MENA Journal of Bioscience Research
Doi: 10.64913/mmrmjbr.v1i2.24
Volume No.1, 2026

MENA MEDICAL RESEARCH

Original Article

OPEN ACCESS

Microbiological Quality of Water Used at Sufi Shrines: Implications for Public Health in Karachi, Pakistan

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Received: 27/01/2026 ; Accepted: 12/07/2026 ; Published: 25/07/2026

Abstract

Karachi is among Pakistan's fastest-growing cities, where rapid population growth and inadequate infrastructure have intensified problems of water contamination, contributing to declining water quality. Shrines in this region serve as vital psycho-social anchors for community identity, where water is essential for drinking, sacred rituals, and ablution (wudu). This study investigates the microbiological quality of water used for drinking and sacred rituals at Sufi shrines in Karachi, Pakistan. 27 water samples were collected from 20 shrines for microbiological analysis targeting turbidity, coliforms, and *Escherichia coli* (*E. coli*). Moreover, the study employed a qualitative scoring system to evaluate shrine cleanliness based on washroom availability, dust presence, drug user presence, and ventilation.
Results show 74.07% of samples contained coliforms and 62.96% contained *E. coli*, exceeding acceptable limits, as assessed against the WHO guideline of 0 CFU/100 mL for *E. coli* in drinking water, and indicating significant fecal contamination. 59.26% of the samples indicated the water to be clear when assessed for turbidity. The scoring system highlighted how visual cleanliness did not correlate with microbial contamination levels, stressing the need for microbial monitoring beyond surface assessments. The findings emphasize significant health risks to shrine visitors, especially vulnerable populations. Immediate interventions at both individual (carrying personal water bottles, use of bottled water) and governmental levels (improved water infrastructure, UV treatment systems) are critical to safeguard public health without disrupting cultural and spiritual practices.

Keywords: Water quality, Shrines, Microbial testing, Karachi, Pakistan, *Escherichia coli*, Fecal contamination

1. Introduction

Shrines are places of religious or spiritual significance dedicated to revered figures, such as deities or saints, that carry deep cultural and historical weight and often serve as anchors of community identity. Beyond their spiritual roles, shrines offer significant psychosocial benefits, providing visitors with a sense of connection, peace, and security in times of hardship, as well as places to seek guidance or physical and emotional healing. Many believe that praying, making offerings, or performing rituals at a shrine is a way to receive spiritual or divine blessings that can help overcome personal or collective challenges. Water plays an essential role in these practices: it is used as drinking water for consumption, wudu (ablution) for washing hands, face, nostrils, and feet prior to prayer, and dum water for bathing in religious ceremonies.

In Pakistan, the Ministry of Auqaf (*Waszarat-e-Auqaf*) oversees mosques, shrines, and *dargahs*, delegating an appointed "Auqaf" representative to the shrines [1]. Despite official efforts, some shrines fail to maintain clean environments, leading to occupation by drug addicts and beggars. This unhygienic environment sometimes deters the middle class from associating with shrines as frequently as the lower class, who often populate these spaces [2].

Many visitors remain unaware of the significant dangers associated with poor water and sanitation. Pakistan suffers from a high prevalence of multiple waterborne infections, including cholera, diarrhea, and *Naegleria fowleri* [3]. Research has shown a strong correlation between unclean drinking water, lack of sanitation, and the prevalence of diarrhea, the major cause of mortality in children under five [4].

Shrines can significantly contribute to the spread of infectious diseases. They serve as hubs for infectious disease transmission because large populations gather in a single space, often including individuals already infected. Prevalent religious and social practices involving water carry potential dangers if the water is not germ-free. This scenario facilitates the potential spread of waterborne pathogens, especially when water is used for multiple ritualistic purposes. Existing literature indicates that water rituals are most likely to transmit pathogens via the fecal-oral route or mucosal surfaces. Specific examples of water-associated rituals linked to contamination include a)The sprinkling of holy water has been connected to bacterial infections such as pneumonia and surgical site infections, b) Mass bathing and dipping rituals, like those performed during the Kumbha Mela in India, are associated with diarrheal diseases (including cholera) and respiratory infections (including COVID-19) [5], c) Ablution, which involves nasal irrigation, poses a risk for contracting *Naegleria fowleri* and subsequent meningoencephalitis, d) Drinking untreated water at shrines exposes visitors to fecal and environmental contaminants, risking enteric infections. Surveys of shrine visitors in Kyoto, Japan, found that a significant portion drank water from their purification ritual (temizu) for spiritual benefits, even though it often contained coliform bacteria [6].

Furthermore, Methicillin-resistant Staphylococcus aureus (MRSA) infections have been isolated from surfaces in shrine environments [7]. However, minimal work has explored these crucial health risks within the context of Pakistan. Despite studies on the social aspects of shrines in Pakistan, scientific evidence on waterborne infections originating from shrines in Karachi remains lacking. To the best of our knowledge, no prior study has conducted a microbiological assessment of water sources specifically at shrine sites in Karachi, leaving a measurable gap in local public health evidence. The lack of data on water quality, especially given its ritualistic use (often involving consumption), underscores a crucial need for further investigation. It is essential that shrine visitors be made aware of the potential risks of infection [8].

This study aims to address this critical research gap by examining the relationships between water quality, environmental hygiene, and the cultural practices of shrine visitors. The purpose is to provide insights that enrich the scientific community and promote informed decision-making among Karachi residents and organizations responsible for preserving cultural heritage.

The research objectives are, first, to assess the quality of the water available at shrines by testing for the presence of Coliforms and *E. coli*. Also, to analyze the general environment around the shrine for potential health concerns. This research does not intend to deter people from their worship, but to raise awareness and encourage authorities to address the potential public health risks at these culturally significant places and to implement preventive measures.

2. Materials and methods

2.1. Study design and setting

The study utilized a mixed-methods approach, integrating both quantitative and qualitative data collection and analysis techniques. The quantitative component focused on microbial analysis to detect specific contaminants in water samples. The qualitative component focused on evaluating the broader environmental factors within the shrine premises. Twenty shrines in Karachi were selected using a mixed sampling strategy: convenience sampling was applied to ensure geographic accessibility, while purposive sampling guided the inclusion of well-known, frequently visited sites across different districts. Together, these approaches aimed to achieve meaningful geographic coverage within the logistical constraints of a time-bound study. This sample size, 20 shrines yielding 27 water samples, reflects both the resource limitations of the study period and the presence of multiple distinct water source types (drinking, ablution, and stream water) at several shrines. The areas covered included: Jodia Bazaar, Saddar, Manghopir, FB Area, Golimar, North Nazimabad, Gulshan-e-Iqbal, Gulistan-e-Johar, Malir, Model Colony, Shah Faisal Colony, Mahmoodabad, PECHS, Teen Hatti, Clifton, and Lyari. Sterilized water bottles were used to collect water samples to avoid contamination. The samples were securely sealed to prevent tampering. These water samples were tested on the same day they were collected to actively prevent any microbial growth that could compromise the integrity of the results.

2.2. Methods

The clarity of the water, defined as its cloudiness or turbidity, was also evaluated qualitatively. Turbidity was measured using an observational scoring system: 1 – Clear, 2 – Slightly Turbid, and 3 – Most Turbid. Coliform and *E. coli* detection was performed using the IDEXX Colilert-18 test kit. Samples were incubated at 35°C for 18 hours, in accordance with the manufacturer's protocol. This kit operates on the Defined Substrate Technology (DST) principle, employing two specific nutrient indicators: ONPG (O-Nitrophenyl-β-D-galactopyranoside) and MUG (4-Methylumbelliferyl-β-D-glucuronide).

The presence of Coliforms triggers a transformational enzymatic response. Specifically, the β-galactosidase enzyme produced by Coliforms interacts with ONPG, causing a noticeable change from colorless to bright yellow. *E. coli* metabolizes MUG using the enzyme β-glucuronidase, resulting in the release of fluorescence when viewed under UV light. The concentration of these microbial pollutants in each water sample was quantitatively determined using the Most Probable

Number (MPN) values. MPN calculation measures the degree of contamination in 100 mL of water samples. The World Health Organization's acceptable bacterial limit of less than 1 bacterium per 100 mL for safe water was used as a benchmark [9].

The MPN values derived for both *E. coli* and Coliforms were analyzed to provide a concise and visually informative depiction of contamination levels. Results were presented via pie charts, showing the distribution of MPN values throughout several predefined ranges. These ranges were structured as follows:

- >2419.6 - 1000 MPN: Highest microbial content, indicating a high level of contamination.
- 1000 - 100 MPN: Moderate level of contamination.
- 100 - 1 MPN: Lower degree of contamination, indicating a cleaner composition.
- <1 MPN: The least number of microbial agents represents the least polluted category.

2.3. Qualitative analysis

Assessment of turbidity scores (1-3) for qualitative analysis, with a focus on cleanliness and maintenance. Careful on-site observations were made regarding variables such as the availability of lavatories, the presence of dust (in the air or on the ground), the functioning of ventilation systems (fans and air conditioning), and any signs of unsafe behavior, including substance use among shrine attendees. All analyses were descriptive; no inferential or correlational analyses were conducted.

These observations were consolidated into a structured rating system. A methodical approach was applied to assign each shrine a score between 0 (lowest cleanliness) and 4 (relatively better cleanliness), based on four key variables:

1. Washroom availability (Yes = 1 point).
2. Dust in the air or on the ground (No = 1 point).
3. Drug addicts on the premises (No = 1 point).
4. Adequate ventilation (Yes = 1 point).

A score of 4 denoted an excellent environment, while 0 reflected poor environmental conditions. This analysis revealed recurrent patterns and interpretations within the qualitative data.

3. Results

The field research involved a comprehensive analysis of the water quality across 20 shrines in Karachi, resulting in the collection and analysis of 27 water samples, covering both drinking water and *wudu* (ablution) water. The primary microbiological indicators analyzed were *Escherichia coli*, Coliforms, and Turbidity.

Figure 1 shows that most water samples collected from the shrines were classified as not turbid, indicating generally clear water across most sites. A considerable number of samples were in the slightly turbid category, reflecting the presence of suspended material in a substantial portion of the samples. In contrast, only a very small subset of samples exhibited high turbidity. These findings indicate that water clarity was generally good across the shrines, although a meaningful proportion of samples showed mild turbidity, pointing to variation in water quality between locations. See Figure 1 for the turbidity distribution of the collected water samples.

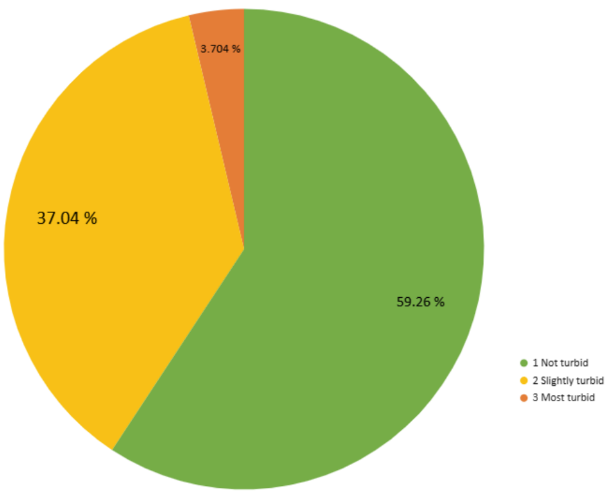

Figure 1: *Distribution of turbidity scores of water samples collected from Sufi shrines in Karachi. Scores were assigned on a three-point observational scale: 1 = Not turbid (clear), 2 = Slightly turbid, 3 = Most turbid. Most samples (59.26%) were visually clear, while 37.04% were slightly turbid and 3.70% were highly turbid.*

Figure 2 illustrates the distribution of coliform bacteria in the shrine water samples based on MPN ranges. Coliforms were detected in most samples, indicating widespread microbiological contamination across the study sites. The largest group of samples fell within the high-contamination range, with elevated coliform counts. This was followed by a notable number of samples in the below-acceptable-limit group, while smaller portions were classified as moderately contaminated and lower contamination, respectively. The dominance of samples with elevated MPN values demonstrates that a substantial proportion of the water sources contained unsafe levels of coliform bacteria. These findings confirm a significant microbiological presence and indicate potential public health risks associated with the use of these water sources.

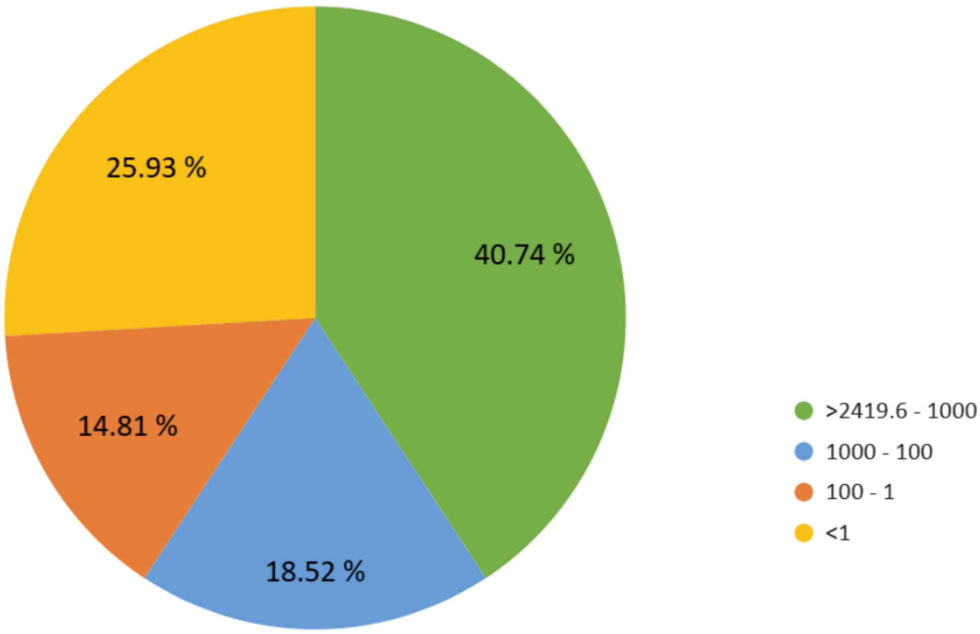

Figure 2: *Coliform contamination in shrine water samples expressed as Most Probable Number (MPN) per 100 mL. Results are grouped into four contamination ranges: >2419.6 MPN (highest), 1000–100 MPN (moderate), 100–1 MPN (lower), and <1 MPN (below WHO acceptable limit). A total of 74.07% of samples exceeded the WHO guideline of 0 CFU/100 mL.*

Figure 3 illustrates the distribution of *E. coli* concentrations in shrine water samples as determined by the MPN method. *E. coli* was detected in a substantial proportion of the samples analyzed, indicating widespread fecal contamination. The contamination levels varied across samples, with a subset exhibiting high MPN values and a smaller subset showing moderate contamination. A comparable number of samples fell within the lower contamination range and below the acceptable detection limit.

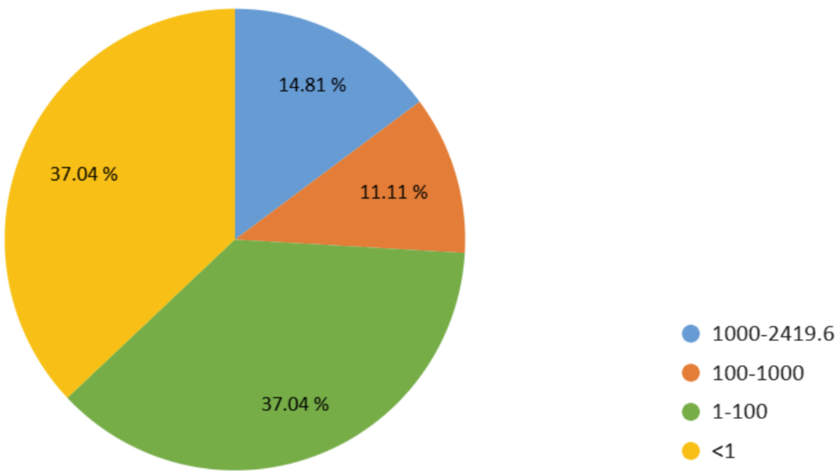

Figure 3: *E. coli concentrations in shrine water samples expressed as Most Probable Number (MPN) per 100 mL, categorized into four ranges: 1000–2419.6 MPN, 100–1000 MPN, 1–100 MPN, and <1 MPN. E. coli was detected in 62.96% of samples, confirming widespread fecal contamination exceeding WHO drinking water standards.*

Shrines often serve as residences for individuals, predominantly from lower socioeconomic strata, due to the availability of necessities such as shelter, food, and water. This fosters a symbiotic relationship where inhabitants assist with maintenance. However, this diverse population includes individuals struggling with drug addiction, and security failings have led to reported instances of theft. An assessment of specific environmental variables based on binary responses yielded the following results:

- Restroom Availability: Present in 60% of surveyed shrines.
- Dust Presence (Air/Floor): Observed in almost 45% of the studied shrines.
- Drug Users on Premises: Regularly visited by people exhibiting traits related to drug addiction in 40% of cases.
- Adequate Ventilation: Efficient ventilation systems (including air conditioning and fans) were present in a remarkable 75% of the shrines examined. The emphasis on ventilation was noticeable across all shrines.

The general cleanliness and atmosphere of each shrine were rated on a scale of 0 to 4 as shown in Figure 4:

- Rating 4 (Excellent): 15% of the shrines achieved this score, indicating the absence of dust and drug addicts, and the availability of washrooms and adequate ventilation.
- Rating 3 (Good): 45% of the shrines.
- Rating 2 (Moderate): 25% of the shrines.
- Rating 1 (Low): 10% of the examined shrines.
- Rating 0 (Poor): 5% of the shrines, indicating deprivation of all necessities needed for shrine cleanliness and safety.

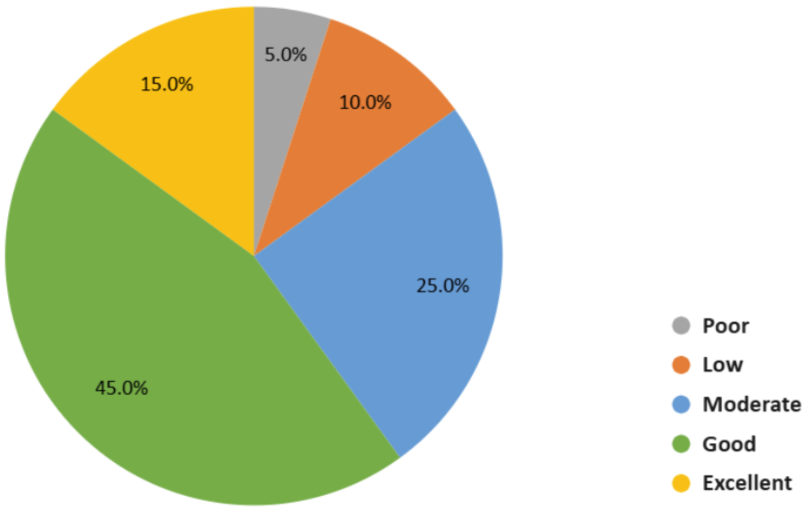

Figure 4: *Environmental cleanliness ratings for surveyed shrines, scored on a 0–4 scale based on four binary variables: washroom availability, absence of dust, absence of drug users, and adequate ventilation. Ratings: 0 = Poor, 1 = Low, 2 = Moderate, 3 = Good, 4 = Excellent. Most shrines (45%) received a rating of 3 (Good), while only 15% achieved the highest rating of 4 (Excellent).*

A critical finding concerning the relationship between environmental hygiene and water safety was that the apparent cleanliness of a shrine does not necessarily indicate the purity of its water. Even shrines that received high qualitative ratings for general cleanliness (scores 3 and 4) surprisingly exhibited high levels of microbial contamination. The observation that coliforms were present in most samples, despite most shrines falling into Moderate or Good cleanliness levels, underscores that surface cleanliness is independent of deep-water quality issues.

4. Discussion

The examination of water quality at Sufi shrines in Karachi has revealed extensive microbiological contamination, posing serious threats to public health. The high prevalence of coliforms and *E. coli* far exceeds the accepted level of <1 organism per 100 mL, requiring immediate action. The presence of coliforms, particularly at MPN levels exceeding 1000 per 100 mL, indicates widespread contamination, likely due to poor infrastructure and inadequate sanitization. *E. coli*, serving as a direct indicator of fecal contamination, confirms that the water sources are compromised.

This microbiological threat aligns dangerously with existing public health challenges in Pakistan, where waterborne diseases are already rampant. Shrines, by nature of attracting large populations, are vulnerable to acting as hubs for the transmission of infectious diseases. This risk is compounded by cultural practices wherein water is central to worship. Visitors often use the water for ablution (*wudu*) or consume it as *dum water*, without recognizing the potential for exposure to pathogens. Activities such as ritualistic bathing at mass gatherings have been linked to the spread of infectious diseases through various transmission routes [10]. Furthermore, specific forms of ablution, which may involve nasal irrigation, pose a risk for exposure to primary amoebic meningoencephalitis (PAM) caused by *Naegleria fowleri*. Naegleria fowleri has also been detected in the piped water supply of Karachi, and studies have shown that water stored in overhead tanks during the summer months with negligible chlorine levels can facilitate the propagation of N. fowleri amebae, which can lead to PAM cases [11]. Moreover, given that 63% of the samples showed *E. coli* contamination, the public using this water is inadvertently exposing themselves to enteric pathogens, leading to diarrheal disease.

The health implications are most severe for children under five, whose immune systems are insufficiently developed to combat sustained exposure to microbes. While adults possess stronger immunity, the consistent exposure highlighted by this study remains harmful, particularly for visitors from lower socioeconomic strata who may already have compromised health or limited access to medical care [12]. The massive influx of visitors to these spiritual sites often overwhelms basic infrastructure, leading to untreated sewage entering natural ecosystems and groundwater [13].

The data from the turbidity assessment showed that a noticeable proportion of the water samples were visibly clear (59.26%), yet highly contaminated, further cementing the need for microbial testing over visual inspection. It is worth noting that turbid water, characterized by cloudiness from suspended particulate matter, may contain dissolved natural salts that can exert osmotic stress on bacterial cells, analogous to brine solutions. The resulting shift in osmotic pressure could theoretically inhibit microbial survival and replication. The observation that several turbid samples in this study returned negative or lower contamination readings is consistent with this hypothesis, though it remains speculative in the absence of chemical water analysis. This phenomenon cannot be relied upon as a safety indicator, and the overall data pattern clearly shows that turbidity is not a reliable proxy for microbial safety.

The environmental assessment revealed important social and infrastructural insights. The formal responsibility for shrine welfare rests with the government's Auqaf department. However, in practice, the maintenance and financial upkeep are often driven by devotees of the revered spiritual leader (*peer*). The systemic failure to maintain sewerage pipelines and the integrity of the water supply, which is likely the root cause of the high MPN values, requires intervention at the governmental level. To improve the biosafety and water quality at these shrines, a multifaceted approach is recommended. At the individual level, visitors should be encouraged to carry their own drinking water, and shrine caretakers should ensure the consistent availability of safe bottled water on the premises to reduce reliance on potentially contaminated sources. At the institutional level, government and municipal authorities must prioritize the regular inspection and maintenance of sewerage and water supply pipelines, as leaks and structural failures likely contribute to cross-contamination and the elevated MPN values observed. Installing large-scale ultraviolet (UV) treatment systems at shrines could further ensure the provision of microbiologically safe water.

5. Limitations and future perspectives

Several limitations of this study should be acknowledged. First, the sample size of 27 water samples from 20 shrines, while geographically distributed, was constrained by the time-bound nature of the project and limits the generalizability of the findings. Second, all samples were collected over a single period in July, so seasonal variation in contamination levels, which may be considerable given Karachi's climatic extremes, could not be assessed. Third, the qualitative cleanliness scoring system, though consistently applied, is inherently subjective and dependent on conditions observed on the day of the visit. Fourth, the study did not include chemical water quality parameters (e.g., pH, chlorine residual, heavy metals), which would provide a more complete picture of water safety. Finally, the lack of control over shrines reflects a genuine gap in the existing literature: no baseline cleanliness or water quality data for Karachi's shrines currently exist against which comparisons could be drawn. These limitations point clearly toward the need for larger, longitudinal, and multi-seasonal study to build on this foundational work.

6. Conclusion

This study provides compelling scientific evidence of widespread microbiological contamination in water sources at Sufi shrines in Karachi. The mixed-methods strategy successfully combined quantifiable MPN results for *E. coli* and coliforms with environmental observations, revealing a significant public health challenge. The central takeaway is that water at Sufi shrines in Karachi is broadly unsafe by WHO standards, and visible environmental cleanliness is not a reliable indicator of microbiological water quality. Critically, the data confirmed that the perceived general cleanliness of a shrine environment does not predict the purity or safety of its water.

To mitigate these risks and enhance water quality, both domestic and large-scale interventions are crucial. Future research should build on this baseline with larger, multi-seasonal studies that include chemical analysis and inferential statistics. This study provides the first microbiological baseline for shrine water quality in Karachi, and we hope it serves as a foundation for that work.

7. Declarations

Funding

This research was funded by Habib University's Graduate School Curation Program (GSCP).

Author Contributions

RL, AN, MSK, AK, JS, HQ: Conceptualization, Investigation, Writing-original draft, Writing-review & editing. All authors contributed equally to all parts of this work and approved the final manuscript.

Ethics Approval and Consent to Participate

Not applicable

Data Availability Statement

Not applicable

Conflicts of Interest

Not applicable

Acknowledgments

The authors would like to thank the Graduate School Curation Program (GSCP) and the Research Office at Habib University for their support for the project.

AI Declaration

The authors confirm that no content in this manuscript was generated using artificial intelligence (AI) tools and the authors take full responsibility for the accuracy and integrity of the work.

8. Abbreviations

The following abbreviations are used in this manuscript:

MRSA	Methicillin-resistant Staphylococcus aureus
DST	Defined Substrate Technology
ONPG	O-Nitrophenyl-β-D-galactopyranoside
MUG	4-Methylumbelliferyl-β-D-glucuronide
MPN	Most Probable Number
PAM	Primary Amoebic Meningoencephalitis
UV	Ultra Violet

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