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Analysis of pH and Total Coliform Bacteria Contamination in Rainwater Based on the Materials and Maintenance of Rainwater Harvesting Systems

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The present study investigates variations in the quality of rainwater, with a focus on the materials and maintenance practices employed in rainwater harvesting (RWH) systems within Ploso Hamlet, Plosobuden Village, Lamongan Regency. The aim of the present study is to monitor pH levels and to identify the presence of total coliform contamination. The present study employed a descriptive quantitative approach, with 30 RWH units being purposively selected from a total of 106. The data were collected through three means: observation, in-depth interviews, and laboratory testing. The result of this study shows that rainwater was contaminated with coliform bacteria, with a mean value of 3.6 MPN/100 ml and a maximum value of >1600 MPN/100 ml, which exceeds the standard for drinking water (0 MPN/100 ml). Furthermore, 48.3% of samples exhibited a pH value that exceeded the acceptable range, with the highest recorded value being 10.7. Maintenance was substandard, with 66.7% of respondents admitting to cleaning their tanks only once a year. Furthermore, none had received education on proper maintenance. In conclusion, the analysis indicates that harvested rainwater in Ploso Hamlet does not conform to the criteria for direct consumption. The study identifies the presence of biological contamination and improper pH levels as the primary causes of the water's unsuitability for human consumption. It is recommended that the knowledge base be augmented through the implementation of a health education programme, complemented by enhanced filtration measures.

Keywords: Biological contamination, Total Coliform Bacteria, pH, Rainwater Harvesting System

INTRODUCTION

Access to drinking water is an essential for maintaining of huma health (Bhavsar et al., 2025; Subba Rao, 2021). Water is a vital component of the Earth's ecosystems, playing a pivotal role in sustaining life as we know it. It is the most abundant compound on the planet's surface, a fact that is widely recognised (Bhavsar et al., 2025). Drinking water refers to water that has undergone treatment or not and is used for various purposes such as drinking, cooking, hygiene, and religious practices (Regulation of the Minister of Health of the Republic of Indonesia Number 2, 2023). The availability of safe and adequate drinking water is essential for protecting public health. In Indonesia, 92.64% of households have access to safe drinking water, with coverage reaching 96.56% in urban areas and 87.06% in rural areas (BPS, 2025). This disparity highlights the inequality in the provision of safe drinking water, particularly in rural areas that face limited infrastructure and resources. One of the main reasons for low access in rural communities is the limited coverage of piped water systems, which reach only about 20% of households. Consequently, many people continue to rely on alternative water sources that may not meet established safety standards (Indayani, 2025). A study conducted in a different field has demonstrated that urban areas have a higher access rate to potable water than rural areas. This finding suggests that rural areas may require greater emphasis on the purification of water and the development of drinking water infrastructure (Chimombo, 2025). The limited access to clean drinking water can pose significant health risks to the community and have considerable ramifications for its socioeconomic status, as well as having adverse effects on the environment (Sebayang et al., 2025).

The challenges posed by water scarcity are being exacerbated by a number of factors, including urbanisation, climate change, and population growth (He et al., 2021; Subba Rao et al., 2024). Lamongan Regency, East Java, is among the regions struggling with the provision of safe drinking water. The proportion of households with access to safe drinking water in Lamongan has steadily declined, from 92.18% in 2020 to 81.9% in 2021, 78.56% in 2022, and 79.26% in 2023 (BPS East Java, 2023). This decline places Lamongan as the regency with the lowest safe drinking water coverage in East Java. The situation is further worsened by seawater intrusion in several areas, such as Deket Subdistrict, which has rendered groundwater brackish, unsafe, and unfit for consumption (Asmoay et al., 2026).

Plosobuden Village in Deket Subdistrict is one of the areas severely affected by seawater intrusion. Groundwater in this village contains very high levels of salinity and Total Dissolved Solids (TDS), with TDS reaching 1,260 mg/L, far exceeding the permissible limit of 300 mg/L, and electrical conductivity recorded at 2,680 μmhos/cm (Najih, 2020). This condition has forced the community to seek alternative sources of drinking water, one of which is rainwater collected through Rainwater Harvesting Systems (Eko Sutrisno & Jazilah, 2024).

Rainwater, however, is susceptible to contamination both before and after reaching the storage system (Liu et al., 2021). It may be polluted in the atmosphere by dust, smoke, and airborne particles, and further contaminated upon contact with rooftops, gutters, and storage tanks. Materials such as metals and asbestos, as well as accumulated organic matter, can be washed into the storage system by rainfall, thereby increasing the risk of both microbiological and chemical contamination (CDC, 2024).

The contamination of residents' wells by seawater has resulted in the community's increased reliance on rainwater as a potable water source. The utilisation of rainwater by the community as a substitute for drinking water and clean water is subject to the influence of environmental conditions and the condition of rainwater storage materials. The unhygienic conditions of the area have the potential to cause biological contamination in the water consumed by the community, especially water sourced from rainwater reservoirs (Fathia et al., 2025). Concurrently, the presence of total coliform bacteria is indicative of microbiological contamination, which can lead to health complications such as diarrhea (Novita et al., 2020). Furthermore, the water may contain elevated pH levels, a consequence of its proximity to the sea and industrial sites in the northern coastal region. It is hypothesised that the ingestion of the water may result in health concerns if it is consumed directly, as deviations in pH have been shown to disrupt the body's acid–base balance and pose risks such as alkalosis (Hafizah & Zamli Tajudin, 2020). Moreover, the materials employed in rainwater Harvesting systems have the capacity to contaminate rainwater collection, as these materials are among the components that can influence bacterial contamination and influencing the pH of rainwater (Zdeb et al., 2020).

Seawater intrusion into residential areas has led to the salination of wells, necessitating the reliance on rainwater by local residents. This study aims to analyse variations in total coliform contamination and pH levels of harvested rainwater, and to evaluate the quality of harvested rainwater in Ploso Hamlet in relation to storage tank materials, roofing materials, and gutter materials, alongside household maintenance behaviour in Ploso Hamlet.

METHODS

Study Design

The present study employed a descriptive quantitative methodology to investigate variations in rainwater quality, with a particular focus on pH levels and total coliform concentrations as influenced by the construction materials and maintenance of rainwater harvesting (RWH) systems in Ploso Hamlet, Lamongan.

Population and sample collection

The research population was divided into two categories, comprising 106 physical RWH units and their corresponding users. From this population, a sample of 30 units and 30 respondents was selected through purposive sampling. This sampling strategy was specifically designed to capture the diversity in materials used for storage tanks, roofs, and gutters, while adhering to the quantitative standard that considers a sample size of 30 or more sufficient for accurate descriptive analysis.

Laboratory analysis

pH measurement analysis (Chemical analysis)

The chemical analysis of the rainwater centred on the pH levels, which were determined using a digital pH meter. In order to maintain measurement precision and prevent cross-contamination, the electrode was thoroughly rinsed with mineral-free deionized water and blotted with lint-free tissue before being submerged in the sample. It is important to note that meticulous care was taken to ensure the electrode stabilised without coming into contact with the vessel's surfaces. Furthermore, automatic temperature compensation was applied and the ambient temperature was recorded in order to maintain data consistency. Subsequent to each measurement, the equipment was meticulously cleaned and stored in accordance with the standard manufacturer protocols.

Microbiological analysis (total coliform)

The most probable number (MPN) method was used to assess the presence of total coliform bacteria. The process was initiated with the preparation of a 15-tube series comprising Lactose Broth or Brilliant Green Lactose Bile Broth and inverted Durham tubes. These were sterilised in an autoclave at 121°C for 15 minutes to ensure effective sterilisation. The inoculation process was executed in an aseptic manner, employing sterile pipettes to deliver the inoculum across three series of five tubes, each containing varying volumes of 10 mL, 1 mL, and 0.1 mL. Following an incubation period of between 24 and 48 hours at temperatures ranging from 35 to 37°C, the tubes were examined for the presence of growth indicators. Such indicators included turbidity of the media and gas production resulting from lactose fermentation. The positive tube combinations that resulted from this process were then recorded and converted into MPN/100 mL values using the standard McCrady probability table. In conclusion, the safety and quality of the rainwater were evaluated by means of a benchmarking process. This entailed the comparison of all laboratory findings with the national drinking water standards established by the Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023.

Data analysis

In this study, the data analysis was conducted in a descriptive manner, with the data presented exclusively in tabular and chart form.

Ethic

This Study was approved by Ethical committee of Health research Faculty of Dentistry Jember university No.3018/UN25.8/KEPK/DL/2025. All of respondent signed the informed consent.

RESULT AND DISCUSSION

pH, and Total Coliform

The laboratory tests on 30 rainwater samples collected from household rainwater harvesting systems (RWH) in Ploso Hamlet revealed considerable variation in both pH and total coliform parameters. The result of this study can be seen on Figure 1.

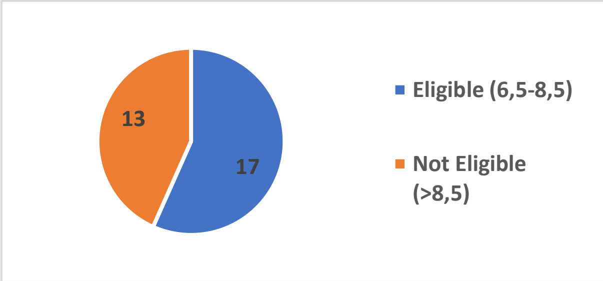

Figure 1. Eligible and ineligible pH level

The analysis of pH revealed that 17 samples (53.3%) were within the standard range (6.5–8.5), while 13 samples (46.7%) exhibited values that exceeded this limit. The highest pH value recorded are 10,7. Elevated pH values were most likely influenced by the interaction of rainwater with storage and gutter materials, particularly concrete or metals, which released alkaline compounds into the water (Rathore et al., 2025). The organoleptic quality of the water was diminished by such conditions, and the potential for health risks was created when the water was consumed continuously (CDC, 2024).

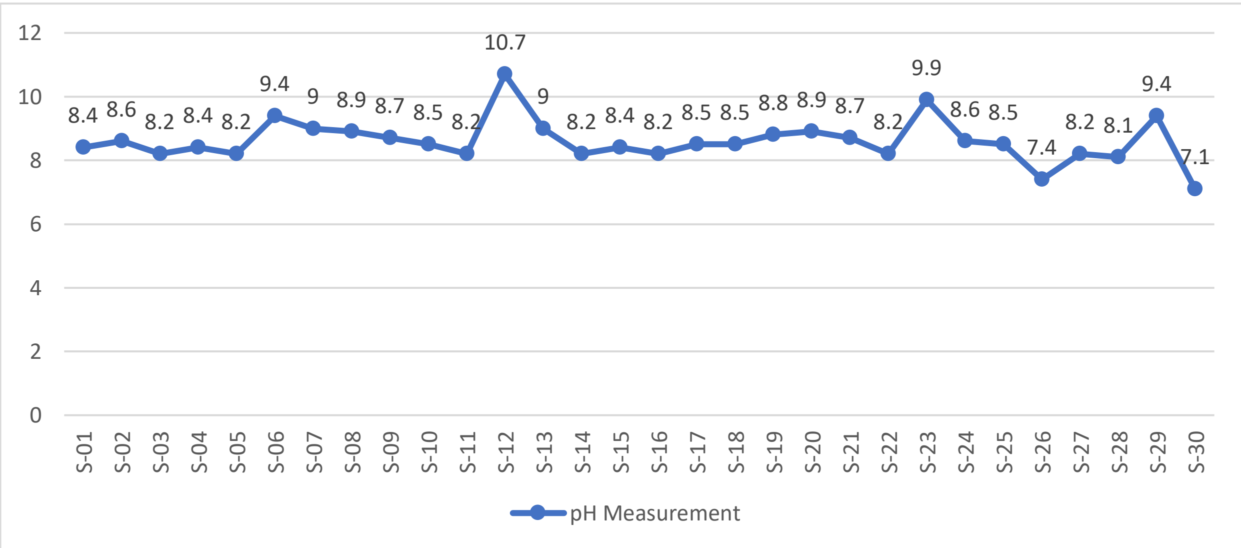

Figure 2. Total result of pH measurement

The pH levels that were recorded were found to be the highest at 10.7 and 9.9 (Figure 2). The elevated pH levels that have been observed in numerous instances can be attributed to a variety of factors, including the utilisation of substandard materials in the construction of rainwater harvesting systems or the presence of acidic rainwater.

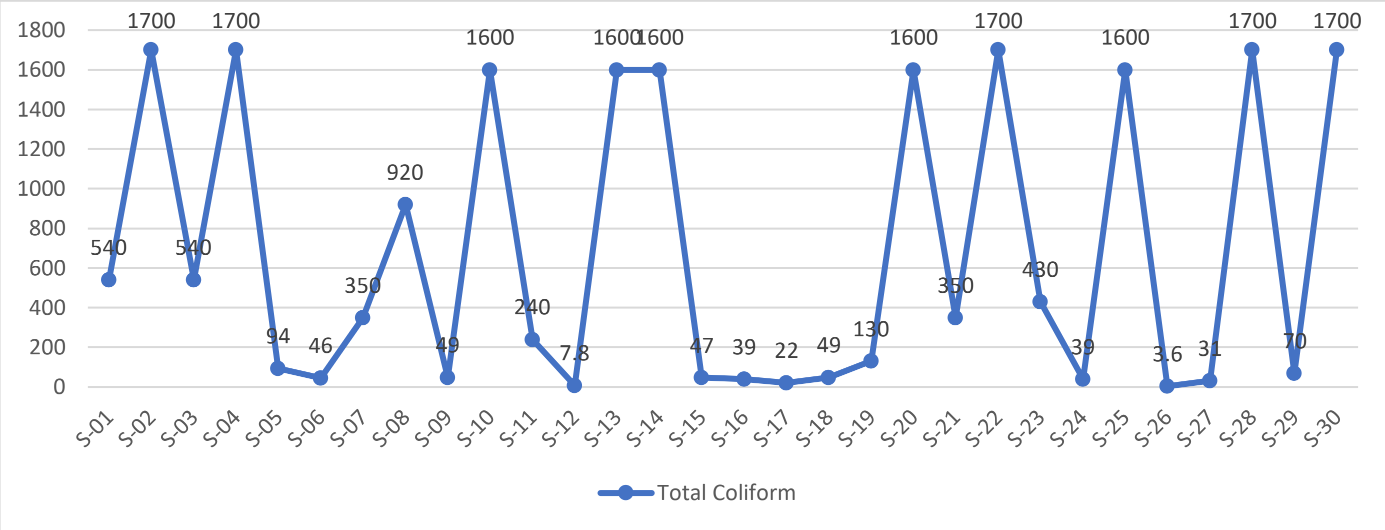

Figure 3. Result of total coliform

The total coliform count of 1700 is a laboratory result that exceeds 1600. The findings indicate that the total coliform standard was not met by any of the samples analysed (i.e. 100% failure rate). Contamination levels exhibited significant variation, ranging from 3.6 MPN/100 mL to more than 1600 MPN/100 mL in nine samples. The findings indicated severe biological contamination, most likely originating from animal droppings, dust, and organic debris that accumulated on rooftops and gutters before being transported into the storage tanks by rainfall. The situation was exacerbated by the infrequency of cleaning. However, the results indicated the presence of total coliform bacteria in excess of 1600 MPN/100 mL, thereby substantiating the assertion that inadequate maintenance practices significantly contributed to the elevated level of contamination.

The material of rooftop, gutter and storage of RWH

The RWH material was observed on 30 respondents. The RWH is divided into three sections: roofs, gutters and storage.

Table 1.
Rooftops material of RWH

Category	Total	Percentage (%)
Clay	26	86.6
Asbestos	4	13.4
Total	30	100

The evaluation of materials indicated that the majority of rooftops were composed of clay (86.6%), as illustrated in Table 1. Despite their structural integrity, clays exhibited a propensity to retain dirt, thereby augmenting the probability of contamination. As demonstrated in Table 3, it is evident that all respondents utilised asbestos roofs, which were identified in multiple units. These units also exhibited elevated coliform counts.

Table 2.
Gutter Materials of RWH

Category	Total	Percentage (%)
Zinc	2	6.7
Tarpaulin	3	10
PVC	23	76.6
Galvalume	2	6.7
Total	30	100

Table 2, demonstrated gutters RWH materials. The construction of gutters was predominantly characterised by the utilisation of PVC (76.6%), yet none of the systems were equipped with a first flush device, thereby permitting the initial wash-off of pollutants to enter directly into the tanks.

Table 3.
Storage Tank Materials

Category	Total	Percentage (%)
PE	3	10
Clay	2	7
HDPE	1	3
Concrete	24	80
Total	30	100

It was observed that a number of respondents utilised water storage tanks constructed from a variety of materials, including polyethylene (PE), clay, high-density polyethylene (HDPE), and concrete. The results of the storage tank observations can be seen in Table 3.
Storage tanks were predominantly constructed of concrete (80%), a material that has been proven to exhibit greater durability than earthenware or plastic. Nevertheless, concrete tanks were still unable to prevent microbiological contamination in the absence of proper maintenance.

pH and total coliform with Cleaning Frequency
Table 4. shows the crosstabulation of pH measurement with cleaning frequency of RWH.

Table 2
Crosstabulation of pH measurement with cleaning frequency of RWH

pH Measurement	Cleaning Frequency		
	>1 Year	1 Year	Total
Eligible	6	11	17
Not Eligible	4	9	13
Total	10	20	30

The data presented in Table 4. indicates that there is no correlation between cleaning frequency and pH measurement. Evidence suggests that respondents who have been cleaning RWH for over a year continue to encounter inadequate results. This finding indicates that the frequency of cleaning does not have a significant impact on pH measurement outcomes.

Table 3.
Total coliform with cleaning frequency

Total Coliform	Cleaning Frequency		Total
	>1 Year	1 Year	
<350	0	14	14
≥350	10	6	16
Total	10	20	30

The total coliform in table 5 grouped based on median value. As illustrated in Table 5, a high prevalence of total coliform was observed in respondents who clean their RWH less than once a year, while those who clean regularly exhibited reduce the total coliform

pH measurement with RWH materials
The pH measurement results obtained in this study demonstrate variability. Rainwater harvesting systems have been identified as a factor that can affect water pH.

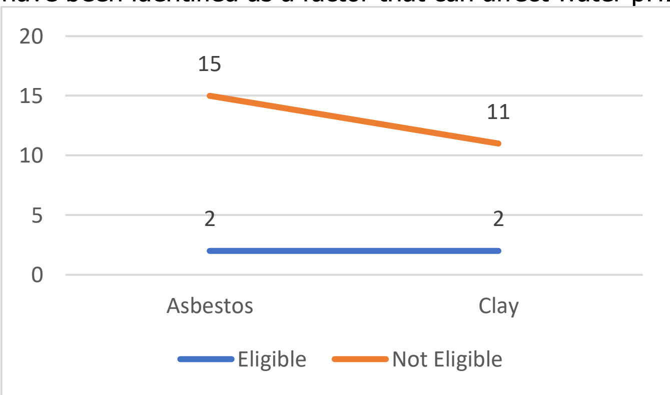

Figure 4. pH measurement with roof material

As demonstrated in Figure 3, the majority of water samples were found to be substandard, indicating that the roofing materials utilised in rainwater harvesting can affect the pH of the water.

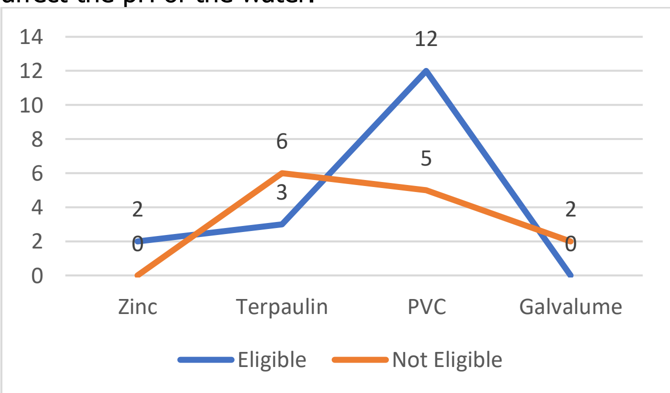

Figure 5. pH Measurement with gutter material

As demonstrated in Figure 4, the pH measurement results obtained using various materials for gutters in respondents' homes demonstrate significant variations. As demonstrated in Figure 4, respondents who utilise tarpaulin and galvalume as gutters exhibit higher levels of pH. This discrepancy can be attributed to the potential impact of tarpaulin and galvalume on the pH level of the water collected by respondents.

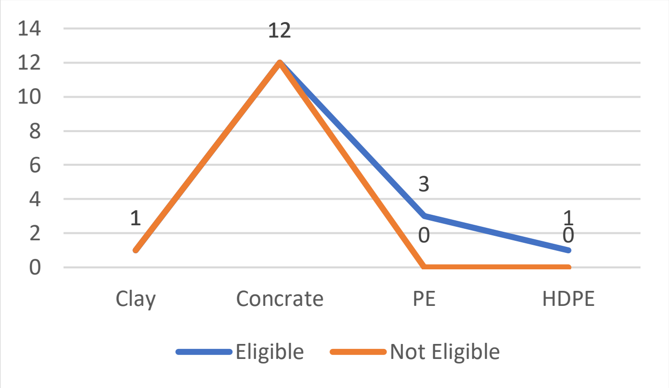

Figure 6. pH Measurement with Storage Material

As demonstrated in Figure 5, the pH measurement results obtained using the respondents' water storage materials are presented. As demonstrated in Figure 5, the pH measurement results for both eligible and ineligible materials are comparable, indicating that the materials employed in water storage do not significantly contribute to an increase in water pH.

Rainwater harvesting is of pivotal importance in the context of environmental sustainability and local water security. However, it should be noted that the success of this practice is inextricably linked to rigorous public health standards. While these systems have been demonstrated to be effective in the capture of precipitation, with a view to mitigating urban runoff and providing an essential backup supply, there is also a potential risk in terms of creating habitats for pathogens and disease-carrying vectors if these systems are neglected.

The composition of the roof and gutters is a significant factor in the minimisation of pollution. As demonstrated in Tables 1 and 2, the majority of households (86.6%) utilised clay tile roofs, while the remaining households (13.3%) employed asbestos roofs. With regard to gutters, PVC was the most prevalent material (76.6%), followed by galvalume (6.6%), zinc (6.6%), and tarpaulin (10%). The present study has demonstrated that the variation in roofing and guttering materials has a significant impact on the chemical and microbiological quality of stored rainwater.

The chemical stability of clay tile roofs is attributable to the fact that they do not directly alter the pH of rainwater. However, the accumulation of dust, moss, and bird droppings is facilitated by the materials' porous surface and rough texture. During periods of rainfall, these organic and inorganic residues are washed into the gutters and subsequently transported into the storage tanks, thereby increasing the microbial load of the collected rainwater. As reported by Mao et al., (2021) and Deng, (2021) also reported similar findings, namely that the presence of microorganisms and organic matter was found to be higher on porous roofing materials than on smoother surfaces, such as metal roofs. Another result from Raimondi et al., (2023) shows that roofing material significantly contributes to the microbiological quality of harvested rainwater, particularly in relation to coliform levels and suspended solids.

In contrast, the use of asbestos roofing, which was employed in a smaller proportion of households, did not have a significant impact on pH levels. Nevertheless, the primary risk associated with this process pertains to the potential release of fine fibres into the storage system during periods of rainfall. The accumulation of such fibres poses long-term health risks, despite their infrequent inclusion in rainwater quality assessments. It is imperative to emphasise that asbestos roofing should be avoided in rainwater harvesting systems, given its potential to release hazardous inorganic contaminants (Macher et al., 2025).

Gutters function as the primary conduit for rainwater entering the storage tank, and their material condition exerts a direct influence on water quality. Polyvinyl chloride (PVC) gutters, the most commonly used, are chemically inert and thus do not affect pH. However, field observations indicated that nearly half of the PVC gutters were in poor hygienic condition. In the absence of regular cleaning procedures, biofilms and organic detritus accumulate on the gutter surfaces, thereby serving as a significant source of microbial contamination (Trinh et al., 2020). Furthermore, none of the surveyed systems in Ploso Hamlet were equipped with a first flush diverter, a simple device designed to exclude the initial runoff of rainwater that typically contains the highest load of contaminants. First flush devices have been shown to have a significant effect on the reduction of microbial contamination, particularly total coliforms, in harvested rainwater (Jamal et al., 2023).

As shows in figure 4 that using a galvalume shows a higher pH. Metallic gutters, including zinc and galvalume, are associated with an elevated risk of corrosion. While a significant proportion of extant literature focuses on roof materials, it is evident that the same mechanism applies to gutters, as both involve direct contact between rainwater and metallic surfaces. This interaction facilitates the leaching of heavy metals, thereby compromising the chemical quality of the water and posing potential health concerns with long-term exposure (Souza de Carvalho et al., 2025).

The findings of the present study indicate that both roofing and guttering materials play a significant role in determining the quality of harvested rainwater (figure 3). Whilst clay tile roofs and PVC gutters appear to be comparatively safer than other materials, their effectiveness is contingent on regular cleaning and maintenance. The absence of first flush devices serves to compound the issue by enabling the initial runoff, which is characterised by its high concentration of pollutants, to enter the storage tank directly. Practical interventions, such as the cleaning of roofs and gutters prior to the rainy season and the installation of simple first flush devices, are therefore essential. These measures are consistent with international recommendations and have been demonstrated to be effective in reducing chemical and microbiological contamination in rainwater harvesting systems (Lay et al., 2024).

In addition to the chemical composition of the water samples, the study also encompassed a comprehensive analysis of their microbiological content. A comprehensive microbiological analysis was conducted, which revealed a pervasive presence of contaminants across all rainwater harvesting units in Ploso Hamlet. It was found that all water samples (100%) tested positive for total coliforms, with values ranging from 3.6 to >1600 MPN/100 mL. This finding suggests that untreated harvested rainwater in the area may be microbiologically unsafe for direct consumption. It is evident that even the lowest count (3.6 MPN/100 mL) exceeds the acceptable limit of 0 MPN/100 mL. Furthermore, nine samples have been found to have reached the maximum detectable threshold (>1600 MPN/100 mL). The present findings are consistent with the findings of another study, which established that microbial contamination is a universal challenge in rainwater harvesting systems, particularly in the absence of treatment measures such as filtration or disinfection (Kennedy et al., 2025).

The uniformity of contamination across all systems suggests that tank material does not play a decisive role in determining microbial water quality. The resultant data demonstrate that concrete tanks have been associated with elevated pH levels; however, this does not appear to have hindered microbial proliferation. In a similar manner, plastic tanks (HDPE/PE), which are chemically inert, also exhibited significant levels of coliform contamination. These results emphasise that microbial risks are not primarily governed by tank material but rather by upstream factors such as roof conditions, gutter cleanliness, and overall maintenance practice. As Posited by Livhuwani et al., (2025), the presence of microbial contamination in rainwater harvested from roof catchments and gutters is indicative of debris accumulation, rather than an inherent problem with the storage tanks themselves.

The presence of microbial contamination was attributed to materials used in the construction of the roof and gutters. The prevalence of clay tile roofs in Ploso Hamlet is indicative of the historical development of the region. These roofs are characterised by their porosity, which leads to the accumulation of organic debris and bird droppings. During periods of rainfall, these contaminants are washed into the storage tanks, thereby elevating microbial loads. The resultant data demonstrate that the utilisation of an asbestos roof, a galvalume gutter, and a clay tank resulted in a coliform level of 350 MPN/100 mL being exhibited. This case demonstrates that combinations of reactive roofing and corrodible guttering materials have the potential to exacerbate microbial risks. As Nwogu et al., (2024) similarly emphasised, roof and gutter debris are pivotal in determining microbial contamination in rainwater harvesting systems.

The laboratory analysis yielded findings that indicated a propensity for pH elevation, a phenomenon that exhibited a robust correlation with the utilisation of concrete tanks. Concrete tanks constituted 66.67% of the total sample, and almost half of these exhibited pH values above the permissible drinking water range (6.5–8.5). The maximum pH recorded was 10.7, thus confirming a clear correlation between the utilisation of concrete as a storage medium and the augmentation of rainwater alkalinity.

The chemical properties of cement, the primary constituent of concrete, underpin this phenomenon. Cement is composed of calcium oxide (CaO) and other alkaline minerals, which, upon hydration, form calcium hydroxide ($Ca(OH)_2$). It has been demonstrated that contact between uncoated concrete surfaces and stored rainwater promotes leaching of calcium and hydroxide ions, thereby elevating the pH level (An et al., 2021). Similar mechanisms were reported by Mao et al., (2021) who demonstrated that rainwater interacting with concrete undergoes pH elevation due to the release of alkaline compounds.

Empirical evidence further indicated that there was no correlation between pH elevation and a reduction in microbial contamination. The presence of total coliforms was detected in concrete tanks with elevated pH values, indicating pH levels of 10.7 and 7.8 MPN/100 mL and 9.9 and 430 MPN/100 mL, respectively. This finding demonstrates that while concrete significantly affects chemical parameters, it does not provide protection against microbial growth. Comparable outcomes were review study from (García-Ávila et al., 2023), reported that concrete elevates rainwater alkalinity without preventing biological contamination.

Furthermore, the sensory characteristics of the water, including its taste and texture, may also be altered. It is hypothesised that the long-term consumption of highly alkaline water may result in digestive health issues. These results are consistent with (Yuan et al., 2025) as well as García-Ávila et al, (2023), both of these studies underscored the significance of selecting suitable storage materials and implementing mitigation measures when the utilisation of concrete is inevitable. The recommended interventions to mitigate the risk of chemical contamination of water include the coating of the interior surfaces of concrete tanks with non-reactive materials, the regular cleaning of the tanks, and the application of simple post-treatment options before the water is consumed.

It is evident that cleaning practices have the capacity to serve as a solution for the reduction of bacterial contamination. The results of the study demonstrated a clear influence of cleaning practices on microbial water quality (table 5). As another respondent has noted, the cleaning is only conducted once every five years. This has been demonstrated to yield a prevalence of remarkably elevated contamination levels, with a quantifiable measurement of >1600 MPN/100 mL being documented. In contrast, the lowest count was recorded by a respondent who maintained a cleaning schedule on an annual basis, with a reading of 3.6 MPN/100 mL. This discrepancy underscores the significance of regular maintenance, as neglecting to clean the system can result in the accumulation of debris, organic matter, and microbial growth, thereby increasing the risk of contamination. However, the efficacy of cleaning is contingent not solely on frequency, but also on the thoroughness of the process. It is imperative to acknowledge that the neglect of critical components, such as roofs and gutters, may nullify the advantages inherent in tank cleaning alone. Recent studies have emphasised the importance of comprehensive maintenance procedures for the optimisation of rainwater harvesting systems. Such procedures include activities such as roof sweeping, gutter clearance, and storage tank scrubbing, which have been shown to substantially enhance the quality of harvested rainwater (Nwogu et al., 2024)

The presence of microbiological contamination has the potential to constitute a public health problem. These findings underscore the considerable risks confronting communities reliant on untreated rainwater. The universal detection of coliforms is indicative of potential exposure to pathogens associated with diarrheal diseases, cholera, and typhoid. Furthermore, the situation in Ploso Hamlet is exacerbated by seawater intrusion, which limits access to safe groundwater. As demonstrated in other studies, coliform bacteria have been shown to have a high prevalence during the rainy season. Furthermore, there is a robust body of evidence to suggest that contaminated water can lead to significant levels of mortality and morbidity, with diseases including typhoid fever, cholera, diarrhoea and hepatitis being particularly prevalent (Colín Carreño et al., 2023). Moreover, the occurrence of total coliforms has been linked with waterborne diseases, such as acute gastroenteritis and various systemic infections (Kurniasari et al., 2026). Furthermore, it has been demonstrated that restricted access to water resources has the potential to exacerbate the propagation of diseases. A further review has indicated that inadequate water, sanitation and hygiene can result in stunting and other infectious diseases, such as diarrhoea (Fitri et al., 2022; Rizaldi et al., 2025).

This dual vulnerability underscores the urgent need for practical interventions. Recent evidence demonstrates that simple measures such as comprehensive cleaning of roofs, gutters, and tanks, combined with the installation of first-flush diverters can significantly reduce microbial loads. Moreover, low-cost filtration technologies have been proven effective in improving the microbiological quality of harvested rainwater to meet drinking water guidelines, making them a feasible and sustainable option for rural communities (Ross et al., 2025).

The present study is subject to certain limitations due to the utilisation of descriptive methods; consequently, it is unable to provide a comprehensive analysis of the relationship or influence between pH and total coliforms in relation to the utilisation of Rainwater Harvesting (RWH) System materials and cleaning frequency. Further research is required to ascertain whether the utilisation of RWH materials which vary in composition is associated with pH or total coliform outcomes. Furthermore, the study's sample size was limited, rendering it inadequate for providing a comprehensive description of the prevailing circumstances in the field

CONCLUSIONS

In conclusion, this study demonstrates that the harvested rainwater in Ploso Hamlet fails to comply with established environmental health standards across both chemical and microbiological dimensions. The prevalence of elevated pH levels in nearly half of the samples is primarily attributed to the leaching of alkaline substances from concrete storage tanks, while the universal presence of total coliform across all tested samples indicates pervasive microbial contamination. These findings underscore that the deterioration of water quality is further compounded by inadequate maintenance practices and the systemic absence of essential design features, such as first-flush diverters and filtration units. Consequently, the integration of informed material selection, rigorous maintenance schedules, and enhanced user awareness is imperative to optimize the management of rainwater harvesting systems and safeguard public health within the community.

RECCOMENDATION

In order to ensure the safety of harvested rainwater for consumption, it is recommended that the community implement a systematic treatment process consisting of adjusting the pH to a range of 6.5–7.5, followed by chlorine disinfection and boiling as a final safety measure. This household-level treatment should be supported by a rigorous maintenance schedule for rainwater harvesting (RWH) systems, with thorough cleanings conducted at least every two months to prevent the accumulation of contaminants. In order to facilitate the aforementioned improvements, it is recommended that the Local Health Office of Lamongan instigate technical education programmes. These programmes should utilise training sessions and accessible media, such as leaflets or instructional videos. Concurrently, the distribution of essential tools, including pH strips and chlorine tablets, should be undertaken by newly established neighbourhood-level water cadres. It is recommended that subsequent research endeavours should be grounded in the findings of this descriptive study. Building upon its findings, future studies should incorporate a more extensive array of physical and chemical parameters. In addition, external environmental factors should be taken into account across a more expansive geographic area. This would facilitate the generation of more generalised and representative insights into the safety of RWH.

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