into two main types: physically clean water and chemically clean water. Chemically clean water is assessed based on its physical, chemical, and biological properties. Based on field data collected from the hamlets of Krajan I, Krajan II, and Jatimulya, the majority of residents rely on groundwater and, most predominantly, water supplied by the Perusahaan Daerah Air Minum (PDAM). As shown in Figure 1, PDAM is the most widely used water source in the area. PDAM provides clean water through a subscription system, with fees based on consumption. Many residents prefer using PDAM water due to the poor quality of their available groundwater sources.

One of the main advantages of PDAM is its ability to ensure a reliable and regulated water supply, particularly in areas where groundwater is susceptible to contamination. In Telukambulu Village, approximately 80% of the population depends on piped or suspended water sources. However, the quality of household water remains inconsistent. Some samples were odorless, indicating acceptable physical conditions, while others had noticeable odors, suggesting possible contamination (Afifah & Asnan, 2015; Li et al., 2025).

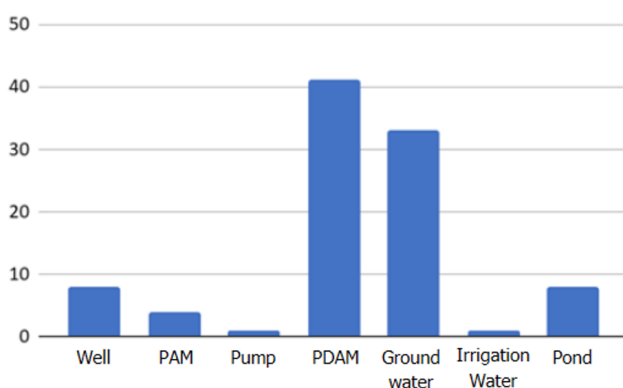


Figure 1. Diagram of water sources in Telukambulu Village in percentage

In Telukambulu Village, water quality remains a critical concern. Observations shown in Figure 2 indicate that approximately 60% of households have odorless water, while the remaining 40% report an unpleasant odor. In terms of visual characteristics, most households use water that appears clear, suggesting low levels of suspended particles. However, some residents encounter water that is slightly cloudy, murky, or discolored, with shades ranging from yellowish and greenish to brown. Clean water is essential not only for supporting human health but also for maintaining ecosystem stability. To be classified as clean, water must meet both physical and chemical quality standards. Physically, clean water should be clear, odorless, and tasteless. Chemically, it should contain low concentrations of pH-altering substances, organic matter, heavy metals, nitrates, sulfates, and chlorine. Based on field data, household water in Telukambulu generally meets physical standards, as the majority of residents report water that is clear and odorless.

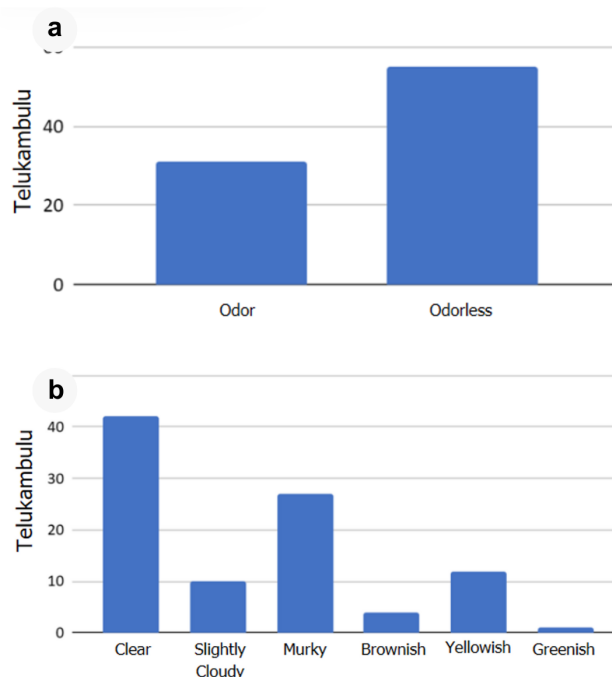


Figure 2. (a) The odor levels in percentage; (b) Water color levels of water in Telukambulu Village in percentage

The level of acidity or alkalinity in water, commonly measured by pH, plays a critical role in determining water quality and its suitability for consumption and daily use. According to the World Health Organization (WHO), the optimal pH range for safe drinking water is between 6.5 and 8.5, with a neutral pH of approximately 7 considered ideal. Neutral water ensures that it is neither too acidic nor too alkaline, making it safe for drinking, cooking, and other household activities.

Water with a pH below 6.5 is classified as acidic and may corrode plumbing systems, leach toxic metals such as lead and copper, and produce an unpleasant sour taste. Prolonged consumption of acidic water may also pose health risks. On the other hand, water with a pH above 8.5

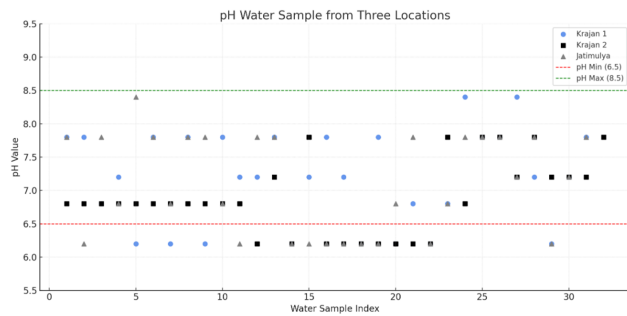


Figure 3. Graph of pH of household water in Telukambulu Village

is considered alkaline, which can result in a bitter taste, the buildup of scale on fixtures and pipes, and reduced effectiveness of cleaning agents such as soaps and detergents (Arhin et al., 2023; Yehia & Said, 2021).

Maintaining water within the recommended pH range is therefore essential to ensure its safety, protect household infrastructure, and support public health. Regular monitoring and appropriate treatment methods, such as the addition of neutralizing agents, are necessary to manage and stabilize the pH of water supplies (Tai et al., 2025).

The graph in Figure 3 illustrates that the average pH levels in the three hamlets of Telukambulu Village range from 6.2 to 8.4, which falls within the World Health Organization's recommended range of 6.5 to 8.5. Water with a pH of 6.2 is slightly acidic, reflecting the presence of substances that release hydrogen ions (H^+) into solution. This mild acidity can occur when water interacts with carbon dioxide to form carbonic acid, a weak acid that plays a role in maintaining pH balance in both biological systems and drinking water.

Despite being slightly below the lower limit, a pH of 6.2 is still generally considered safe for household use, particularly in the absence of corrosive effects or harmful metal leaching. Therefore, the observed pH range of 6.2 to 8.4 in Telukambulu Village suggests that most household water sources are acceptable for daily activities such as drinking and cooking. In addition to pH, water hardness is another important parameter influencing water quality. Hardness is primarily caused by the presence of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions. Water is classified as soft if it contains less than 60 mg/L of hardness, moderately

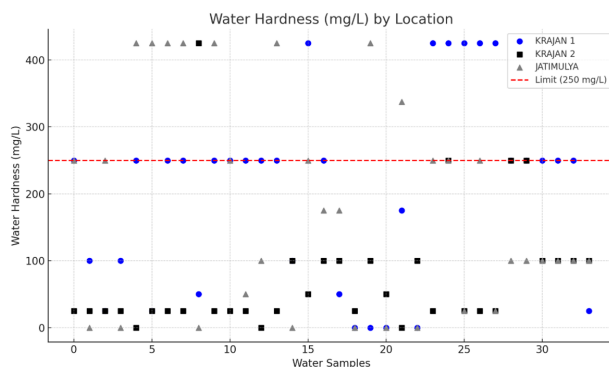


Figure 4. Graph of household water hardness in Telukambulu Village

if between 60 and 180 mg/L, and hard if above 180 mg/L. In most household settings, typical hardness levels range between 60 and 120 mg/L (Ingin et al., 2024).

The observation data (Figure 4) show that the hardness levels of household water in Telukambulu Village range from 0 to 425 mg/L, indicating a wide variation in calcium and magnesium concentrations. High hardness can cause scale buildup on appliances and pipes, reduce the effectiveness of soaps and detergents, and lead to maintenance issues. On the other hand, very low hardness may result in slightly acidic-tasting water that is less suitable for daily use due to the lack of essential minerals. To manage high water hardness, households may monitor water quality regularly, install filtration systems at the water inlet, or use acid-based cleaning agents such as vinegar to remove scale from equipment and pipes.

Chlorine is widely used as a disinfectant in drinking water and sanitation systems. In this study, total chlorine levels varied significantly across samples. The ideal concentration of total chlorine in drinking water ranges from 0.2 to 0.4 mg/L. Levels below this range may result in ineffective disinfection, increasing the risk of bacterial and viral contamination and contributing to unpleasant taste and odor (Akram & Rehman, 2018). Conversely, excessive chlorine concentrations can lead to health concerns such as

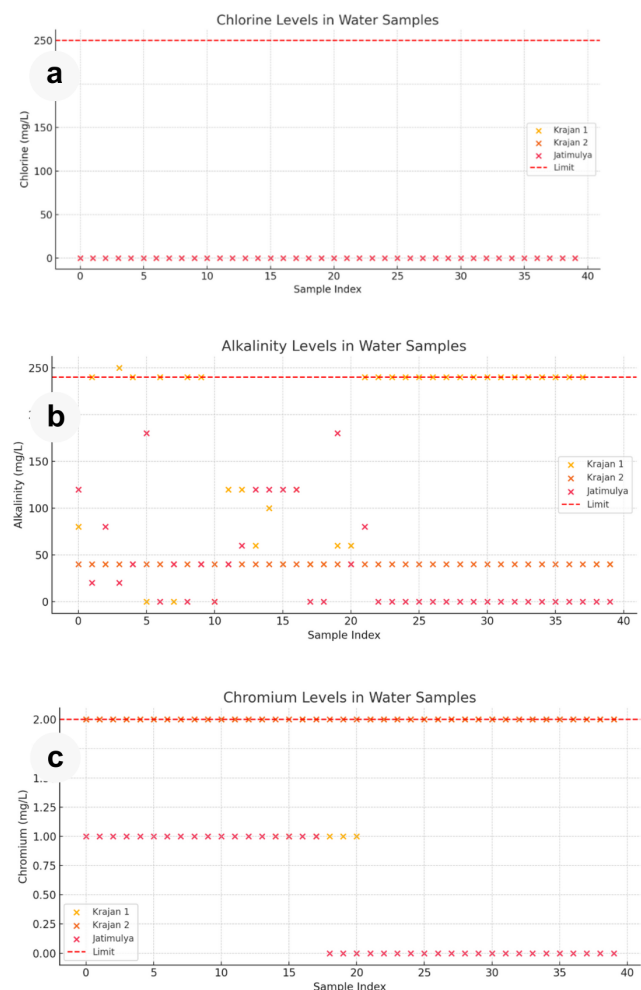


Figure 5. (a) Total chlorine; (b) Total alkalinity; (c) Total chromium in household water in Telukambulu Village

skin and eye irritation and have been linked to long-term risks including certain types of cancer, in addition to producing an undesirable taste and odor in the water (Botlagunta et al., 2015).

Figure 5 (a) shows that total chlorine levels in Telukambulu Village range from 0 mg/L to 250 mg/L. Dusun Krajan I exhibited particularly high chlorine concentrations, resulting in strong odors and potential health risks such as skin and eye irritation. To reduce chlorine levels, water can be left in open containers to allow for natural evaporation, treated with dechlorinating agents, or boiled although boiling does not fully eliminate chlorine.

Figure 5 (b) indicates that total alkalinity values also range from 0 mg/L to 250 mg/L. Low alkalinity, which may result from acidic groundwater or excessive purification, can be corrected using alkaline materials such as hydrated lime. In contrast, high alkalinity, often caused by limestone presence or alkali metal contamination, can be managed through filtration or by adding acids like sulfuric acid to adjust pH levels (Fitriani et al., 2023).

Figure 5 (c) shows that chromium levels in household water in Telukambulu Village range from 0 mg/L to 2 mg/L, with some samples significantly exceeding the general safety threshold of 0.05 mg/L. Elevated chromium concentrations may result from industrial pollution, chemical runoff contaminating groundwater, or poor water management practices. Chromium contamination also contributes to increased alkalinity levels in the water. To address low alkalinity, materials such as porcupine lime or hydrated lime can be used to raise the pH. Conversely, high alkalinity can be reduced through filtration or by adding acids such as sulfuric acid. To manage chromium contamination, installing appropriate water filtration systems is essential to ensure concentrations remain within safe limits. These combined strategies are necessary to preserve the safety and quality of household water in Telukambulu Village (Ahmed et al., 2021; Prasad et al., 2021).

Other chemical parameters such as nitrate, nitrite, bromine, mercury, copper, lead, iron, and cyanuric acid were found to be within acceptable limits and therefore do not negatively affect household water quality in Telukambulu Village, as presented in Table 1. However, based on the complete observation data, water purification is still necessary for both groundwater and surface water sources to ensure long-term safety. Household water filters offer a practical and affordable solution for addressing clean water challenges in the area. Furthermore, increasing public awareness of the importance of clean water for health and daily needs remains essential for supporting sustainable water use and public well-being (Saraswati et al., 2023).

After Following the water quality screening process, the results were disseminated to the residents of Telukambulu Village through a dedicated community session. This activity aimed to communicate the findings of the evaluation, which identified key concerns such as inconsistent chemical parameters, including pH, alkalinity, and chlorine levels, that influence the suitability of water for daily use such as drinking and cooking. The presentation emphasized the potential health risks associated with poor water quality and underscored the importance of maintaining safe and clean water for household purposes.

In addition to presenting the screening results, the session introduced a simple and practical household water filtration system designed to address the identified water quality issues. A hands-on demonstration was conducted to explain its operation, maintenance procedures, and overall benefits. The filtration system is a gravity-based, multi-layer device constructed from PVC pipes and filled with accessible filtering materials such as filter cotton, silica sand, activated carbon, manganese sand, and zeolite. These materials are arranged in layers to progressively remove suspended particles, odors, organic matter, and heavy metals from the water. This technology was selected for its cost-effectiveness, ease of assembly using locally available materials, and long-term sustainability, making it a viable

Table 1 . Chemical parameter values of household water in Telukambulu Village

No	Parameter	Value	WHO Standard
1	Hardness	0-425 mg/L	<500 mg/L acceptable
2	Alkalinity Total	0-250 mg/L	No health-based guideline
3	Carbonate Root	0-300 mg/L	No health-based guideline
4	Total Chlorine	0 mg/L and 250 mg/L	Max. 5 mg/L
5	Free Chlorine	0-0.5mg/L	0.2–0.5 mg/L (at point of use); max. 5 mg/L
6	Bromine	0-1 mg/L	No health-based guideline
7	Nitrate	0-50 mg/L	Max. 50 mg/L
8	Nitrite	0 mg/L	Max. 0.2 mg/L
9	Fluoride	0 mg/L	Max. 1.5 mg/L
10	Cr(VI)	0-2 mg/L	Max. 0.05 mg/L (total chromium)
11	Copper	0 mg/L	Max. 2 mg/L
12	Lead	0-5 mg/L	Max. 0.01 mg/L
13	Mercury	0 mg/L	Max. 0.006 mg/L
14	Iron	0-0.3 mg/L	Max. 0.3 mg/L
15	Cyanuric Acid	0 mg/L	No health-based guideline
16	pH	6.2-8.4	6.5-8.5

option for the community without requiring significant financial or technical resources. Through the demonstration, participants acquired practical skills and knowledge that enable them to independently improve the quality of water used in their households.

The dissemination and training session received active participation from the residents of Telukambulu Village, reflecting a strong interest and commitment to improving their living conditions. Community members asked questions, shared personal experiences related to water quality, and expressed a willingness to adopt the filtration technology in their households. Several residents showed further initiative by volunteering to assist in assembling the filters during the demonstration, indicating a developing sense of ownership and responsibility.

This interactive engagement not only enhanced community awareness of water quality management but also encouraged the adoption of sustainable practices. Through this collaborative approach, the program successfully delivered practical knowledge and tools to support improved access to clean water, thereby contributing to better health, hygiene, and overall quality of life in Telukambulu Village.

Through this collaborative approach, the program effectively delivered practical guidance and tools to support the community in ensuring access to safe and clean water. These efforts contributed to improvements in health, hygiene, and overall quality of life in Telukambulu Village. This process is illustrated in Figure 6, which depicts the dissemination of water quality findings (Figure 6 (a)) and the introduction of simple household filtration technology (Figure 6 (b)) to local residents.



Figure 6 . (a) Findings dissemination; (b) Simple filtration technology introduction

4. CONCLUSION

The community service program implemented in Telukambulu Village successfully enhanced public awareness of household water quality and its impact on health. Water quality testing using test strips revealed that several key chemical parameters, including pH, alkalinity, and chlorine, did not fully meet the safety standards set by the World Health Organization (WHO) and the Indonesian Ministry of Health Regulation No. 32 of 2017. These findings helped the community understand that water which appears clear and odorless may still pose health risks if it does not meet chemical safety criteria.

During the dissemination session, residents actively engaged by asking questions and showing interest in adopting the introduced household filtration system. Several households began implementing the system, and informal feedback indicated noticeable improvements in water clarity and taste. Although limited in duration, the program effectively raised awareness, fostered community participation, and provided practical tools for managing water quality. As a result, the initiative contributed to promoting better health, hygiene, and overall well-being within the village.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest. The funding agency had no involvement in the design of the study, the collection or analysis of data, the preparation of the manuscript, or the decision to publish this article.

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