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Characterization of microbiological quality and physico-chemical parameters of clean water in primary healthcare facilities within the Kalideres District

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ABSTRACT
The availability of clean water that meets quality standards in primary healthcare facilities is a fundamental requirement to prevent nosocomial infections and ensure patient safety. This study aims to characterize the microbiological quality and physico-chemical parameters of clean water within the Kalideres Community Health Center (Puskesmas) and its supporting units, based on the standards of the Minister of Health Regulation Number 2 of 2023. Water sampling and testing across 11 locations were conducted using the aseptic grab sampling method, in compliance with a combination of international ISO standards, Indonesian National Standards (SNI), APHA Standard Methods, and the laboratory's internal Work Instructions (IK). The results indicate significant water quality degradation, particularly regarding microbiological parameters, where locations such as the Pegadungan 1 Supporting Health Center (Pustu) exhibited *Total Coliform* levels exceeding >1000 colonies/100ml, and the Kalideres Community Health Center unit was found to be contaminated with both *Total Coliform* and *E. coli* at concentrations surpassing >1000 colonies/100ml. Physical parameters showed critical values for turbidity at Pustu Kamal 2, reaching 19.10 NTU, which far exceeds the 3 NTU regulatory limit. Chemically, Manganese (Mn) concentrations were detected exceeding the 0.1 mg/L threshold at Pustu Pegadungan 4 (0.2455 mg/L) and Pustu Pegadungan 2 (0.1227 mg/L). In conclusion, the water quality in the majority of primary healthcare facilities in the Kalideres region is in a concerning state due to massive bacteriological contamination and non-compliance with several physico-chemical parameters. This situation underscores the urgent need for technical interventions, including the implementation of water treatment systems and more rigorous disinfection protocols, to mitigate health risks for both medical staff and the general public.

Keywords:
Characterization; Clean Water Quality; Microbiological Contamination; Physico-chemical Parameters; Primary Healthcare Facilities.

Introduction

Access to clean water constitutes a foundational pillar of sustainable development explicitly outlined in the Sustainable Development Goals (SDGs) Target 6.1, which mandates the universal availability of safely managed drinking water for all global populations by 2030 (WHO, 2022). National strategic frameworks have deeply integrated this commitment into the 2025–2029 National Medium-Term Development Plan (RPJMN) to systematically expand public access to adequate environmental sanitation and safe water infrastructure across the archipelago (Bappenas, 2025). Profound challenges continue to arise from the progressive degradation of raw water quality driven by rapid, massive urbanization and unchecked anthropogenic pollution in expanding urban settings (Trinata et al., 2025). This deteriorating quality of essential water

resources directly threatens public health security, particularly within densely populated metropolitan areas that remain heavily reliant on shallow groundwater extraction for daily survival (Kemenkes RI, 2024). Regular water monitoring serves as an indispensable environmental surveillance instrument for early microbial and chemical contaminant detection to systematically prevent the transmission of waterborne diseases (Arwin et al., 2024).

The long-term realization of national health autonomy will be severely hindered without a systematic and highly disciplined surveillance framework due to the compounding economic burden of high morbidity rates stemming from water-associated infectious diseases (Saimi, 2023). Safeguarding the strict integrity of water quality within public amenities must remain a top priority in national environmental policy frameworks to ensure comprehensive civil biosecurity (Syaharani, 2025). This imperative is most pronounced in Primary Healthcare Facilities (FKTP), such as community health centers (Puskesmas), which serve as vital frontliners in the public health system across diverse municipal jurisdictions. These essential institutions are legally and ethically mandated to guarantee the highest possible environmental sanitation standards to protect the communities they serve, establishing a sanitary environment that actively supports clinical safety, prevents secondary infections, and completely upholds public confidence in institutional medical care. Maintaining these dynamic standards ensures an uncompromised operational baseline across all tiers of regional healthcare delivery, minimizing localized environmental hazards that could otherwise threaten patient well-being and safety metrics at any given moment.

The continuous provision of compliant clean water within these primary care environments is not merely a routine operational requirement, but a fundamental component of infection prevention and control (IPC) protocols designed to mitigate Healthcare-Associated Infections (HAIs) (CDCP, 2021). Microbial contamination within medical water distribution networks can act as an immediate transmission vehicle for various opportunistic pathogens, drastically compromising the safety of vulnerable, immunocompromised patients (Hadiatun et al., 2026). Empirical evidence clearly demonstrates that health policies prioritizing adequate water supply and robust sanitation yield significant, measurable reductions in water-based diseases (Wulandari & Marniati, 2024). Water quality standards encompassing microbiological, physical, and chemical parameters must therefore be rigorously monitored to support medical sterilization and patient hygiene. Strict compliance with these water standards constitutes a key criterion in periodic puskesmas accreditation to ensure institutional healthcare quality assurance, extending far past technical clinical merits. Inconsistencies in maintaining water quality can directly erode public trust in government-managed medical services (Teguh Ardiansyah et al., 2024). Internal oversight remains an unconditional prerequisite for modern institutional health delivery systems under this persistent operational dynamic.

The implementation of environmental health regulations across Indonesia has been substantially tightened with the formal enactment of the Ministry of Health Regulation (Permenkes) Number 2 Year 2023, which replaced outdated standards to better match contemporary pollution dynamics. This current regulation enforces highly rigorous Environmental Health Quality Standards (SBMKL), particularly for microbiological parameters, which strictly mandate a zero-tolerance threshold for Total coliforms and Escherichia coli. Enforcing this ruleset represents a critical, preventive government intervention to mitigate biological contamination risks that are increasingly exacerbated by shifting climate patterns and deficient environmental sanitation. These evolving statutory standards require diligent healthcare managers to adopt advanced water treatment technologies and perform routine, thorough maintenance on distribution pipe infrastructure (Kemenkes, 2023). Failure to comply with these environmental quality standards can carry severe legal implications for the operational licensing of public healthcare facilities (Dwitasari & Tauchid Noor, 2025). Water quality characterization in primary units is thus critical as an environmental audit to ensure statutory compliance. This analytical process bridges laboratory outputs directly with health policy enforcement metrics.

Kalideres Subdistrict represents complex urban environmental challenges characterized by severe land subsidence, saltwater intrusion, and domestic wastewater cross-contamination into vulnerable shallow aquifers (Hasibuan et al., 2023). These precarious geophysical conditions necessitate targeted engineering interventions, as they constantly jeopardize compliance with clean water standards in public amenities (Asseggaf et al., 2017; Taftazani et al., 2022). Microbiological parameters are exceptionally critical here, given that coliform bacteria signify systemic disinfection failures, while Escherichia coli confirms fecal pollution and the dangerous dissemination of antibiotic resistance genes (Richiardi et al., 2023). This biological hazard is intrinsically linked to biofilm formation risks inside aging distribution networks (Erdei-Tombor et al., 2024). Elevated turbidity levels can shelter pathogenic microflora from disinfectant agents like chlorine, thereby lowering active sanitary barriers (USEPA, 2022). Excessive concentrations of manganese and iron typical of coastal geologies can cause widespread damage to medical infrastructure, foster bacterial scale deposition, and induce piping corrosion if pH and total dissolved solids are not monitored simultaneously (Kristianingsi et al., 2021; Amin et al., 2024; Kemenkes RI, 2024).

An urgent need exists to conduct a comprehensive environmental assessment of water quality across the Kalideres Puskesmas and its auxiliary units due to these interconnected background issues. This specific study is designed to characterize medical water profiles against the mandatory indices of Permenkes No. 2/2023 to identify critical gaps between actual field conditions and regulatory baselines. The resulting characterization supports municipal decision-makers by providing solid scientific justification to allocate public resources toward upgrading environmental sanitation infrastructure. This study establishes a vital baseline for developing stringent water safety plans within primary care facilities to maximize patient and healthcare worker safety. The risk of catastrophic waterborne disease outbreaks in medical environments can be significantly minimized through periodic mapping. The practical contributions of this research are anticipated to reinforce environmental health surveillance networks in West Jakarta against future water pollution challenges. Systematic improvements to water quality and sanitary infrastructure can be fully realized by leveraging data-driven approaches to sustain safe healthcare delivery for the entire community over the long term.

Methods

Figure 1 show the research flow diagram this study utilizes a quantitative descriptive approach to evaluate the water quality in primary healthcare facilities within the Kalideres District. Table 1 show water sampling was conducted simultaneously on August 26, 2025, across eleven distinct locations, encompassing the central Kalideres Community Health Center (samples number 1 and 8) and various Supporting Health Center (Pustu) 3 units. The sampling sites included Pustu Pegadungan 1, Pustu Pegadungan 2, Pustu Pegadungan 3, Pustu Pegadungan 4, Pustu Semanan 1, Pustu Semanan 2, Pustu Tegal Alur 1, Pustu Tegal Alur 3, and Pustu Kamal 2. The sampling procedure was performed independently by the Kalideres Community Health Center staff, and the samples were subsequently transported to the Regional Health Laboratory (Labkesda) of DKI Jakarta Province in good condition for immediate analysis. The water sampling procedure begins with the preparation of sterilized, labeled containers and the use of the grab sampling technique, performed after flushing the water for 2–3 minutes to ensure it represents the conditions of the primary source. The physical and chemical samples are then stored in a cool box at a temperature of 4 ± 2^{o}C and transported to the laboratory within a maximum of 24 hours to maintain parameter stability. All collected samples were categorized as clean water intended for daily sanitation and hygiene purposes within the medical environment. Site selection was determined based on the geographical representation of healthcare services in the area to obtain a comprehensive overview of the clean water safety profile for both the public and healthcare professionals.

Table 1. Water sampling across eleven distinct locations, the central Kalideres Community Health Center

Cluster	Total Points	Map Code	Sampling Point Coordinates (DMS)	Spatial Distribution Characteristics
Pegadungan	5	Puskesmas Kalideres Pustu Pegadungan 1 Pustu Pegadungan 2 Pustu Pegadungan 3 Pustu Pegadungan 4	6°08'04.2"S 106°42'27.7"E 6°08'09.6"S 106°42'03.6"E 6°08'20.4"S 106°42'12.6"E 6°07'55.2"S 106°42'32.4"E 6°08'27.6"S 106°42'43.2"E	Core Research Center. Highest density of points, anchored by the central Kalideres Community Health Center (S1).
Tegal Alur	2	Pustu Tegal Alur 1 Pustu Tegal Alur 3	6°07'22.8"S 106°41'16.8"E 6°07'08.4"S 106°41'52.8"E	North-Central Sector. Serves as a buffer area covering light industrial zones and dense residential housing.
Semanan	2	Pustu Semanan 1 Pustu Semanan 2	6°09'28.8"S 106°42'07.2"E 6°09'50.4"S 106°42'21.6"E	Southeast Sector. Directly adjacent to the transit railway corridor and borders the neighboring Cengkareng District.
Kamal	1	Pustu Kamal 2	6°06'07.2"S 106°41'34.8"E	Extreme Northern Sector. Situated closest to the coastal edge and main access routes toward North Jakarta.
Kalideres	1	Pustu Kalideres	6°09'07.2"S 106°41'20.4"E	Southwest Sector. Positioned right along the urban boundary line facing Tangerang City.

The analysis of physico-chemical parameters was conducted using Indonesian National Standard (SNI) methods and widely recognized international methodologies at the Jakarta Regional Health Laboratory (Labkesda). Physical parameters included testing for temperature (IK.03/PP16.5-Air-17025/Labkesda), Total Dissolved Solids or TDS (IK.01/PP16.5-Air-17025/Labkesda), turbidity (IK.02/PP16.5-Air-17025/Labkesda), color (SNI 6989.80:2011), and odor (SNI 3554:2015). Concurrently, chemical parameters were analyzed using the Standard Methods for the Examination of Water and Wastewater (APHA) and SNI protocols to ensure data accuracy. The analyzed chemical suite encompassed acidity levels or pH (SNI 6989.11:2019), Nitrate and Nitrite (Std Met. APHA 4110C/23/2017), Hexavalent Chromium (Std Met. APHA 3500-Cr.B/23/2017), as well as metal concentrations for Iron and Manganese (Std Met. APHA 312B/23/2017; 3030B/23/2017). All chemical analyses commenced on August 26, 2025, coinciding with the sample receipt date, to maintain the integrity of chemical specimens sensitive to temperature fluctuations and temporal degradation. The utilization of KAN-accredited laboratory instrumentation guarantees high-level precision and validity in measuring these physico-chemical parameters, adhering to strict laboratory standard operating procedures.

Microbiological examination procedures focused on detecting the presence of contamination indicator bacteria, specifically *Total Coliform* and *Escherichia coli*, utilizing the ISO 9308-1:2014 standard method. Water samples of 100 ml were processed via membrane filtration or equivalent techniques to enumerate bacterial colonies per unit volume (colonies/100ml). Although the samples were received at the laboratory on August 26, 2025, microbiological testing officially commenced on August 27, 2025, following mandatory laboratory preparation phases. The incubation process was carried out under controlled temperature conditions to optimize the growth of target bacteria, if present within the samples. The ISO 9308-1:2014 method was selected for its specificity and sensitivity in detecting bacteriological pathogens in both drinking

and clean water. Test results were systematically recorded for each location, with the data reflecting the microbial density at the time of field sampling. This biological analysis constitutes the most critical component in determining water safety aspects regarding the risk of gastrointestinal infection transmission among healthcare facility users.

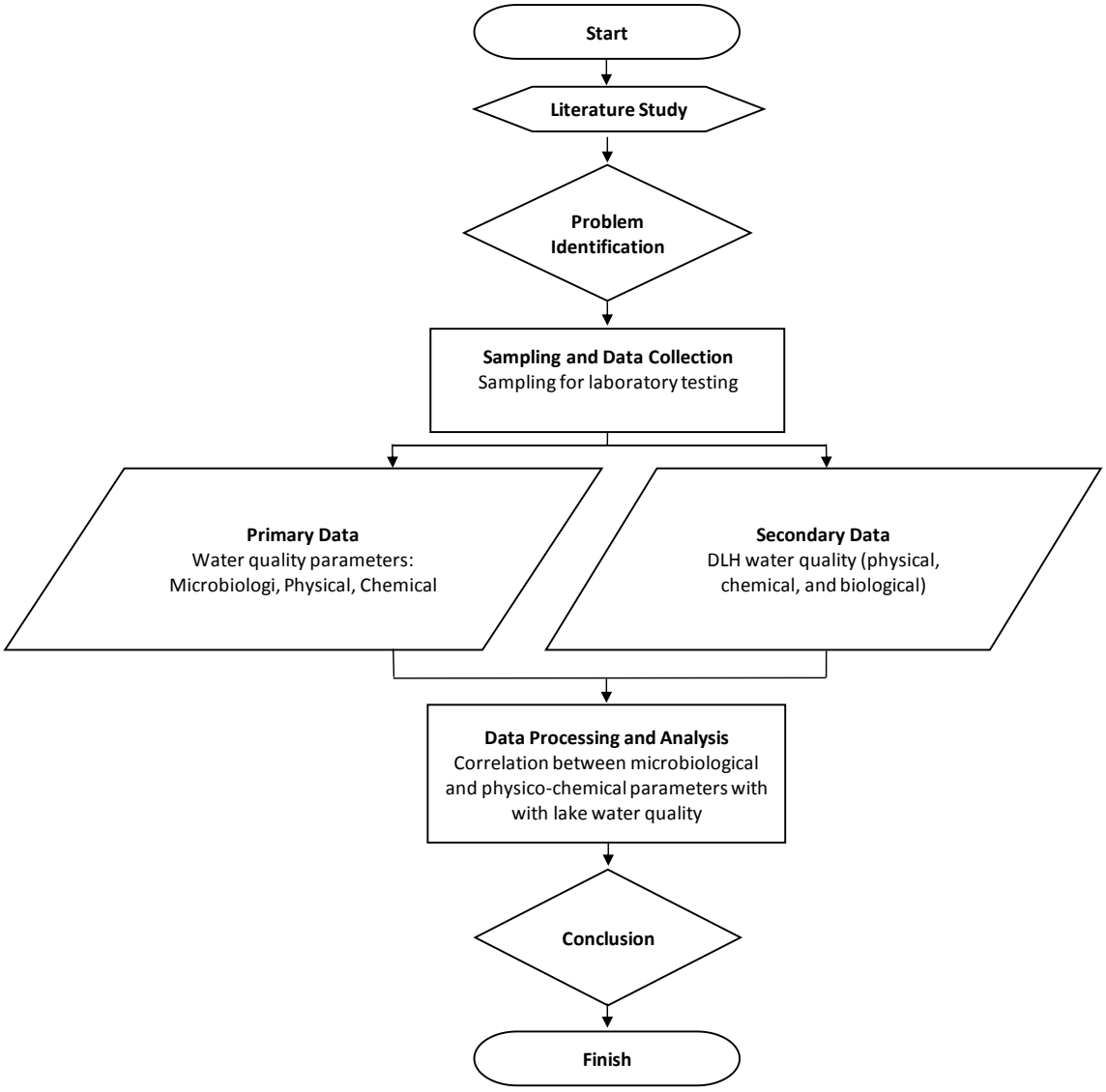

Figure 1. Research flow diagram

All laboratory data were interpreted with reference to environmental health quality standards established in the Minister of Health Regulation (Permenkes) Number 2 of 2023. This regulation serves as the implementation of Government Regulation No. 66 of 2014 concerning Environmental Health, which mandates strict thresholds for every parameter. According to these regulations, the maximum allowable concentration for microbiological parameters (*Total Coliform* and *E. coli*) is 0 colonies/100ml. For physical parameters, the maximum turbidity limit is set at 3 NTU, Total Dissolved Solids (TDS) at 300 mg/L, and color at a maximum of 10 TCU. Regarding chemical parameters, the quality standard limits nitrate levels to 20 mg/L, nitrite to 3 mg/L, hexavalent chromium to 0.01 mg/L, iron to 0.2 mg/L, and manganese to a maximum of 0.1 mg/L. Furthermore, the water must be odorless and maintain a pH within the required normal range for health regulations. Compliance evaluation was performed by directly comparing laboratory test results against these maximum allowable concentrations to determine the water's suitability status for each healthcare service unit.

Results and Discussions

Laboratory analysis results for eleven clean water sampling points within the Kalideres Community Health Center's service area indicate significant quality variations, with several critical parameters exceeding the thresholds established in the Minister of Health Regulation (Permenkes) No. 2 of 2023. Microbiologically, massive contamination was detected in the samples from the Kalideres Community Health Center (Lab No. 8) and the Tegal Alur 1 Supporting Health Center (Pustu), where *Total Coliform* and *Escherichia coli* counts far surpassed the zero-colony quality standard. Regarding physical parameters, Pustu Kamal 2 exhibited a very high turbidity level (19.10 NTU), while the Kalideres Community Health Center (Lab No. 8) also exceeded the limit with a value of 4.77 NTU. Chemically, the primary issue was identified in Manganese (Mn) concentrations, which exceeded the 0.1 mg/L limit at Pustu Pegadungan 2 (0.1227 mg/L) and Pustu Pegadungan 4 (0.2455 mg/L). Other chemical parameters, including Nitrate, Nitrite, Iron, and Hexavalent Chromium, generally remained below the permissible thresholds across all testing locations. Detailed results of the microbiological, physical, and chemical parameter testing for the clean water samples in the Kalideres Community Health Center's service area are presented in Table 2, Table 3, and Table 4.

Table 2. Observation Results of Microbiological Parameter Testing for Clean Water Samples in the Kalideres Community Health Center Working Area

No	Sampling Location	*Total Coliform* (colonies/100ml)	*E.coli* (colonies/100ml)	Quality Standards (Permenkes 2/2023)	Quality Standard Compliance
1	Puskesmas Kalideres	63.6	0	0	Non-compliant
2	Pustu Pegadungn 1	>1000	0	0	Non-compliant
3	Pustu Pegadungn 2	0	0	0	Compliant
4	Pustu Pegadungn 3	17	0	0	Non-compliant
5	Pustu Pegadungn 4	0	0	0	Compliant
6	Pustu Semanan 1	8	6	0	Non-compliant
7	Pustu Semanan 2	0	0	0	Non-compliant
8	Pustu Kalideres	>1000	>1000	0	Non-compliant
9	Pustu Tegal Alur 1	240	30	0	Non-compliant
10	Pustu Tegal Alur 3	60	0	0	Non-compliant
11	Pustu Kamal 2	0	0	0	Compliant

Table 3. Observation Results of Physical Parameter Testing for Clean Water Samples in the Kalideres Community Health Center Working Area

No	Sampling Location	Temperature (°C)	TDS (mg/L)	Turbidity (NTU)	Color (TCU)	Odor
	Maxsimum Consentrasion	-	300	3	10	Odorless
1	Puskesmas Kalideres	22.5	87	1.20	ND < 0.70	Odorless
2	Pustu Pegadungn 1	22.3	208	1.92	ND < 0.70	Odorless
3	Pustu Pegadungn 2	22.1	226	1.36	ND < 0.70	Odorless
4	Pustu Pegadungn 3	24.6	91	0.72	ND < 0.70	Odorless
5	Pustu Pegadungn 4	24.4	201	1.03	ND < 0.70	Odorless
6	Pustu Semanan 1	24.9	83	0.54	ND < 0.70	Odorless
7	Pustu Semanan 2	24.9	83	0.54	ND < 0.70	Odorless
8	Pustu Kalideres	25.1	127	4.77	ND < 0.70	Odorless
9	Pustu Tegal Alur 1	25.1	113	0.64	ND < 0.70	Odorless
10	Pustu Tegal Alur 3	25.1	119	0.72	ND < 0.70	Odorless
11	Pustu Kamal 2	25.2	104	19.10	ND < 0.70	Odorless

Table 4. Observation Results of Chemical Parameter Testing for Clean Water Samples in the Kalideres Community Health Center Working Area

No	Sampling Location	pH	Nitrate (mg/L)	Nitrite(mg/L)	Chromium (mg/L)	Iron (mg/L)	Manganese (mg/L)
	Maximum Threshold	6.5-8.5	20	3	0.01	0.2	0.1
1	Puskesmas Kalideres	7.62	8.13	ND<0.122	ND<0.0003	ND<0.0021	ND < 0.0027
2	Pustu Pegadungan 1	7.32	1.80	ND<0.122	ND<0.0003	ND<0.0021	0.0892
3	Pustu Pegadungan 2	7.39	2.12	ND<0.122	ND<0.0003	ND<0.0021	0.1227
4	Pustu Pegadungan 3	6.97	7.57	ND<0.122	ND<0.0003	ND<0.0021	0.0661
5	Pustu Pegadungan 4	7.02	1.21	ND<0.122	ND<0.0003	ND<0.0021	0.2455
6	Pustu Semanan 1	7.11	15.62	ND<0.122	ND<0.0003	ND<0.0021	0.0321
7	Pustu Semanan 2	7.21	6.92	ND<0.122	ND<0.0003	ND<0.0021	ND < 0.0027
8	Pustu Kalideres	7.04	8.70	ND<0.122	ND<0.0003	ND<0.0021	0.0173
9	Pustu Tegal Alur 1	7.53	11.13	ND<0.122	ND<0.0003	ND<0.0021	ND < 0.0027
10	Pustu Tegal Alur 3	7.50	11.19	ND<0.122	ND<0.0003	ND<0.0021	ND < 0.0027
11	Pustu Kamal 2	7.56	6.47	ND<0.122	ND<0.0003	ND<0.0021	ND < 0.0027

Note : ND**:** Not Detected (below the instrument's detection limit)

Based on the research findings in Table 2, the laboratory test results for microbiological parameters in this study indicate an alarming level of contamination in several primary healthcare units. The test results show that the Kalideres Community Health Center (Lab No. 8) and the Pegadungan 1 Supporting Health Center (Pustu) exhibited *Total Coliform* counts exceeding >1000 colonies/100ml, while *E. coli* in the central unit also reached >1000 colonies/100ml. This condition far surpasses the zero-threshold mandated by the Minister of Health Regulation No. 2 of 2023. These high bacteriological counts indicate domestic waste infiltration into the distribution system or a failure in the protection of raw water sources. The microbiological contamination rates in Kalideres Sub-district are contrastingly influenced by environmental and demographic factors. The high levels of *Total Coliform* in Kalideres and Pegadungan 1 are triggered by organic matter runoff resulting from flood vulnerability across all 5 urban villages (kelurahan), 78 sub-district-level fire incidents, and residual vegetation from urban farming that produces 2,861.6 quintals of seasonal vegetables (BPS Jakarta Barat, 2025). However, the high concentration of *E. coli* bacteria in Kalideres compared to Pegadungan 1, where it was undetected (negative), is purely driven by anthropogenic density. Kalideres Urban Village is a highly congested area with a density of 16,328.01 people/km^2 and a birth load reaching 4,578 lives, causing closely packed conventional septic tanks to trigger fresh fecal waste seepage into surface water. Conversely, Pegadungan Urban Village surrounding Pegadungan 1 features a much looser spatial layout with the lowest density of 13,300.27 people/km^2 ((Table 3.1 Population, Percentage Distribution of Population, Population Density, and Population Sex Ratio by Villages/Subdistricts in Kalideres District, 2024) due to its vast area (7.52 km^2), providing a safe distance for sanitation infrastructure that effectively prevents cross-contamination of human feces into the surrounding environment (BPS Jakarta Barat, 2025). Consistent with the findings of Annisa, Pratiwi, and Alamsyah (2023), massive microbiological contamination in public facilities in North Jakarta is often caused by the close proximity of wells to septic tanks as well as aging piping infrastructure. Failure to achieve the zero bacteriological standard places both patients and medical staff at high risk for acute waterborne disease infections (Setiawan & Hendra, 2023).

The microbiological contamination levels in this study are significantly higher than those reported by Febrina et al. (2024) in the service area of the Surakarta Community Health Center, Central Java, which recorded an average *Total Coliform* count of 130 colonies/100ml. This stark difference reflects the heavier environmental pressure in densely populated urban areas like Kalideres, where groundwater quality has severely degraded due to extreme population density. As explained by Putri et al. (2025), regions with poor environmental sanitation tend to have

higher microbial loads in shallow aquifers. The presence of *E. coli* in samples from the Semanan 1 Supporting Health Center (6 colonies/100ml) and the Tegal Alur 1 Supporting Health Center (30 colonies/100ml) underscores the existence of active fecal pollution within the clean water system. This necessitates an immediate evaluation of borehole integrity and the efficacy of the chlorination disinfection units used across all relevant healthcare service units

The physical parameter test results in Table 5 indicate that turbidity levels represent a primary critical issue, particularly at the Kamal 2 Supporting Health Center (Pustu), which reached 19.10 NTU. This value far exceeds the maximum standard threshold of 3 NTU established in environmental health regulations. High turbidity levels not only impact aesthetic aspects, reducing user comfort, but also technically interfere with the efficacy of the chlorination process. According to Farrell et al. (2018), suspended particles causing turbidity can act as a 'shield' for pathogenic bacteria against exposure to disinfectant agents, thereby rendering the water sterilization process suboptimal. The results obtained at Pustu Kamal 2 indicate potential mechanical issues with sand filters or the possibility of a well casing leak, allowing soil particles to enter the clean water system. These poor physical water conditions require special attention to ensure the sterility of water used in basic medical procedures.

Compared to research conducted by the DKI Jakarta Environmental Agency (DLH) (2025) regarding surface water quality in Jakarta, the turbidity figures at several Pustu units in this study show higher anomalies for the groundwater category. This reinforces the suspicion of localized interference in the boreholes of each respective unit. Conversely, temperature and Total Dissolved Solids (TDS) parameters across all locations, including Pustu Pegadungan 2 (226 mg/L) and the Kalideres Community Health Center (87 mg/L), remain within safe limits below 300 mg/L. These TDS results are relatively lower and more favorable compared to studies in the coastal areas of North Jakarta, which record elevated TDS levels with an average of 1,114 mg/L and maximum values reaching 3,020 mg/L due to seawater intrusion (Wijayanti et al., 2025). The consistency of relatively stable TDS and temperature values suggests that despite turbidity and biological issues, the water source has not chemically undergone significant salinization, indicating high potential for restoration through appropriate filtration systems.

Table 5. Characterization of microbiological quality and physico-chemical parameters of clean water in Primary Healthcare Facilities within the Kalideres District

Facility Name	Total Coliform (colonies /100ml)	E. coli (colonies /100ml)	Turbidity (NTU x10)	Mangane se (mg/L x1000)	Std: *Total Coliform* & *E.coli* (colonies /100ml)	Std: Turbidity (30)	Std: Mangane se (mg/L x1000)
Puskesmas Kalideres	63.3	0.0	12.0	<2.7	0.0	30.0	100.0
Pustu Pegadungan 1	>1000.0	0.0	19.2	89.2	0.0	30.0	100.0
Pustu Pegadungan 2	0.0	0.0	13.6	122.7	0.0	30.0	100.0
Pustu Pegadungan 3	17.0	0.0	7.2	66.1	0.0	30.0	100.0
Pustu Pegadungan 4	0.0	0.0	10.3	245.5	0.0	30.0	100.0
Pustu Semanan 1	8.0	0.0	5.4	32.1	0.0	30.0	100.0
Pustu Semanan 2	0.0	0.0	5.4	<2.7	0.0	30.0	100.0
Pustu Kalideres	>1000.0	>1000.0	47.7	17.3	0.0	30.0	100.0
Pustu Tegal Alur 1	240.0	30.0	6.4	<2.7	0.0	30.0	100.0
Pustu Tegal Alur 3	60.0	0.0	7.2	<2.7	0.0	30.0	100.0
Pustu Kamal 2	0.0	0.0	191.0	<2.7	0.0	30.0	100.0

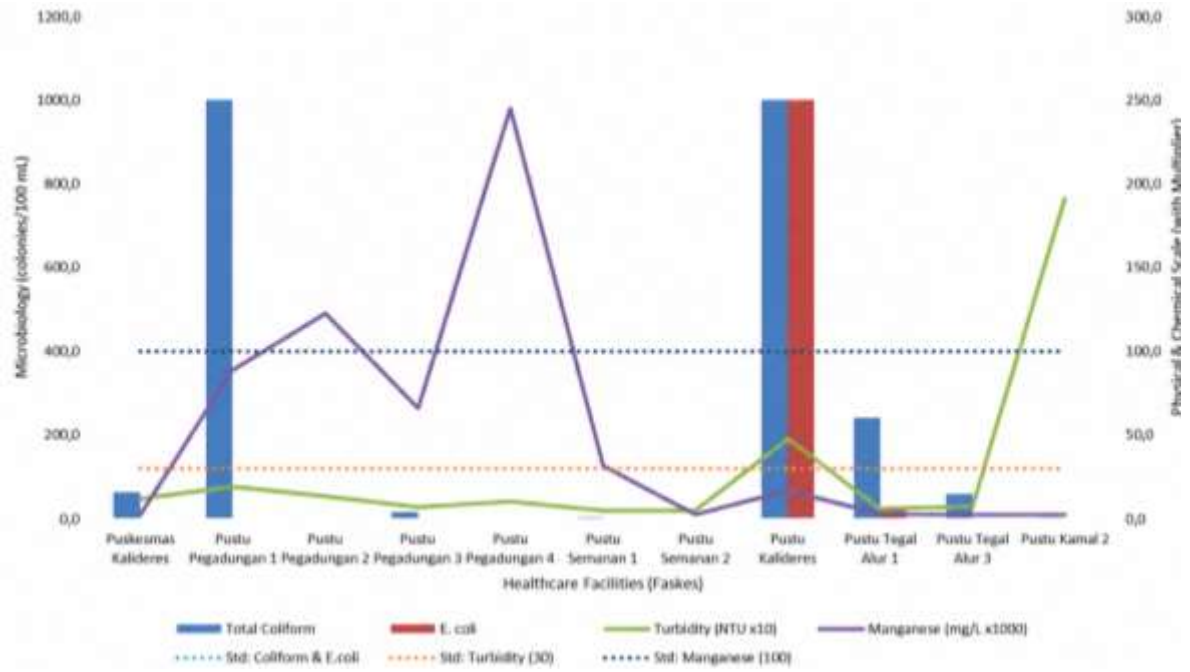

Figure 2. Characterization of microbiological quality and physico-chemical parameters of clean water in Primary Healthcare Facilities within the Kalideres District

Chemical parameter test results in Table 4 reveal specific issues regarding Manganese (Mn) concentrations that exceed quality standards in the Pegadungan area. Laboratory data indicates that Manganese levels at the Pegadungan 4 Supporting Health Center (Pustu) reached 0.2455 mg/L and at Pustu Pegadungan 2 reached 0.1227 mg/L, whereas the maximum standard is 0.1 mg/L. The long-term excessive presence of manganese can lead to the accumulation of black sediment within piping networks and staining on medical equipment and sinks. Previous research by Asseggaf et al. (2021) confirms that Manganese (Mn) concentrations in North Jakarta naturally possess relatively high dissolved metal content, particularly iron and manganese. If not addressed through manganese greensand filter units, these metals can produce an unpleasant metallic taste and damage clean water infrastructure components within the health centers (Marlinae et al., 2021). Nevertheless, other chemical parameters such as Nitrate and Nitrite across all units including Pustu Semanan 1 (Nitrate at 15.62 mg/L) remain compliant.

In comparative studies regarding clean water chemical standards in the Jabodetabek industrial area, the manganese levels in this research are classified as moderate; however, they still require corrective action due to the site's status as a healthcare facility. Research by the Kemenkes & UNICEF (2020) indicates that exceeding heavy metal thresholds in public facilities is often overlooked because the impacts are not immediate, unlike bacteriological contamination. However, to maintain the quality of primary healthcare services, compliance with all chemical parameters is mandatory to prevent corrosion of medical equipment, which is highly sensitive to water quality. Other chemical parameters, such as Iron (Fe) and Hexavalent Chromium, which remained below the instrument detection limit in nearly all samples, indicate that raw water sources are generally still free from hazardous heavy metal industrial waste contamination. This presents an opportunity for treatment optimization focused specifically on microbiological aspects and manganese removal.

Overall, the laboratory data analysis (Figure 2) confirms a significant gap in compliance with the Minister of Health Regulation (Permenkes) No. 2 of 2023 standards within the Kalideres Community Health Center environment. Water quality inconsistencies between units, where the Semanan 2 Supporting Health Center (Pustu) successfully met all criteria, while other units failed significantly regarding microbiological parameters, highlight disparities in the maintenance of sanitation facilities. The synthesis of these results supports WHO policy asserting that healthcare

facilities require the implementation of more rigorous Water Safety Plans (WSP). Urgent technical recommendations include the improvement of automated disinfection systems, periodic cleaning of water storage tanks, and the installation of specialized manganese filters in the Pegadungan area. Through the integration of technological improvements and routine monitoring management, the Community Health Center can ensure a safe and hygienic environment for the public, aligned with national health development targets.

Conclusion

Water quality at Primary Healthcare Facilities in the Kalideres Region largely fails to meet the environmental health standards of Permenkes No. 2 of 2023 due to significant multi-parameter contamination risks. Critical hot spots are characterized by massive bacteriological pollution with *Total Coliform* and *E. coli* > 1000 colonies/100 mL at the Kalideres Community Health Center and *Total Coliform* at the Pegadungan 1 Auxiliary Health Center, extreme physical degradation in turbidity (19.10 NTU) at the Kamal 2 Auxiliary Health Center, and elevated chemical manganese levels (0.2455 mg/L) in the Pegadungan area.

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Conflicts of interest

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