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SACRED WATER OR SAFE WATER? A SCIENTIFIC ASSESSMENT OF DRINKING WATER QUALITY AT THE SUNAN AMPEL MAUSOLEUM, SURABAYA

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Abstract

Water is a fundamental human necessity that must be available in a safe and potable form. In religious heritage contexts such as the Sunan Ampel Mausoleum in Surabaya, drinking water is not only consumed but also revered as spiritually significant, often perceived as sacred. This dual perception raises the question of whether such water is both spiritually and scientifically "safe." This study evaluated the quality of drinking water stored in traditional clay jars and stainless steel tanks, assessed against the Indonesian Ministry of Health Regulation No. 492/Menkes/Per/IV/2010. Three samples were analyzed for physical (temperature, TDS, pH), chemical (nitrite), and microbiological (Coliform and Escherichia coli, MPN method) parameters. The stateresults showed that while temperature was relatively high (≥30 °C), other physicochemical values remained within permissible limits [TDS: 135–186 mg/L; pH: 7.79–8.05; nitrite: <0.1 mg/L]. In contrast, all samples were microbiologically contaminated, exceeding the permissible limit of 0/100 mL. These findings demonstrate that, although the water meets physical and chemical standards, it poses a significant microbiological health risk. The study underscores the importance of sanitation monitoring and simple water treatment at religious sites, reinforcing the Islamic principle of halalan thayyiban (lawful and wholesome) consumption and highlighting the integration of scientific evidence with religious belief in safeguarding public health.

1. INTRODUCTION

Water is an essential element that sustains human life. Within the body, it serves as a solvent for biochemical reactions, regulates temperature, and facilitates the transport of nutrients and waste products [1]. An average adult requires approximately 2–2.5 liters of water daily to maintain optimal physiological functions [2]. However, unsafe drinking water is a major vehicle for disease transmission, including diarrhea, cholera, and other gastrointestinal disorders [3].

From an Islamic perspective, the Qur'an emphasizes the principle of consuming what is both lawful (halal) and wholesome (thayyib). As stated in Surah Al-Baqarah (2:168):

يٰٓاَيُّهَا النَّاسُ كُلُوْا مِمَّا فِى الْاَرْضِ حَلٰلًا طَيِّبًاۖ وَّلَا تَتَّبِعُوْا خُطُوٰتِ الشَّيْطٰنِۗ اِنَّهٗ لَكُمْ عَدُوٌّ مُّبِيْنٌ ١٦٨

Translation: "*O mankind, eat from whatever is on earth [that is] lawful and good, and do not follow the footsteps of Satan. Indeed, he is to you a clear enemy*" (Qur'an, Surah Al-Baqarah 2:168).

This verse underlines that food and beverages must not only meet legal permissibility but also health-related quality. Thus, the consumption of contaminated water contradicts the halalan thayyiban principle and endangers human health [4].

Drinking water quality in Indonesia is governed by the Regulation of the Minister of Health No. 492/MENKES/PER/IV/2010, which specifies physical, chemical, and microbiological standards [5]. Physically, water must be clear, odorless, and colorless, with acceptable levels of total dissolved solids (TDS). Chemically, pH should fall between 6.5–8.5, and nitrite levels must not exceed 3 mg/L [6], [7]. Microbiologically, drinking water must be free from *Escherichia coli* and coliform bacteria, which indicate fecal contamination [8]. Meeting these parameters is essential to ensure public safety.

In religious heritage sites such as the Sunan Ampel Mausoleum in Surabaya, drinking water is provided in earthen jars and stainless steel tanks for pilgrims. This water, sourced from nearby wells and distributed into containers, is perceived not only as potable but also as spiritually meaningful. Many pilgrims even take it home as a symbolic blessing [9], [10]. However, due to the absence of treatment and the open nature of the containers, such water is vulnerable to microbial contamination [11].

Previous studies have shown that while water from these jars often complies with physical and chemical standards, microbiological contamination, particularly with *Escherichia coli*, remains a recurring problem [12]. Moreover, most scientific research on drinking water quality in Indonesia has focused on household sources, public utilities, or refillable water stations [2], [13], [14]. Scientific assessments of water safety in religious public spaces are still scarce, despite the high level of social interaction and significant water consumption in such environments.

This study addresses that gap by evaluating the quality of drinking water at the Sunan Ampel Mausoleum as both a public health issue and a religious concern. By integrating scientific evidence with the Islamic concept of halalan thayyiban, the research provides a novel perspective on how religious heritage sites can embody both spiritual significance and social responsibility in ensuring safe water provision. Despite the growing concern over drinking water safety, scientific investigations in religious heritage settings remain limited, particularly in understanding how storage practices influence contamination risk. Existing studies have primarily focused on household or municipal water systems, with little attention given to open-access water provided in pilgrimage sites, where water is frequently handled, stored, and consumed under high human interaction. Moreover, the role of container material such as porous earthen jars versus non-porous stainless-steel tanks in shaping microbiological contamination has not been systematically examined in such contexts.

In this study, the concept of halalan ṭayyiban is not only treated as a normative principle but also as an analytical lens, where the "ṭayyib" dimension is operationalized through measurable physicochemical and microbiological safety parameters. Within this framework, this study aims to (1) assess the quality of drinking water at the Sunan Ampel Mausoleum based on selected key parameters, (2) compare contamination levels between different storage container types, and (3) evaluate potential contamination pathways associated with storage conditions and handling practices. It is hypothesized that water stored in porous earthen jars is more susceptible to microbiological contamination than water stored in stainless-steel tanks due to differences in material properties and exposure to environmental factors.

2. MATERIALS AND METHODS

This study employed a quantitative descriptive design to evaluate the quality of drinking water stored in earthen jars and *stainless-steel* tanks at the Sunan Ampel Mausoleum, Surabaya. Samples were analyzed for physical, chemical, and microbiological parameters, referring to the Indonesian National Standards (SNI) and the Regulation of the Minister of Health No. 492/MENKES/PER/IV/2010. Laboratory analyses were conducted at the Microbiology Laboratory and the Animal Tissue Culture Laboratory, Faculty of Science and Technology, Universitas Islam Negeri Sunan Ampel Surabaya.

Study Design and Sampling Strategy

This study employed a cross-sectional descriptive design with a comparative component to evaluate differences in water quality between storage container types at the Sunan Ampel Mausoleum, Surabaya. A total of three sampling points were selected based on commonly used drinking water sources for pilgrims, consisting of one stainless-steel tank (Sample I) and two earthen jars located in different areas (Samples II and III).

Water samples were collected at a single time point during peak pilgrimage activity to reflect typical usage conditions. Each sample was analysed in triplicate to ensure measurement reliability. The selection of sampling locations considered accessibility, frequency of use, and exposure to environmental conditions, which may influence contamination risk.

For water stored in open containers (earthen jars and tanks), samples were collected directly from the storage units rather than from distribution taps. The flushing procedure described in SNI guidelines was applied only where water was accessed via a tap system; however, in this study, sampling primarily represented the actual point-of-consumption conditions.

This design enables a comparative evaluation of microbiological contamination between porous (earthen jars) and non-porous (stainless-steel tank) storage systems.

Microbiological quality control was ensured by following standard aseptic techniques, sterilization procedures, and incubation conditions according to established MPN protocols. Negative controls (sterile media without sample inoculation) were used to confirm the absence of contamination in culture media.

The integration of religious belief in this study is conceptual rather than empirical, where the principle of *halalan ṭayyiban* is used as an interpretative framework to contextualize the scientific findings, rather than as a directly measured variable.

Equipment Sterilization

All glassware (test tubes, measuring cylinders, Erlenmeyer flasks) was cleaned, dried, and covered with cotton plugs. Petri dishes were wrapped in paper and, along with other equipment placed in heat-resistant plastic bags, sterilized in an autoclave at 121 °C for 30 minutes. Inoculating loops were sterilized by flaming over a Bunsen burner. All culture media used for inoculation were sterilized separately in an autoclave at 121 °C for 15 minutes [15].

Sample Collection

Sampling for physical and chemical parameters followed SNI 8995:2021, while microbiological sampling followed SNI 9063:2022. At each sampling point, taps were flushed for 1–2 minutes before collection.

Samples for physical and chemical testing were placed into clean containers, while microbiological samples were collected in sterile bottles, ensuring no contact with tap surfaces. Containers were sealed, labeled, and transported in a chiller at 4–6 °C until analysis [16].

Physical and Chemical Analysis

Total Dissolved Solids (TDS): Prior to testing, water samples were homogenized and poured into beakers. A calibrated TDS meter probe was immersed in the sample until readings stabilized (~2 minutes). The meter was cleaned after each measurement. Measurements were performed in triplicate for each sample [17].

Temperature: Water temperature was measured in situ using the TDS meter's temperature function. The probe was immersed in a homogenized sample until a stable reading appeared, recorded in triplicate for each sample [17].

pH: pH values were determined using a calibrated pH meter. Electrodes were immersed in homogenized samples until the readings stabilized (≈5 seconds). Measurements were conducted three times per sample [17].

itrite Levels: Nitrite was analyzed according to SNI 06-6989.9-2004 and confirmed by a commercial water strip test.

Solution Preparation: Reagents included sulfanilamide solution (5 g sulfanilamide in 300 mL distilled water + 50 mL concentrated HCl, diluted to 500 mL), N-(1-naphthyl) ethylenediamine dihydrochloride (NEDA) solution (200 mg in distilled water, stored in dark bottles), nitrite stock solution (12.32 g $NaNO_2$ in 10 mL distilled water = 250 mg/L NO_2^--N), intermediate solution (10 mg/L), and standard solution (0.5 mg/L).

Sample Testing: For each sample (25 mL), 1 mL sulfanilamide and 1 mL NEDA were added sequentially, with incubation (2–8 min and 10 min, respectively) for color development. Absorbance was measured at 543 nm using a UV-Vis spectrophotometer. Blank and spiked controls were included [18].

Calculation: Nitrite concentrations were determined from calibration curves or regression equations. Recovery (%) was calculated as:

$$\% \, recovery = \frac{(E-F) \times 100\%}{G}$$

where E = concentration of spiked sample (mg/L), F = concentration of unspiked sample (mg/L), and G = added nitrite concentration. The G value was determined as:

$$G = \frac{(y \times z)}{v}$$

where y = volume of added solution (mL), z = concentration of standard solution (mg/L), v = final sample volume (mL).

Precision was assessed using Relative Standard Deviation (RSD):

$$\text{RSD} = \left(\frac{SD}{\underline{x}}\right) \times 100\%$$

where SD = standard deviation,

are replicate values, and n = number of replicates [19].

$$\text{SD} = \sqrt{\frac{(x_1 - \underline{x})^2 + (x_2 - \underline{x})^2}{n-1}}$$

Where E = the concentration of the spiked sample (mg/L), F = the concentration of the unspiked sample (mg/L), and G = the concentration of nitrite added as the target value, also expressed in mg/L.

Water Strip Test: A nitrite strip was immersed in the sample for 2 seconds, removed, and left for 30 seconds before comparing the color to the reference scale [20].

Microbiological Analysis

Microbiological quality was evaluated using the Most Probable Number (MPN) method, consisting of presumptive, confirmatory, and completed tests.

Presumptive Test: Samples (10, 1, and 0.1 mL) were inoculated into *Lactose Broth* (double and single strength) with Durham tubes (3–3–3 series) and incubated at 37 °C for

48 hours. Tubes showing acid/gas formation were considered presumptive positives [21].

Confirmatory Test: Positive cultures were transferred into *Brilliant Green Lactose Bile Broth* (BGLB) and incubated at 37 °C for 48 hours. Gas production ≥10% confirmed coliform presence, and MPN values were estimated using Thomas tables [22].

Completed Test: Positive BGLB cultures were streaked onto Eosin *Methylene Blue Agar* (EMBA) plates and incubated at 37 °C for 24 hours. Colonies with metallic green sheen indicated E. coli, while purple colonies indicated other coliforms [22]..

Data Analysis

All data were tabulated and averaged. Results were compared with the Indonesian Minister of Health Regulation No. 492/MENKES/PER/IV/ 2010 and WHO guidelines for drinking water quality..

3. RESULTS

Study Limitations

This study has several limitations. The number of sampling points was limited (one stainless-steel tank and two earthen jars), which restricts the generalizability of the findings. In addition, no direct measurements of container hygiene practices, user behavior, or dissolved metal concentrations were conducted, limiting the ability to fully explain the observed differences. Future studies should incorporate a larger number of sampling sites and include behavioral and environmental variables.

The sampling locations differed in terms of exposure and usage intensity. The stainless-steel tank was located in a relatively enclosed area with lower direct contact, while the earthen jars were placed in open-access areas with higher frequency of use by pilgrims.

The quality of drinking water at the Sunan Ampel Mausoleum was evaluated using physical, chemical, and microbiological parameters. Samples were collected from one stainless steel tank (Sample I) and two earthen jars (Samples II and III) located in different areas around the site. Five parameters were tested: temperature, total dissolved solids (TDS), pH, nitrite concentration, and microbiological indicators (total coliforms and *Escherichia coli* using the MPN method).

Table 1. Results of Physichal, Chemical, and Microbiological Tests of Drinking Water

Parameter	This Study (2025)			Indonesia MoH Standard (2010)	WHO Standard (2017)	Previous Studies (Afdholi et al., 2021)	Compliance
	I	II	III				
Temperature (°C)	30,9	30,6	30,9	Ambient ± 3°C	Ambient ± 3°C	± 0,1°C-± 2,6°C	✓meets
pH	8,03	7,8	7,98	6,5-8,5	6,5-8,5	7,36-7,83	✓ meets
Parameter	This Study (2025)			Indonesia MoH Standard (2010)	WHO Standard (2017)	Previous Studies (Afdholi et al., 2021)	Compliance
	I	II	III				
TDS (mg/L)	185 ± 1.0	146 ± 9.0	185 ± 1.0	500	500	253-285	✓ meets
Nitrite (mg/L)	-0,0006	0,0898	0,0284	3	3	-	✓ meets
Total Coliform (MPN/100 mL)	43	240	460	0	0	11-28	✗ fail
Escherichia coli (MPN/100 mL)	43	93	480	0	0	11-28	✗ fail

Note: Compliance marked as ✓ if meets both MoH and WHO standards; ✗ if exceeds permissible limits. Values represent the mean ± standard deviation of triplicate measurements (n = 3) for each sampling point. Due to the limited number of sampling locations (one stainless steel tank and two earthen jars), comparisons between container types were conducted descriptively, and no inferential statistical analyses were performed

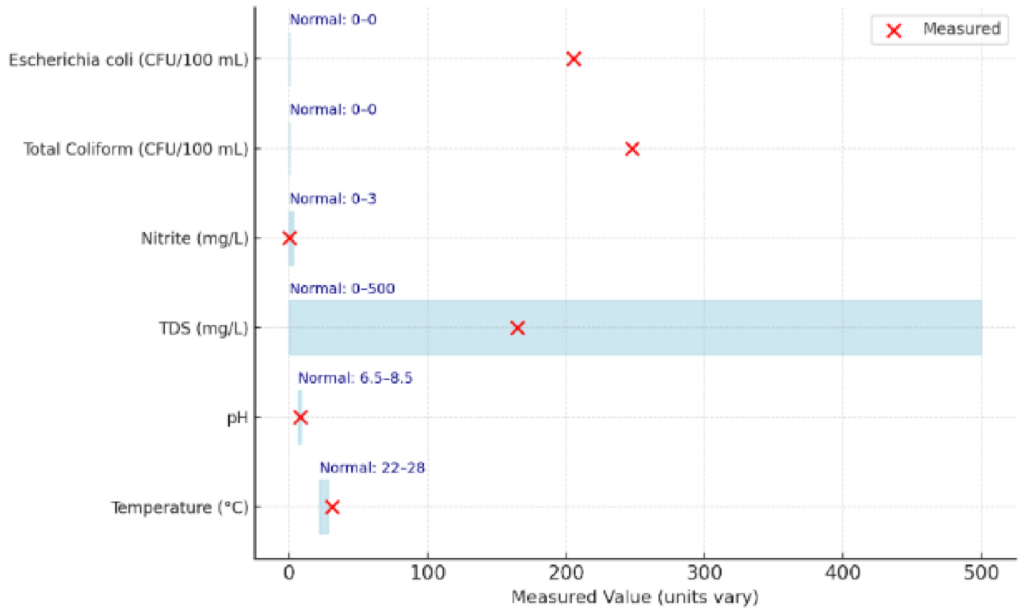

Figure 1. Boxplot-style Comparison of Physical, Chemical, and Microbiological Water Quality Parameters

Physical and Chemical Parameters

The results of temperature, TDS, pH, and Nitrite are presented in Table 1. Temperature remained stable across all replicates (30.6–30,9 °C), slightly exceeding the recommended limit for drinking water (<30 °C). TDS values ranged between 146–185 mg/L, with the highest values recorded in the stainless steel tank (Sample I) and the lowest in Barrel II. These values were well below the maximum permissible level of 500 mg/L set by the Indonesian Ministry of Health and WHO guidelines. pH measurements were relatively uniform (7.8–8.03), falling within the acceptable range of 6.5–8.5 (Figure 1.).

Nitrite analysis was performed using a UV–Vis spectrophotometer at a wavelength of 543 nm. Calibration was conducted with ten standard nitrite solutions (0–0.200 mg/L). The calibration curve exhibited strong linearity between concentration (X) and absorbance (Y), described by the regression equation: $y = 1.126x + 0.0014$, with a high coefficient of determination, indicating the reliability of the method.

Based on this calibration curve, nitrite concentrations in the three water samples were determined from absorbance measurements and verified using a commercial water strip test. The concentrations consistently remained below 0.1 mg/L, well below the maximum permissible limit of 3 mg/L set by the Indonesian Ministry of Health (2010) and WHO guidelines (Figure 1.). These findings indicate that the water samples are clear, slightly alkaline, and chemically safe for human consumption.

Microbiological Parameters

The microbiological analysis presented in Table 1. indicates that, based on the MPN 3-3-3 series table calculated using the Thomas formula, the Total Coliform counts in the three samples ranged from 43 to 460 MPN/100 mL, as evidenced by gas formation exceeding 10% (Figure 2.), with the lowest value observed in Sample I and the highest in Sample III.

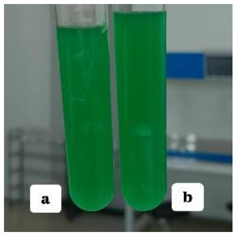

Figure 2. Results of the confirmative Most Probable Number (MPN) test using Lactose Broth medium. (a) Tubes showing negative results, indicated by a clear medium and the absence of gas in the Durham tube, (b) Tubes showing positive results, characterized by turbidity and (>10%) gas formation in the Durham tube.

Meanwhile, the counts of *Escherichia coli* ranged from 43 to 480 MPN/100 mL, confirmed by the presence of metallic green colonies (Figure 2.), with the lowest value in Sample I and the highest in Sample III. All of these results exceeded the standards set by the Indonesian Ministry of Health (2010) and the WHO (2017), which require 0 MPN/100 mL for both parameters; therefore, all samples were categorized as non-compliant with drinking water quality requirements (Figure 1.).

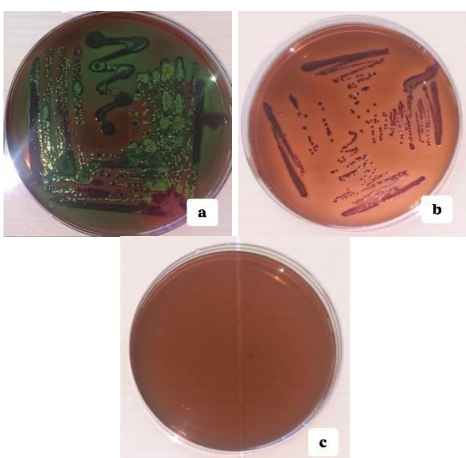

Figure 3. Results of the completed test for coliform detection using Eosin Methylene Blue (EMB) agar medium. (a) Positive result, Colonies exhibit a metallic green sheen. (b) Negative result, Colonies appear purpel without metallic sheen. (c) Control, Sterile medium showing no microbial growth

4. Discussion

Physicochemical Quality

Temperature values in all samples exceeded the recommended limit of 25 ± 3 °C set by the Indonesian Ministry of Health Regulation No. 492/Menkes/Per/IV/2010 and the WHO (2017). Although elevated temperature does not pose a direct health risk, it facilitates microbial proliferation and may accelerate the decomposition of organic compounds [23,24]. Total dissolved solids (TDS) ranged from 146-185 mg/L, well below the permissible limit of 500 mg/L, indicating that the water is safe in terms of dissolved mineral content [25]. Variations among storage types suggest that stainless steel tanks may release trace ions such as nickel or iron [26], whereas earthen jars, being more inert and porous, can adsorb certain ions, thereby reducing TDS levels [27].

The pH of the samples (7.79–8.05) was within the acceptable range (6.5–8.5). While slightly alkaline, these values are not hazardous, though they may impart a mildly bitter taste [17]. Container material likely contributed to differences in pH, with stainless steel tanks showing higher values due to leaching of ions, whereas earthen jars provided more stable readings [28,29].

Nitrite concentrations, determined by UV–Vis spectrophotometry and confirmed by strip tests, ranged from below detection limits to 0.0898 mg/L. These values are far below the 3 mg/L threshold of the Ministry of Health and WHO standards, suggesting that nitrite contamination is not a concern in this setting. Method validation indicated high reliability, with excellent linearity (R^2 = 0.9999), acceptable precision (%RSD = 3.16%), and satisfactory recovery (90.2%). These results demonstrate that the applied analytical approach is robust for field samples [18–20]. Although nitrite concentrations were low, their potential health risks should not be overlooked: excessive nitrite can cause methemoglobinemia in infants and form carcinogenic nitrosamines in the gastrointestinal tract [7,31].

Microbiological Quality

In contrast to the favorable physicochemical results, microbiological testing revealed contamination in all samples. Coliform and *Escherichia coli* were consistently detected, with MPN values reaching up to 480/100 mL, far exceeding the regulatory standard of 0/100 mL. The presence of metallic green sheen colonies on EMB agar confirmed *Escherichia coli* contamination, while purple colonies indicated other coliforms [32–34]. These findings classify the water as unsafe for drinking according to national regulations and WHO guidelines. Contamination is likely linked to the porous structure of earthen jars, which facilitate microbial infiltration when not regularly cleaned, while stainless steel tanks, though less porous, may still become contaminated if hygiene is not maintained [30,31].

Religious and Public Health Implications

Although some pilgrims perceive water from the Sunan Ampel Mausoleum as spiritually blessed, Islamic teachings emphasize that what is consumed must also be wholesome (thayyib). As stated in Surah Al-Baqarah (2:172),

يٰٓاَيُّهَا الَّذِيْنَ اٰمَنُوْا كُلُوْا مِنْ طَيِّبٰتِ مَا رَزَقْنٰكُمْ وَاشْكُرُوْا لِلّٰهِ اِنْ كُنْتُمْ اِيَّاهُ تَعْبُدُوْنَ ١٧٢

Translation: "*O you who have believed, eat from the good things which We have provided for you and be grateful to Allah if it is (indeed)] Him that you worship.*" (Surah Al-Baqarah 2:172).

This verse explains that believers are commanded to consume what is both pure and safe. This principle highlights that religious practice must align with health standards, and unsafe water contradicts the Qur'anic directive of halalan thayyiban.

Importantly, while this water is regarded as sacred, its hygienic quality must still be safeguarded. Failing to do so not only endangers public health but may also undermine the very belief in its sanctity. Ensuring cleanliness and safety, therefore, becomes a shared responsibility particularly for government authorities, mosque managers, and local custodians of religious heritage sites. By maintaining both spiritual significance and hygienic standards, sacred water can continue to be respected without compromising health or faith.

Recommendations for Safe Water Provision

To safeguard pilgrims, water treatment measures must comply with Ministry of Health Regulations No. 32/2017 and 492/2010. Preventive actions include appropriate well placement, regular water quality monitoring, and application of multistage filtration (sand, activated carbon, ceramic) followed by disinfection (chlorination or UV treatment) [35–38]. Implementing these strategies in religious heritage sites will ensure that water provision reflects both public health protection and Islamic values of purity and safety.

5. Conclusion

Drinking water stored in jars and tanks at the Sunan Ampel Mausoleum in Surabaya was found to be physically and chemically within acceptable limits, although temperatures slightly exceeded the ideal threshold. In contrast, microbiological analysis revealed contamination with Coliform and Escherichia coli, exceeding permissible standards and rendering the water unfit for consumption. Observed differences between container types suggest that porous earthenware jars may be more prone to contamination than stainless steel tanks; however, this finding should be interpreted with caution due to the limited number of samples and the absence of statistical analysis and supporting data on hygiene and environmental factors.

These findings highlight that, while the water is regarded as sacred, its hygienic quality must still be safeguarded to prevent undermining the very belief in its sanctity. Ensuring that sacred water remains both spiritually meaningful and microbiologically safe is therefore a shared responsibility of local authorities, site managers, and the community. This study underscores the Islamic principle of halalan thayyiban—that what is consumed must be not only lawful but also pure, clean, and safe—although this aspect is discussed conceptually rather than based on primary empirical data.

Novelty Highlight Statement

This study provides a novel contribution by addressing the limited scientific assessment of drinking water quality in religious heritage settings, where water is not only consumed but also perceived as spiritually significant. Unlike previous studies that primarily focus on conventional water sources, this research specifically evaluates untreated well water distributed through open and semi-open storage systems (earthen jars and stainless steel tanks) in a high-traffic pilgrimage site.

The novelty of this study lies in its context-based approach, integrating physicochemical and microbiological analysis with the concept of halalan thayyiban as a conceptual framework to interpret water safety beyond regulatory compliance. Furthermore, this study highlights the role of storage type and site-specific practices as potential risk factors for microbiological contamination in communal religious settings.

By linking scientific findings with culturally embedded water-use practices, this research offers context-sensitive insights and practical implications for improving water management in religious heritage sites. Future studies are encouraged to adopt similar integrative approaches across diverse cultural and religious contexts, incorporating larger sample sizes, behavioral observations, and statistical analyses to strengthen the evidence base and expand the societal impact of safe and culturally informed water management practices

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