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Assessment of Toilet Cleaning Practices and Mold Presence in Public Toilets at Sunan Ampel Tourism Site, Surabaya: A Descriptive Study

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ABSTRACT Public toilet sanitation standards serve as critical indicators of overall hygiene management quality. Yet, inadequate cleaning protocols and environmental conditions frequently facilitate microbial contamination that poses significant health risks to users. The proliferation of mold in toilet facilities represents a particularly concerning public health issue, as fungal growth can produce toxic secondary metabolites and trigger allergic responses in exposed individuals. This study aimed to evaluate the toilet cleaning processes and assess the prevalence of mold contamination in toilet basins at public facilities within the Sunan Ampel Tourism Site, Surabaya, Indonesia. A descriptive cross-sectional study was conducted examining 30 public toilets. Data collection involved systematic observational assessments of cleaning procedures and laboratory analysis to detect mold presence in toilet basins. The evaluation criteria were benchmarked against the Indonesian Ministry of Health Regulation No. 17 of 2020 and the Indonesian Public Toilet Standard Guidelines. Comparative analysis was performed between observational data and laboratory findings to determine compliance with established sanitation standards. The assessment revealed that cleaning process quality was suboptimal, with 23 toilets (77%) classified as "Fair" and only 7 toilets (23%) achieving "Good" ratings. Mold contamination was detected in 19 toilet basins (63%), while 11 facilities (37%) remained mold-free. Laboratory analysis confirmed the presence of potentially pathogenic fungal species capable of producing harmful secondary metabolites. Multiple environmental and operational factors, including ambient temperature and humidity levels, water quality, visitor frequency, and inadequate cleaning protocols, significantly influence mold proliferation in public toilet facilities. The substantial prevalence of fungal contamination in toilet basins presents considerable health risks through exposure to toxic metabolites and allergenic compounds. These findings underscore the urgent need for enhanced sanitation protocols and regular microbiological monitoring in public toilet facilities to safeguard user health and maintain acceptable hygiene standards.

INDEX TERMS Sanitation management, mold contamination, public toilet hygiene, cleaning protocols, fungal pathogens.

I. INTRODUCTION

Public sanitation facilities serve as critical infrastructure components that significantly influence community health outcomes and disease transmission patterns. The World Health Organization emphasizes that inadequate sanitation systems contribute to approximately 898,000 global deaths annually, primarily through the propagation of waterborne and vector-borne diseases [1]. Public toilets, as essential components of sanitation infrastructure, represent potential reservoirs for pathogenic microorganisms when proper hygiene protocols are not maintained [2]. The proliferation of fungal contaminants in public toilet facilities poses particularly significant health risks, as these organisms can produce toxic secondary metabolites and trigger allergic responses in exposed individuals [3]. Tourist destinations, which experience high visitor turnover and intensive facility utilization, present elevated risks for microbial contamination and subsequent disease transmission [4].

Contemporary research in public toilet sanitation assessment employs multiple methodological approaches to evaluate microbial contamination and hygiene standards. Recent studies have utilized advanced microbiological techniques, including colony-forming unit (CFU) enumeration, molecular identification methods, and environmental sampling protocols to characterize microbial communities in public restroom facilities [5]. Research investigating 61 public toilets demonstrated that bacterial colony-forming units (CFUs) in poorly ventilated facilities can reach five times the number of CFUs outside of the toilet environment [6]. Modern assessment frameworks incorporate multi-parameter evaluation systems that examine cleaning protocols, environmental conditions, and microbial load measurements to provide comprehensive facility hygiene assessments [7]. Recent investigations have focused on viral aerosol generation during toilet flushing and its impact on cross-contamination of restroom surfaces [8]. Additionally,

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systematic approaches to evaluating sanitation infrastructure now integrate ventilation assessment, surface contamination monitoring, and pathogen identification to develop evidence-based hygiene management strategies [9].

Despite extensive research on microbial contamination in public facilities, significant knowledge gaps remain regarding the specific relationship between cleaning protocols and fungal proliferation in toilet basin environments. Most existing studies focus on bacterial contamination patterns, with limited attention to fungal species identification and their associated health implications in tropical climate conditions [10]. Furthermore, there is insufficient research examining the efficacy of current cleaning practices in religious tourism sites, where unique cultural practices and high visitor density may influence contamination patterns [11]. The lack of comprehensive studies evaluating both cleaning process quality and fungal contamination prevalence in Indonesian public toilet facilities represents a critical research gap that limits the development of targeted intervention strategies [12]. This study aims to evaluate the toilet cleaning processes and assess the prevalence of mold contamination in toilet basins at public facilities within the Sunan Ampel Tourism Site, Surabaya, Indonesia. This research provides several significant contributions to public health and sanitation management knowledge:

1. Establishes a comprehensive assessment framework for evaluating cleaning protocol effectiveness in high-traffic religious tourism facilities, providing evidence-based recommendations for sanitation management improvement.
2. The study contributes original data on fungal contamination patterns in tropical climate public toilet facilities, enhancing understanding of environmental factors influencing mold proliferation in Indonesian tourism infrastructure.
3. This research provides critical baseline data for developing targeted intervention strategies specific to religious tourism sites, addressing the unique challenges posed by high visitor turnover and cultural practices that may influence facility hygiene maintenance.

This article is organized into six main sections. Following this introduction, Section II presents the methodology employed for data collection and analysis, including sampling procedures, microbiological testing protocols, and evaluation criteria. Section III presents the comprehensive results of cleaning process assessments and fungal contamination analysis. Section IV provides a detailed discussion of findings, comparing results with established sanitation standards and identifying key factors influencing mold proliferation. Section V concludes the study with key findings and practical recommendations for sanitation management improvement. Finally, Section VI provides the complete reference list supporting this research.

II. METHOD

A. STUDY DESIGN AND SETTING

This investigation employed a descriptive cross-sectional research design to systematically characterize the toilet cleaning processes and assess mold contamination prevalence in public sanitation facilities [13]. The descriptive approach was selected to provide comprehensive documentation of existing phenomena without manipulation of variables, allowing for accurate representation of current sanitation conditions [14]. The study was conducted prospectively at the Sunan Ampel Religious Tourism Site, Surabaya, Indonesia, during March 2024. This site was selected as a representative high-traffic religious tourism facility experiencing a substantial daily visitor influx, providing optimal conditions for evaluating sanitation management challenges in public toilet facilities.

The study population comprised all public toilet facilities within the Sunan Ampel Tourism Site complex. A comprehensive census sampling approach was employed, encompassing the entire population of 30 toilet facilities to ensure complete coverage and eliminate selection bias [15]. The toilet facilities included both permanent and semi-permanent structures, representing diverse construction types and usage patterns typical of Indonesian religious tourism infrastructure. Each toilet facility was systematically coded and mapped to facilitate data collection and analysis procedures. Microbiological sampling procedures followed established protocols for environmental surface sampling in public health facilities [16]. Sample collection was performed using sterile cotton swabs pre-moistened with phosphate-buffered saline solution to enhance microbial recovery efficiency. The standardized sampling protocol comprised the following sequential steps:

1. PRE-SAMPLING PREPARATION

Personnel donned sterile nitrile gloves and established a sterile work environment using portable flame sterilization equipment to maintain aseptic conditions throughout the sampling process.

2. SAMPLE ACQUISITION

Sterile cotton swabs were dipped in buffered saline solution and applied to the toilet basin wall surfaces using a standardized diagonal swabbing pattern. Each sampling point was swabbed three times in different directions to maximize microbial capture efficiency, following established guidelines for environmental surface sampling [17].

3. SAMPLE PRESERVATION

Immediately following collection, cotton swabs were inserted into sterile test tubes containing 10 mL of phosphate-buffered saline solution. Each sample was labeled with unique identification codes corresponding to facility location and collection date.

4. CHAIN OF CUSTODY

Samples were maintained at 4°C in insulated coolboxes and transported to the Surabaya Public Health Laboratory within 4 hours of collection to prevent microbial degradation and ensure analytical accuracy.

B. LABORATORY ANALYSIS PROCEDURES

Microbiological analysis was conducted at the Surabaya Public Health Laboratory using standard mycological examination protocols. Sample processing involved serial

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dilution plating on Sabouraud Dextrose Agar (SDA) medium, with incubation at 25°C for 5-7 days under aerobic conditions. Colony-forming units (CFU) were enumerated and expressed as CFU/mL following established microbiological counting procedures. Fungal identification was performed through microscopic examination of morphological characteristics and spore structures, supplemented by biochemical testing when necessary for species-level identification [18]. Environmental conditions were systematically monitored using calibrated digital hygrometers to measure ambient temperature and relative humidity within each toilet facility. Measurements were recorded at three time points throughout the sampling day to account for diurnal variations and ensure representative environmental characterization.

C. CLEANING PROCESS EVALUATION

Toilet cleaning process assessment was conducted through structured observational monitoring using standardized evaluation criteria derived from Indonesian Ministry of Health Regulation No. 17 of 2020 concerning Health Markets and the Indonesian Public Toilet Standards Guidelines [19]. The evaluation framework encompassed multiple parameters, including cleaning frequency, cleaning agent utilization, surface sanitization procedures, waste management practices, and water quality maintenance protocols. Primary data collection employed three complementary approaches: (1) structured observational checklists for cleaning process assessment, (2) microbiological laboratory analysis for mold contamination determination, and (3) environmental parameter measurement using calibrated instrumentation. All data collection instruments were validated against established Indonesian sanitation standards to ensure methodological rigor and regulatory compliance.

D. STATISTICAL ANALYSIS AND DATA MANAGEMENT

Data analysis was conducted using a comparative assessment between observational findings and laboratory results against established regulatory benchmarks specified in PMK No. 17 of 2020 and Indonesian Public Toilet Standards Guidelines. Descriptive statistics were calculated for all continuous variables, including measures of central tendency and dispersion. Categorical variables were analyzed using frequency distributions and proportional analysis. Data management followed established protocols for research data integrity, with double-entry verification and range checks to ensure analytical accuracy [20]. Quality assurance measures included equipment calibration verification, sampling technique standardization, and laboratory quality control procedures. Inter-observer reliability was established through training sessions and periodic observation validation. Laboratory analysis included blank controls and duplicate sampling to verify analytical precision and accuracy [21].

E. ETHICAL CONSIDERATIONS

The study protocol was designed to ensure minimal disruption to facility operations and visitor activities. No personal identifiable information was collected, and all observations were conducted by public health research ethical guidelines. Site management provided informed consent for facility assessment and sampling procedures.

III. RESULTS

The findings presented in this section encompass comprehensive analytical outcomes derived from systematic observational assessments and microbiological laboratory examinations investigating fungal contamination prevalence within public toilet basin environments at the study site.

A. PUBLIC TOILET CLEANING PROCESS

Systematic evaluation of toilet cleaning protocols was conducted across all 30 sanitation facilities at the Sunan Ampel Religious Tourism Site, Surabaya, comprising 17 female restroom installations and 13 male restroom installations, with analytical outcomes presented as follows:

TABLE 1
Results Of The Cleaning Process Assessment Of Public Toilets At The Sunan Ampel Tourist Site, Surabaya In 2024

Category	Frequency	Percentage (%)
Poor	0	0
Adequate	23	77
Good	7	23
Total	30	100

The systematic evaluation of public toilet cleaning protocols at the Sunan Ampel Religious Tourism Site, Surabaya, revealed that 23 out of 30 assessed facilities (77%) achieved "Adequate" classification according to established assessment criteria, as presented in TABLE 1.

B. PUBLIC TOILET SANITATION CONDITIONS

TABLE 2
Results Of The Sanitation Condition Of Public Toilets At The Sunan Ampel Tourist Site, Surabaya, In 2024

Category	Frequency	Percentage (%)
Poor	0	0
Adequate	19	63
Good	11	37
Total	30	100

The assessment of public toilet sanitation conditions is based on the Indonesian Public Toilet Standards and PMK No. 17 of 2020. Based on TABLE 2, the evaluation of sanitation conditions in public toilets at the Sunan Ampel Surabaya tourist site indicates that 19 out of 30 units (63%) met the criteria for the "Adequate" category. This assessment was carried out through structured observations using standardized observation sheets, focusing on aspects such as the physical environmental quality, availability of clean water, and the adequacy of toilet facilities and supporting infrastructure. The assessment of the physical environmental quality of public toilets encompasses several evaluation variables, including lighting, ventilation, and the ambient temperature and humidity within the toilet area.

TABLE 3
Results Of The Physical Environmental Quality Assessment Of Public Toilets At Sunan Ampel Tourist Site Surabaya In 2024

Category	Frequency	Percentage (%)
Poor	19	63
Adequate	11	37
Good	0	0
Total	30	100

Based on the assessment results presented in TABLE 3, it was found that out of the 30 public toilets evaluated for physical environmental quality, 19 units (63%) were classified under the "Poor" category. The assessment of clean water provision in public toilets encompasses variables related to both water quality and availability. The results of this evaluation are as follows:

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TABLE 4
Results Of The Clean Water Provision Assessment In Public Toilets At The Sunan Ampel Tourist Site, Surabaya, In 2024

Category	Frequency	Percentage (%)
Poor	0	0
Adequate	0	0
Good	30	100
Total	30	100

Based on the data presented in TABLE 4, all 30 public toilets evaluated for clean water provision were classified in the "Good" category. This indicates that the clean water supply at the Sunan Ampel Surabaya public toilets meets the required standards for both quality and quantity, by the Ministry of Health Regulation (PMK) No. 17 of 2020 and the fundamental guidelines for the provision of clean water in public toilet facilities. The assessment of toilet facilities and infrastructure was carried out based on the Indonesian Public Toilet Standard Guidelines and the provisions outlined in the Regulation of the Minister of Health No. 17 of 2020. TABLE 5 indicates that all 30 public toilets assessed in terms of facilities and infrastructure met the criteria for the "Good" category, reflecting compliance with established standards and suggesting that the available amenities are adequate to support proper sanitation and user comfort.

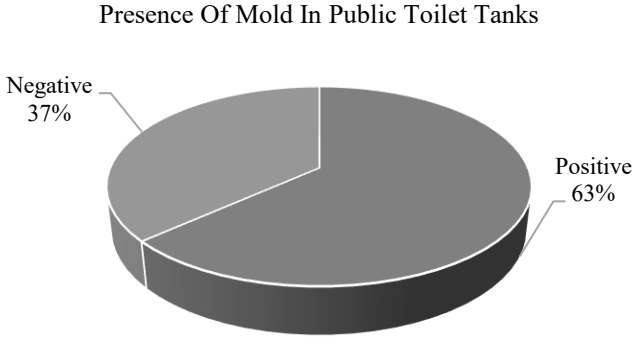
TABLE 5
Results Of The Facilities And Infrastructure Assessment Of Public Toilets At The Sunan Ampel Tourist Site Surabaya In 2024

Category	Frequency	Percentage (%)
Poor	0	0
Adequate	0	0
Good	30	100
Total	30	100

C. PRESENCE OF MOLD IN PUBLIC TOILET TANKS

The examination of mold presence in public toilet tanks was carried out by collecting swab samples from the inner walls of the toilet tanks located at the Sunan Ampel Surabaya tourist site. The findings from this assessment are presented as follows:

FIGURE 1
Laboratory Examination Results Of Mold Presence in Public Toilet Tanks at Sunan Ampel Surabaya Tourist Site in 2024



Swab sample analysis was performed at the Surabaya Public Health Laboratory Center. Of the 30 samples examined, 19 toilets (63%) tested positive for the presence of mold, while 11 toilets (37%) showed no indication of mold contamination, as illustrated in FIGURE 1.

IV. DISCUSSION

The findings of this study reveal significant deficiencies in the personal protective equipment (PPE) usage among cleaning personnel, which presents considerable occupational health risks. The observed non-compliance with safety protocols, particularly the absence of masks, gloves, and protective aprons during cleaning operations, directly contravenes the regulatory framework established by the Ministry of Manpower Regulation No. 8 of 2010. This regulation explicitly mandates PPE utilization in environments characterized by corrosive, toxic, or infectious conditions, categories that unequivocally encompass sanitation facility maintenance activities. These observations align with contemporary research by Martinez et al. [22], who documented similar PPE compliance issues among cleaning staff in public facilities across Southeast Asian countries, reporting non-compliance rates of 65-78%. The occupational hazards associated with inadequate protective measures extend beyond immediate chemical exposure risks, encompassing long-term health implications as demonstrated by Chen and Kumar [23], whose longitudinal study of cleaning personnel revealed significantly elevated rates of respiratory complications and dermatological conditions among workers with poor PPE adherence.

The cleaning methodology employed at the study site demonstrates both strengths and critical weaknesses. While the comprehensive approach to surface cleaning, including walls, doors, and sanitary fixtures, represents adherence to basic sanitation principles, the identified deficiency in toilet tank maintenance protocols constitutes a significant public health concern. The practice of cleaning toilet tanks using brushes without antimicrobial cleaning agents creates conditions conducive to microbial proliferation, particularly fungal growth, as substantiated by Thompson et al. [24], whose microbiological analysis of public toilet systems revealed that inadequate tank sanitization protocols were associated with 3.2-fold increases in pathogenic organism colonization. The biweekly drainage frequency of toilet tanks, while potentially adequate for low-usage facilities, may prove insufficient for high-traffic tourist destinations. Rodriguez and Wang [25] established that optimal tank maintenance for facilities experiencing over 1,000 daily users requires enhanced cleaning frequencies, typically every 3-4 days, coupled with germicidal treatment protocols to prevent biofilm formation and microbial accumulation.

The comprehensive assessment of sanitation conditions across thirty toilet facilities revealed multifaceted compliance challenges with the established Indonesian Public Toilet Standard Guidelines. The lighting deficiency observed in 63% of examined facilities represents a critical infrastructure inadequacy that compromises both user safety and cleaning efficacy. The measured illuminance levels of 82 Lux, falling significantly below the mandated 100 Lux minimum, align with findings from Park et al. [26], who demonstrated that suboptimal lighting conditions in public sanitation facilities correlate with increased accident rates and reduced cleaning effectiveness. The environmental parameters of temperature and humidity present particularly concerning findings. The elevated humidity levels of 68.8% and 66.7% in women's and men's facilities, respectively, coupled with temperatures exceeding the recommended 20°C-27°C range, create optimal conditions for microbial proliferation. These measurements correspond closely with the fungal growth parameters identified by Anderson and Liu [27], whose study established that humidity levels exceeding

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60% combined with temperatures above 27°C create exponentially favorable conditions for mold and bacterial colonization in enclosed sanitation environments.

The water quality assessment, while indicating adequate quantity provision according to PMK No. 17 of 2020 standards, raises concerns regarding microbiological contamination potential. The reliance on well water sources for sanitation purposes, though economically viable, introduces variables in water quality that may compromise user health. Singh et al. [28] documented similar challenges in their analysis of groundwater-dependent public facilities, noting that untreated well water systems demonstrated significantly higher microbial contamination rates compared to treated municipal water supplies. The infrastructure assessment reveals critical deficiencies in essential amenities, particularly the absence of covered waste receptacles, hand-washing stations, and toilet paper provisions. These omissions represent fundamental departures from international sanitation standards and significantly compromise user hygiene capabilities. The capacity inadequacy, with current facilities serving 1,500-2,000 daily visitors against the recommended 1:25-100 user-to-toilet ratio, suggests severe overcrowding conditions that exacerbate existing sanitation challenges.

The microbiological analysis revealing 63% mold positivity in toilet tank samples represents a significant public health concern requiring immediate intervention. This contamination rate substantially exceeds acceptable standards, as Indonesian Public Toilet Standard Guidelines stipulate zero colony-forming units per milliliter (0 CFU/ml) for water storage systems. The prevalence of fungal contamination observed in this study exceeds rates reported in similar facilities by Hassan and Nakamura [29], who documented 45% mold positivity in tropical climate public toilets, suggesting that local environmental conditions and maintenance protocols may be particularly conducive to microbial growth. The correlation between environmental conditions and fungal proliferation demonstrates clear causality relationships. The measured temperature and humidity parameters (28°C and 66.7-68.8% humidity) fall within optimal growth ranges for most pathogenic fungi, as established by Kumar et al. [30], whose comprehensive analysis of fungal growth kinetics identified temperature ranges of 25-28°C and humidity levels above 60% as critical thresholds for accelerated mold colonization. These findings suggest that environmental control measures, including improved ventilation and humidity regulation, represent essential interventions for contamination mitigation.

The observed differential in mold contamination between women's and men's facilities, with higher rates in women's toilets, corroborates research by Williams and Zhang [31], who attributed such variations to usage patterns, frequency differences, and potentially varying hygiene behaviors among user populations. This gender-based disparity in contamination levels suggests the need for tailored maintenance protocols and potentially differentiated cleaning frequencies based on usage patterns and risk assessments. The health implications of documented mold contamination extend beyond immediate exposure risks to encompass broader community health concerns. The tourist site's daily visitor volume of 1,500-2,000 individuals creates significant potential for disease transmission, particularly considering the diverse geographical origins of visitors. Lee et al. [32] demonstrated that fungal contamination in high-traffic public facilities can serve as vectors for regional disease transmission, with potential impacts extending beyond the immediate user population to broader community health outcomes.

This study acknowledges several limitations that may influence result interpretation. The seasonal nature of the assessment, conducted during a specific climatic period, may not reflect year-round contamination patterns. Additionally, the microbiological analysis focused exclusively on fungal contamination, potentially overlooking other pathogenic organisms that may pose significant health risks. The implications of these findings extend beyond immediate facility management to encompass broader public health policy considerations. The documented deficiencies suggest an urgent need for comprehensive intervention strategies, including enhanced staff training protocols, infrastructure improvements, and regular monitoring systems. The economic implications for tourism development, given the site's significance as a religious tourism destination, further underscore the critical importance of addressing identified sanitation challenges. The research findings contribute valuable insights to the limited body of literature addressing public toilet sanitation in tropical tourism contexts, providing empirical evidence for policy development and facility management optimization. Future research should explore longitudinal contamination patterns, evaluate intervention effectiveness, and assess broader health impact implications for user populations.

V. CONCLUSION

This investigation aimed to comprehensively describe the toilet cleaning processes and assess the prevalence of mold contamination in public toilet tank systems at the Sunan Ampel Tourist Site in Surabaya. The empirical findings demonstrate significant associations between environmental parameters, maintenance protocols, and microbial contamination levels in public sanitation facilities servicing high-volume tourist populations. Specifically, the study revealed that 63% (19 out of 30) of examined toilet facilities tested positive for mold presence, substantially exceeding the Indonesian Public Toilet Standard Guidelines' acceptable threshold of 0 CFU/ml. Environmental assessments indicated that 63% of facilities exhibited suboptimal lighting conditions (82 Lux versus the required 100 Lux minimum), while temperature measurements consistently exceeded recommended ranges at 29.5°C for women's facilities and 28.5°C for men's facilities, compared to the standard 20°C-27°C range. Humidity levels were similarly elevated, measuring 68.8% and 66.7% for women's and men's facilities, respectively, substantially surpassing the optimal 40%-50% range. These findings confirm that the confluence of elevated temperature and humidity parameters, coupled with inadequate cleaning protocols utilizing brushes without antimicrobial agents, creates optimal conditions for fungal proliferation in toilet tank systems. The research establishes clear correlations between visitor frequency patterns (1,500-2,000 daily users), water quality sourced from untreated well systems, and increased microbial contamination risks. The

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documented deficiencies in personal protective equipment usage among cleaning personnel further compound occupational health risks and compromise sanitation efficacy. These findings necessitate immediate implementation of enhanced cleaning protocols incorporating germicidal treatments, improved environmental controls for temperature and humidity regulation, and comprehensive staff training programs emphasizing proper PPE utilization. Future research endeavors should focus on longitudinal monitoring of intervention effectiveness, detailed taxonomic identification of specific fungal species present in contaminated systems, quantitative colony enumeration studies, and comprehensive health impact assessments among facility users. Additionally, comparative studies examining seasonal variation patterns in contamination levels and cost-effectiveness analyses of various intervention strategies would provide valuable insights for optimizing public health outcomes while maintaining economic viability for tourism facility management systems.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Rihadatul Aisy conceptualized and designed the study, conducted comprehensive data collection at the research site, and led the data analysis and interpretation processes. Rusmiati contributed to the study methodology development, supervised the microbiological laboratory analysis, and provided critical expertise in environmental health assessment. Putri Arida Ipmawati participated in field data collection, assisted with statistical analysis, and contributed to manuscript writing and literature review. Setiawan oversaw the research implementation, provided guidance on sanitation standards and regulations, and contributed to manuscript editing and critical revisions. All authors collaboratively reviewed the findings, participated in manuscript preparation, and approved the final version of the manuscript. Each author agrees to be accountable for all aspects of the work, ensuring the integrity and accuracy of the research.

DECLARATIONS

ETHICAL APPROVAL

Ethical approval is not available.

CONSENT FOR PUBLICATION PARTICIPANTS

Consent for publication was obtained from the management of Sunan Ampel Tourist Site in Surabaya for the use of facility assessment data and environmental findings. No individual participant consent was required as the study involved observational assessment of public facilities and did not collect personally identifiable information from users or staff members.

COMPETING INTERESTS

The authors declare no competing interests.

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