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Analysis Of Domestic And Clinical Liquid Waste Quality At Dr. H. Jusuf Regional Hospital In 2025

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ABSTRAK

Limbah cair rumah sakit merupakan sumber pencemar lingkungan potensial jika tidak dikelola secara tepat. RSUD Dr. H. Jusuf SK menghasilkan limbah cair domestik dan klinis yang memerlukan pengelolaan melalui Instalasi Pengolahan Air Limbah (IPAL) untuk memenuhi baku mutu pemerintah. Penelitian ini bertujuan menganalisis kualitas limbah cair domestik dan klinis selama Januari–Desember 2025, mengevaluasi kesesuaiannya dengan peraturan baku mutu, serta membandingkan karakteristik kedua jenis limbah. Metode penelitian menggunakan pendekatan kuantitatif deskriptif dengan pengambilan sampel rutin setiap bulan dan analisis laboratorium terhadap parameter fisika, kimia, dan mikrobiologi, termasuk pH, BOD, COD, TSS, minyak dan lemak, amoniak, dan total coliform. Limbah klinis dianalisis tambahan untuk sulfida, fenol, seng, nitrat, nitrit, dan fluorida guna memperoleh gambaran komprehensif. Hasil penelitian menunjukkan seluruh parameter utama limbah domestik berada di bawah ambang baku mutu, dengan pH 6,57–8,35, BOD 2,64–11,51 mg/L, COD 10,19–43,98 mg/L, TSS 7–29 mg/L, minyak dan lemak 0,10–1,68 mg/L, amoniak <0,01–0,5 mg/L, dan total coliform 0–51,8 jumlah/100 mL. Parameter tambahan limbah klinis juga rendah dan aman. Temuan ini menegaskan bahwa pengelolaan limbah cair melalui IPAL RSUD Dr. H. Jusuf SK efektif dan tidak menimbulkan risiko pencemaran signifikan. Kesimpulannya, pemantauan rutin dan peningkatan kapasitas IPAL tetap diperlukan untuk menjaga kualitas lingkungan dan kesehatan masyarakat sekitar.

ABSTRACT

Hospital liquid waste is a potential environmental pollutant if not properly managed. Dr. H. Jusuf Regional Hospital generates domestic and clinical liquid waste that requires treatment through a Wastewater Treatment Plant to meet government quality standards. This study aimed to analyze the quality of domestic and clinical liquid waste from January to December 2025, evaluate compliance with regulatory standards, and compare the characteristics of the two types of waste. The study employed a descriptive quantitative approach with routine monthly sampling and laboratory analysis of physical, chemical, and microbiological parameters, including pH, BOD, COD, TSS, oil and grease, ammonia, and total coliform. Clinical waste was further analyzed for sulfide, phenol, zinc, nitrate, nitrite, and fluoride to provide a comprehensive profile. Results showed that all main parameters of domestic waste were below regulatory thresholds, with pH 6.57–8.35, BOD 2.64–11.51 mg/L, COD 10.19–43.98 mg/L, TSS 7–29 mg/L, oil and grease 0.10–1.68 mg/L, ammonia <0.01–0.5 mg/L, and total coliform 0–51.8 counts/100 mL. Additional clinical waste parameters were also low and safe. These findings confirm that wastewater management through the hospital's treatment plant is effective and does not pose significant environmental risks. Routine monitoring and capacity enhancement of the treatment facility remain necessary to maintain environmental quality and public health.

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1. Introduction

Hospital liquid waste is one of the sources of environmental pollution that has the potential for significant public health risks if not managed properly. Hospitals as healthcare institutions produce various types of waste, including solid waste, infectious medical waste, pharmaceutical waste, and liquid waste. Hospital liquid waste comes from medical and non-medical activities, such as treatment rooms, operating rooms, laboratories, emergency departments, kitchens, laundry, bathrooms, and offices. These wastes are generally classified into domestic waste and clinical waste, which have different pollutant characteristics. Domestic waste is similar to household waste, but it is larger in volume and often contains organic matter, detergents, and nutrients. Meanwhile, clinical waste is more complex because it contains pharmaceutical chemical residues, pathogenic microorganisms, heavy metals, radioactive materials, and other biological materials that can pose a risk to humans and ecosystems (Ahmed & Salih, 2024; Nugroho, Sari, & Wirawan, 2018).

The characteristics of hospital liquid waste are an important indicator in assessing its potential impact on public health and the environment. Physical, chemical, and microbiological parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), pH, ammonia, oil and fat, and total coliform are often used to monitor waste quality. If these parameters exceed the set quality standards, liquid waste can degrade surface and underground water quality, trigger the growth of pathogenic microorganisms, and increase the risk of gastrointestinal diseases, skin infections, and the spread of antibiotic-resistant bacteria (WHO, 2021).

Globally, hospital liquid waste management is an important challenge due to the complexity of its pollution. International studies show that hospitals produce waste with a high organic load, heavy metals, pharmaceutical residues, and pathogenic microorganisms, which can get into water bodies if not treated effectively (Global Health Science Group, 2025). Improper management of liquid waste can lead to eutrophication, deterioration of water quality, and negative impacts on aquatic ecosystems, including the death of aquatic organisms and changes in biodiversity. Furthermore, recent research suggests that clinical waste can be a reservoir for antibiotic-resistant bacteria (ARBs) and resistance genes (ARGs), which have the potential to spread to the environment and pose a public health risk (Ahmed & Salih, 2024).

In Indonesia, hospital liquid waste management is regulated by government regulations. Regulation of the Minister of Environment and Forestry Number 68 of 2016 establishes quality standards for domestic waste, while Regulation of the Minister of Environment and Forestry Number 5 of 2014 regulates the management of liquid waste from industries and health facilities. In addition, the Regulation of the Minister of Health Number 7 of 2019 stipulates the obligations of hospitals in managing liquid waste through Wastewater Treatment Plants (WWTP) and routine monitoring to maintain environmental quality and public health (Ministry of Health of the Republic of Indonesia, 2017). Although this regulation has been implemented, many hospitals, especially in the regions, still face obstacles in WWTP capacity, limited treatment technology, and inconsistent waste quality monitoring (Putri, Hidayat, & Siregar, 2020).

Several studies in Indonesian hospitals provide an overview of the successes and challenges of liquid waste treatment. Research at Djoelham Hospital, Binjai shows that waste treatment generally meets quality standards, but the effectiveness of reducing BOD and COD is relatively low compared to TSS (Nugroho et al., 2018). Evaluation at Surabaya Hospital showed that the use of combined technology such as Sequence Batch Reactor, Membrane Bioreactor, and aerobic biofilter was able to reduce BOD by more than 70% and E. coli by almost 99.93%, thereby reducing the risk of microbiological pollution (Soetjipto & Wardhana, 2019). A study in Sorong reported that although most of the parameters met quality standards, fluctuations in the Coli Group persisted, indicating the need for regular monitoring and more effective management (Putri et al., 2020). Other studies in Makassar and Sumbawa showed variations in waste parameters throughout the year, thus posing challenges in ensuring consistency in meeting quality standards and their impact on the quality of rivers around hospitals (World Health Organization [WHO], 2021).

Nonetheless, studies that analyze domestic and clinical waste simultaneously with long-term monitoring are still limited. Many studies only assessed one type of waste or used short observation periods, so they do not reflect seasonal fluctuations or daily variations that could affect the overall effectiveness of WWTP. This research gap is important because a comprehensive understanding of both types of waste is needed to design more appropriate management strategies and evaluate environmental impacts holistically (WHO, 2021). In addition, an understanding of the differences in domestic and clinical waste characteristics can assist hospitals in planning WWTP capacity, selecting appropriate treatment technologies, and ensuring compliance with government quality standards.

The local context at dr. H. Jusuf SK Hospital as a regional general hospital is very important. The hospital serves a large population with a wide range of medical and non-medical services, resulting in a large amount of liquid waste every day. Routine waste quality analysis is key to assessing the effectiveness of management through WWTP and preventing environmental pollution that can have an impact on public health around the hospital. This monitoring also supports hospitals' efforts to comply with government regulations, increase environmental management capacity, and provide scientific data that can be used as a reference for policymakers in the health and environmental sectors.

In addition to the technical aspects of treatment, hospital liquid waste management is also closely related to the principles of sustainable development and public health protection. Water as a vital resource has an important role in people's daily lives, so the decline in water quality due to hospital waste pollution can have a wide impact, especially for vulnerable groups such as children, the elderly, and people with limited access to sanitation. Long-term exposure to water contaminated with medical waste has the potential to increase the incidence of environmentally-based diseases and increase the burden of public health financing.

In the context of modern healthcare, the increasing number of patient visits, the complexity of medical procedures, and the increasingly diverse use of chemicals and pharmaceuticals have also increased the volume and characteristics of hospital liquid waste. This condition demands an adaptive waste management system based on scientific evidence. However, in many regional hospitals, liquid waste management is still not a top priority over clinical services, so the evaluation of WWTP performance is often limited to administrative fulfillment, rather than to a comprehensive environmental quality assessment.

Therefore, research on the quality of hospital liquid waste is not only important as a form of regulatory compliance, but also as part of preventive efforts to protect public health and the environment. A systematic scientific approach through domestic and clinical waste quality analysis is expected to provide a solid basis for policy improvement, strengthening hospital environmental management systems, and data-driven decision-making at the local and regional levels.

Based on this background, this study aims to analyze the quality of domestic and clinical liquid waste at dr. H. Jusuf SK Hospital during the January-December 2025 period, evaluate its suitability with government quality standards, and comprehensively compare the characteristics of the two types of waste. The results of the study are expected to provide strong scientific evidence related to the effectiveness of hospital waste management, support better environmental management strategies, and protect the health of the surrounding community.

2. Methods

2.1. Design and location of research

This study is a quantitative descriptive observational research with a longitudinal approach to monitor the quality of hospital liquid waste periodically for one year. This design was chosen so that temporal variations in domestic and clinical liquid waste can be identified systematically, so that the evaluation of the effectiveness of the Wastewater Treatment Plant (WWTP) can be carried out thoroughly.

Data collection was carried out during the period from January to December 2025. The location of the research is dr. H. Jusuf SK Hospital, Tarakan, North Kalimantan Province, Indonesia, with the focus of the research being on the hospital's Wastewater Treatment Plant (WWTP), which handles domestic liquid waste from kitchens, laundry, bathrooms, and offices, as well as clinical liquid waste from treatment rooms, action rooms, laboratories, and emergency departments. The selection of this location aims to obtain representative data on the quality of liquid waste produced by the hospital during the routine service period.

The type of research and design used allows researchers to observe and measure the physical, chemical, and biological parameters of liquid waste on a regular basis without intervention, so that the results obtained reflect real conditions in the field. As such, the study is replicative, and sampling procedures and laboratory analysis can be repeated by other researchers at similar hospitals or locations with the same design and method.

2.2. Population and sample

The target population in this study is all domestic and clinical liquid waste produced by dr. H. Jusuf SK Hospital during the January-December 2025 period. Affordable population is defined as a sample of liquid waste taken regularly every month from the hospital's WWTP output point, which represents the actual condition of liquid waste generated by all hospital activities, both medical and non-medical.

The inclusion criteria in this study include:

1. Samples of liquid waste from the hospital's routine operational activities, including kitchens, laundry, bathrooms, offices, treatment rooms, action rooms, laboratories, and emergency departments.
2. Samples were taken at a predetermined time on a regular basis every month throughout the study period.

Exclusion criteria include:

1. Liquid waste derived from non-routine activities or special laboratory experiments that do not represent the normal operating conditions of the hospital.
2. Samples that are subjected to external contamination during the collection or storage process so that they can affect the accuracy of laboratory analysis.

The sampling technique used is total sampling, where all liquid waste that passes through the WWTP output point and meets the inclusion criteria is taken as a sample. Every month, sampling is carried out once for domestic waste and for clinical waste, so that for 12 months a total of 12 samples were obtained for physical, chemical, and microbiological analysis.

The determination of the sample count is based on methodological considerations and standard laboratory practices, where monthly sampling over a period of one year is considered sufficient to detect seasonal variations and fluctuations in hospital activities that may affect the quality of liquid waste. This technique is in accordance with hospital waste quality monitoring guidelines which recommend regular sampling at least once per month to obtain representative data (Metcalf & Eddy, 2014; Sembiring & Hutagalung, 2020).

Thus, all samples obtained reflect the real condition of the liquid waste produced by the hospital during the research period, so that the analysis of the quality of liquid waste can be carried out replicatively and scientifically valid.

2.3. Operational variables and definitions

The variables in this study consist of independent variables**,** dependent variables**,** and potential confounding variables that can affect the quality of hospital liquid waste. All variables are operationally defined so that they can be objectively measured and replicated by other researchers.

The independent variable is the type of hospital liquid waste, which is differentiated into domestic liquid waste and clinical liquid waste. This variable is used to compare the characteristics of waste quality based on the source of hospital activity.

The dependent variable **is the** quality of liquid waste, which is measured through physical, chemical, and microbiological parameters according to hospital wastewater quality standards. This parameter is used as an indicator of the level of pollution and the effectiveness of liquid waste treatment through WWTP.

Potential confounding variables in this study include variations in hospital service activities and patient burden, which can affect fluctuations in the concentration of liquid waste pollutants. These variables were not analyzed quantitatively, but were controlled by routine sampling at the same time each month and under normal operating conditions of the hospital. To clarify the measurements, the operational definitions of each variable are presented in the following table.

Table 1. Operational Definition of Research Variables

No	Variable	Variable Type	Operational Definition	Method of Measurement / Method	Measurement Scale
1	Types of liquid waste	Independent	Classification of liquid waste based on the source of hospital activity	Identify waste sources (domestic or clinical)	Nominal
2	pH	Dependents	The acidity or alkalinity of the liquid waste	pH meter (electrometric method)	Interval
3	BOD	Dependents	Biological oxygen requirement for organic matter degradation for 5 days	APHA incubation method	Ratio
4	COD	Dependents	Chemical oxygen requirement for total oxidation of organic matter	Closed reflux method	Ratio
5	TSS	Dependents	Concentration of suspended solids in liquid waste	Gravimetric methods	Ratio
6	Oils and fats	Dependents	Oil and fat content in liquid waste	Gravimetric extraction method	Racing
7	Ammonia	Dependents	Nitrogen concentration of ammonia in liquid waste	Spectrophotometry Nessler	Ratio
8	Total coliform	Dependents	Number of bacteria indicators of fecal pollution	MPN Method	Ratio
9	Sulfide	Dependents (additional)	Concentration of sulfide compounds in clinical waste	Metode kolorimetri	Ratio
10	Phenol	Dependents (additional)	Concentration of phenol compounds in clinical waste	Metode kolorimetri	Ratio
11	Zinc (Zn)	Dependents (additional)	Zinc heavy metal concentration	AAS	Ratio
12	Nitrate	Dependents (additional)	Nitrogen nitrate concentration	Spectrophotometers	Ratio
13	Nitrite	Dependents (additional)	Nitrogen nitrite concentration	Spectrophotometers	Ratio
14	Fluoride	Dependents (additional)	Concentration of fluoride in liquid waste	Ion selective electrode	Ratio

2.4. Data Collection Techniques

The data in this study was collected through direct wastewater sampling in the field and secondary data collection from official sources**.** Primary data was obtained by sampling domestic and clinical liquid waste at the output point of the Wastewater Treatment Plant (WWTP) of dr. H. Jusuf SK Hospital. Sampling was carried out routinely every month during the January-December 2025 period using sterile sample containers and water extraction aids in accordance with liquid waste monitoring standards. Each sample is assigned an identification code that contains information on the date of collection, type of waste, and location of collection to maintain data traceability.

Liquid waste quality analysis is carried out using physical, chemical, and microbiological measurement instruments that have gone through internal calibration and quality control processes. Laboratory testing is carried out by PT Sucofindo's accredited laboratory**,** with reference to the *Standard Methods for the Examination of Water and Wastewater* (APHA-AWWA, 2023 edition). The parameters analyzed included pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), oils and fats, ammonia, total coliform, and additional parameters of clinical waste. The use of international standard methods ensures the validity and reliability of measurement results, so that the data obtained can be scientifically accounted for and replicated in similar studies.

Secondary data was obtained from the official document of the dr. H. Jusuf SK Hospital in 2025, which includes hospital profiles, WWTP capacity and operational systems, as well as internal liquid waste quality monitoring records. In addition, secondary data is also sourced from applicable official laws and regulations and technical guidelines, namely the Regulation of the Minister of Environment and Forestry Number 68 of 2016 concerning Domestic Wastewater Quality Standards and the Regulation of the Minister of Environment and Forestry Number 5 of 2014 concerning Wastewater Quality Standards of Health Service Facilities. All secondary data are used as a basis for comparison in evaluating the conformity of liquid waste quality with the set quality standards.

In this study, no questionnaire instruments were used, so validity and reliability tests in the form of statistics, such as Cronbach's alpha, were not carried out. However, the reliability of the data is ensured through the use of standard measuring instruments, consistent sampling procedures, and analysis by accredited laboratories, so that the results of the study have a high level of accuracy and precision.

2.5. Data Analysis

Data from domestic and clinical liquid waste quality testing results were analyzed using univariate analysis in accordance with descriptive research objectives. Before the analysis, all data first goes through editing, coding, and tabulation stages to ensure completeness, consistency, and readability of the data.

A univariate analysis was conducted to describe the distribution and characteristics of each liquid waste quality parameter measured during the January–December 2025 period. The parameters analyzed included pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), oils and fats, ammonia, total coliform, and additional parameters in clinical waste, namely sulfides, phenols, zinc (Zn), nitrate, nitrites, and fluoride. This analysis includes the calculation of the minimum, maximum, average, and range values of each parameter to provide a comprehensive picture of the quality of hospital liquid waste.

The results of the univariate analysis were then descriptively compared with the wastewater quality standards stipulated in the Regulation of the Minister of Environment and Forestry Number 68 of 2016 and the Regulation of the Minister of Environment and Forestry Number 5 of 2014. This comparison was carried out to assess the level of conformity of liquid waste quality with applicable standards and to evaluate the performance of the Wastewater Treatment Plant (WWTP) of dr. H. Jusuf SK Hospital during the research period.

The entire process of data processing and analysis is carried out using Microsoft Excel and SPSS statistical software version 26 to ensure the accuracy of calculations and ease of presenting data in the form of tables and graphs. This analysis is descriptive and does not aim to test causal relationships, so neither bivariate nor multivariate analyses are carried out.

2.6. Research Ethics

This study followed ethical principles for environmental health research. The research did not involve human participants, patients, medical records, or personal identity data, because the object of the study was hospital liquid waste. Therefore, individual informed consent was not required. However, permission from Dr. H. Jusuf Regional Hospital was needed before collecting or using wastewater monitoring data.

Institutional approval was obtained from the hospital management or the responsible unit before the study was conducted. The hospital was informed about the purpose of the research, the type of wastewater data used, the parameters analyzed, and the period of study from January to December 2025. The data were used only for academic and scientific purposes.

All wastewater quality data were kept confidential and reported in general form. The study did not mention or evaluate individual patients, hospital staff, or specific hospital units. The results were presented objectively to describe the quality of domestic and clinical liquid waste and to assess whether the wastewater treatment plant met the required environmental standards.

During sampling and laboratory analysis, safety procedures were followed because wastewater may contain biological or chemical contaminants. Researchers and laboratory workers used appropriate protective equipment and handled samples carefully to prevent exposure, contamination, or environmental harm.

The researcher reported the findings honestly and without changing the laboratory results. The study was conducted to support better wastewater management, environmental protection, and public health.

3. Results

Table 2. Results of Univariate Analysis of Water Quality Parameters

Parameter	**Units**	**Minimum Score**	**Maximum Value**	**Average**
pH	–	6,57	8,35	7,34
BOD	mg/L	2,64	11,51	7,80
COD	mg/L	10,19	43,98	27,80
TSS	mg/L	7	29	17,62

The results of univariate analysis show that pH values have relatively narrow variations and are concentrated under neutral conditions. This describes the stability of the degree of acidity during the observation period. The BOD and COD parameters show variations between times, which reflect the difference in the load of organic matter in the wastewater. However, the lower average value than the maximum value indicates that the general condition of wastewater tends to be under control. The TSS value also shows moderate variation, which indicates fluctuations in the number of suspended particles due to changes in flow characteristics and treatment processes.

Table 3. Results of Univariate Analysis of Specific Chemical Parameters

Parameter	**Units**	**Minimum Score**	**Maximum Value**	**Rerata**
Oils & Fats	mg/L	0,10	0,91	0,40
Amonia	mg/L	<0.01	0,50	0,06
Sulfida	mg/L	<0.001	0,023	0,006
Phenol	mg/L	0,003	0,012	0,009
Zinc (Zn)	mg/L	<0.003	0,262	0,058

Univariate analysis of specific chemical parameters showed that all parameters had relatively low average values with a limited range of variation. Very small minimum values on some parameters indicate a period with very low concentrations of pollutants. The maximum value variation reflects fluctuations in pollutant loads that are likely to be affected by the activity of the waste source and the effectiveness of the treatment process. In general, the distribution of parameter values shows a centralized tendency to low values.

Table 4. Results of Univariate Analysis of Nutrient Parameters and Microbiology

Parameter	Units	Minimum Score	Maximum Value	Rerata
Nitrat	mg/L	<0.05	<0.05	<0.05
Nitrite	mg/L	0,08	0,87	0,45
Fluoride	mg/L	0,01	0,58	0,26
Total Coliform	Jml/100 mL	0	51,8	7,62

The results of the univariate test showed that the nitrate levels did not experience significant variations during the observation period, which was reflected in the uniform minimum and maximum values. The nitrite and fluoride parameters showed a wider variation in values, indicating a change in concentration between sampling times. The total coliform parameters showed an uneven distribution of data with a considerable range of values, reflecting fluctuations in the microbiological conditions of wastewater during the observation period.

Table 5. Physical and Organic Parameters of Wastewater to Quality Standards of the Minister of Environment and Forestry Regulation No. 68 of 2016 and the Minister of Environment and Forestry Regulation No. 5 of 2014

Parameter	Units	Average Score	Quality Standards	Status
pH	–	7,34	6–9	Eligible
BOD	mg/L	7,80	30	Eligible
COD	mg/L	27,80	100	Eligible
TSS	mg/L	17,62	30	Eligible

The pH value that is within the quality standard range shows a relatively neutral condition of wastewater, so that it is not acidic or extremely alkaline that has the potential to damage aquatic ecosystems. From a public health perspective, a stable pH plays a role in reducing the risk of skin irritation and aquatic biota disturbances that can affect the ecological chain.

BOD and COD values that are below the threshold indicate that the content of organic matter in wastewater can be well controlled. This condition reflects the effectiveness of the biological processing process in reducing the burden of organic pollutants, so that the potential for a decrease in the quality of receiving water bodies that can have an impact on public health is lower.

The controlled TSS parameters indicate that the number of suspended particles in wastewater is relatively low. Excessive suspended solids can be carriers of pathogenic microorganisms and interfere with light penetration in waters, so this condition indicates less environmental risk.

Table 6. Specific Chemical Parameters of Wastewater to Quality Standards of the Minister of Environment and Forestry Regulation No. 68 of 2016 and Regulation of the Minister of Environment and Forestry No. 5 of 2014

Parameter	Units	Average Score	Quality Standards	Status
Oils & Fats	mg/L	0,40	5	Eligible
Amonia	mg/L	0,06	10	Eligible
Sulfida	mg/L	0,006	0,5	Eligible
Phenol	mg/L	0,009	0,5	Eligible
Zinc (Zn)	mg/L	0,058	5	Eligible

Low oil and fat levels indicate a lack of potential for film layer formation on the surface of the water that can inhibit oxygen exchange. In the context of environmental health, this condition reduces the risk of disturbance of aquatic ecosystems and unpleasant odors that can affect the comfort of the community.

The controlled ammonia value reflects the nitrification process that is going well in the treatment system. Ammonia in high concentrations is known to be toxic to aquatic organisms and can have an indirect impact on human health through degradation of water quality.

Sulfide and phenol parameters that are well below the threshold indicate a low potential exposure to toxic compounds. Chronic exposure to these compounds in high concentrations can lead to health problems, so controlled conditions reflect minimal public health risks.

Low zinc concentrations indicate that wastewater does not contain significant amounts of heavy metals. This is important considering that exposure to heavy metals can accumulate in the environment and potentially cause long-term health effects.

Table 7. Nutrient and Microbiological Parameters on Quality Standards of the Minister of Environment and Forestry Regulation No. 68 of 2016 and the Minister of Environment and Forestry Regulation No. 5 of 2014

Parameter	Units	Average Score	Quality Standards	Status
Nitrat	mg/L	<0.05	20	Eligible
Nitrite	mg/L	0,45	1	Eligible
Fluoride	mg/L	0,26	2	Eligible
Total Coliform	Jml/100 mL	7,62	3000	Eligible

Nitrate and nitrite levels that are within safe limits indicate that the balance of the nitrification and denitrification processes can be maintained. From a public health perspective, nutrient control is important to prevent eutrophication and lower the risk of health problems associated with declining water quality.

Controlled fluoride concentrations indicate that there is no risk of overexposure that can have an impact on health, such as fluorosis, if the water of the recipient body is used by the community.

The low total coliform parameters reflect relatively safe microbiological conditions. In the context of public health, this parameter is important as an indicator of potential pathogen contamination that can cause water-based diseases, so this condition indicates a low level of risk.

4. Discussion

The findings of this study show that the physical, chemical, and microbiological parameters analyzed are within the limits set by laws and regulations. These conditions reflect that the wastewater management process is able to effectively control the pollutant load during the observation period. In the context of public health, wastewater quality control has an important role in preventing exposure to polluting agents that have the potential to cause environment-based diseases.

Organic parameters such as BOD and COD describe the presence of organic matter that can affect the quality of the receiving water body. The control of this parameter is related to the biological decomposition process that runs optimally, so that it can reduce the risk of degrading the quality of the aquatic environment which has implications for public health, especially in people who use water bodies as a source of daily activities.

In addition, nutrient parameters such as ammonia, nitrates, and nitrites indicate controlled conditions. Theoretically, the presence of nutrients in high concentrations can trigger eutrophication that impacts aquatic ecosystems and increases the risk of indirect diseases through degradation of water quality. Thus, the results of this study indicate that the treatment mechanism is able to limit these potential impacts.

The parameters of heavy metals and toxic compounds, including sulfides, phenols, and zinc, indicate low concentrations. From a public health perspective, long-term exposure to these compounds is known to be associated with chronic health disorders. Therefore, this condition reflects a relatively controlled level of exposure for the community around the recipient's environment.

The results of this study are in line with research conducted by Said et al. (2020) which reported that domestic wastewater management in accordance with operational standards is able to keep organic and nutrient parameters within safe limits. This similarity shows the consistency of the effectiveness of the treatment system at various locations with relatively similar waste characteristics.

These findings also support the study of Putri and Handayani (2019) which stated that the concentration of heavy metals in domestic wastewater tends to be lower than industrial waste, making it easier to control through conventional treatment systems.

However, the results of this study are different from the findings of Rahman et al. (2021) who reported an excess of nitrite levels at several monitoring points. These differences can be explained by variations in treatment plant capacity, differences in daily waste loads, and characteristics of the waste sources studied.

In addition, the WHO report (2018) emphasizes that microbiological parameters are often indicators of wastewater treatment system failure. In contrast to the report, the results of this study show a controlled microbiological condition, which may be related to the implementation of the disinfection process and routine maintenance of the system.

The findings of this study have implications for environmental management and public health policies. Compliance with quality standards shows that the environmental regulations implemented can function as an instrument to protect public health from exposure to water pollutants. This reinforces the importance of regular monitoring and evaluation of wastewater quality as part of preventive efforts in public health.

In public health practice, these results are relevant as a basis for strengthening environmental quality monitoring programs, especially in areas with potential exposure to domestic waste. Continuous monitoring allows for early detection of changes in water quality that can impact public health.

This study has limitations in a descriptive design that does not allow the explanation of direct cause-and-effect relationships. In addition, the data used is periodic measurement data so that the daily variation in water quality has not been fully accommodated. These limitations need to be considered in interpreting the results and in generalizing research findings

In addition, the results of this study also need to be understood in the framework of environmental determinants of public health. Environmental quality, especially as it relates to domestic wastewater, is an important risk factor in the transmission of environmentally-based diseases. The inconsistency of wastewater quality parameters with the quality standards set by laws and regulations indicates the potential for biological and chemical exposure that can have a direct or indirect impact on public health. This condition reinforces the view that inadequate environmental management is not only a technical issue, but also a preventive public health issue.

From the perspective of sanitation system theory, effective wastewater management requires integration between technical, institutional, and behavioral aspects of the community. The findings of this study indicate that the fulfillment of environmental quality standards is not only influenced by the availability of facilities, but also by consistency in operation, maintenance, and supervision. This is in line with the concept of environmental health governance which emphasizes the importance of the role of regulations, compliance with standards, and continuous supervision in maintaining environmental quality.

When associated with the context of national policy, the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016 and PermenLHK Number 5 of 2014 have provided a clear normative framework regarding quality standards and obligations for wastewater management. However, the results of this study show that the existence of regulations has not always been followed by an optimal level of compliance in the field. This indicates a gap between policy and implementation, which is often influenced by limited resources, technical capacity, and weak oversight.

From a promotive and preventive point of view, this condition has the potential to increase the burden of diseases related to poor sanitation, such as diarrheal diseases, gastrointestinal infections, and other water-based diseases. Therefore, the results of this study strengthen the urgency of integrating environmental health programs and public health programs more comprehensively. A cross-sectoral approach is crucial, considering that wastewater quality issues cannot be solved by the health sector alone, but require collaboration with the environment, infrastructure, and local government sectors.

Furthermore, the findings of this study also have implications for risk-based intervention planning. Identification of parameters that do not meet quality standards can be the basis for determining pollution control priorities. This approach is in line with the principles of environmental health risk management which emphasizes prevention efforts from an early stage through controlling pollutant sources, routine monitoring, and building the capacity of managers.

However, the interpretation of the results of this study needs to consider the existing limitations. The observational research design provides an overview of conditions at a certain time, so it cannot explain the dynamics of changes in environmental quality in the long term. In addition, the results of this study reflect more the specific conditions of the research site, so caution is needed in generalizing to other regions with different environmental characteristics and management systems.

Overall, this additional discussion emphasizes that the results of the research are not only technically relevant, but also have strategic significance in efforts to improve the quality of public health through sustainable environmental management.

From an environmental health perspective, open waste burning is a high-risk practice precisely because it combines frequent exposure, close distance, and highly variable toxic mixtures. Unlike many industrial pollution sources that can be monitored at fixed sites, household burning is distributed and often unrecorded. This makes exposure harder to regulate and easier to normalize. When the social goal is immediate cleanliness and the service environment does not provide convenient alternatives, behavioral change campaigns that simply instruct "do not burn" are likely to fail or produce only temporary compliance.

The reviewed evidence strengthens the argument that plastics deserve special attention in environmental health interventions. In controlled experiments, plastics show very high particulate and polycyclic aromatic hydrocarbon emissions compared with wood fuel. This supports an implication for Kesling practice: risk communication should move beyond generic "smoke is bad" messaging and emphasize that burning mixed packaging waste is not equivalent to burning leaves, because the chemistry and toxicity can be dramatically different. Emerging work in atmospheric chemistry and toxicology further suggests that plastic-burning particulate matter is not only abundant but also chemically reactive, containing persistent radicals, metals, and oxidative potential that may plausibly intensify inflammation pathways. This offers a more mechanistic explanation that can strengthen environmental health arguments in policy discussions, especially when communities question why outdoor smoke should be a priority.

The Indonesian context supports a systems-oriented conclusion. Evidence that includes Indonesia shows that open burning is closely linked to service gaps and local cleanliness norms, and regulations alone may not work when people lack feasible disposal pathways. This implies that environmental health solutions should be framed as enabling healthier choices, not only correcting individual behavior. When waste collection becomes predictable and accessible, burning can decline without requiring unrealistic daily effort from households.

This review also has limitations. As a literature review, it depends on available studies, and not all Indonesian settings are equally represented in recent English-language journals. In many studies, health outcomes are inferred from exposure indicators rather than measured through longitudinal clinical designs, and confounding sources of air pollution can complicate attribution. Even so, the convergence of combustion evidence, exposure plausibility, and reported respiratory impacts provides a strong basis for preventive action, particularly given the avoidable nature of the practice and the feasibility of infrastructure-based solutions.

5. Conclusion

This study concludes that the wastewater quality conditions reviewed through physical, chemical, and microbiological parameters are under controlled conditions and reflect the performance of wastewater management that runs consistently during the observation period. Univariate analysis showed that the variation in values between parameters was relatively stable, thus illustrating the absence of extreme fluctuations that have the potential to increase the risk of environmental pollution. Evaluation of conformity with quality standards based on applicable laws and regulations shows that wastewater management has met the stipulated provisions, thus contributing to maintaining the quality of the aquatic environment. Overall, the findings of this study indicate that the wastewater treatment system implemented plays a role in controlling potential environmental impacts and supporting public health protection efforts through the prevention of exposure to water-based pollutants.

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7. References

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