



Assessment of Wastewater Pollution Levels from the Laboratory Building and Water Quality Status of the Reservoir Using the Pollution Index (IP) and STORET Method

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ABSTRACT

Increased practical and research activities at the Smart Food Technology Building of the Lampung State Polytechnic may generate laboratory wastewater that could degrade the water quality of the campus reservoir, the receiving water body, if not properly treated. This study aimed to determine the wastewater pollution level in the campus building's drainage channels and assess the water quality status of the reservoir using the Pollution Index (IP) and STORET methods. The parameters analyzed included pH, DO, TDS, TSS, COD, BOD, and Total Coliform. The results indicated that wastewater in the drainage channels was polluted, with COD, BOD, and Total Coliform levels exceeding domestic wastewater quality standards set by the Regulation of the Minister of Environment and Forestry Number 68 of 2016. The reservoir water quality assessment indicated a lightly polluted category under the PI method (average Pij value of 2.47) and a moderately polluted category under the STORET method (score of -30); COD, BOD, and Total Coliform consistently exceeded the Class II quality standards stipulated in Government Regulation Number 22 of 2021 across both methods. Based on these findings, source wastewater management is essential to prevent further deterioration of reservoir water quality.

1. INTRODUCTION

The increase in practical and research activities at the Lampung State Polytechnic (Polinela) particularly within the Smart Food Technology Integrated Laboratory Building has led to a higher demand for laboratory facilities. Significant wastewater discharge from campus institutional buildings (Kwiatek et al., 2026), and excessive water resource consumption (Mustafaraj et al., 2026), combined with intensified laboratory operations (Tran et al., 2026) contribute to surface water pollution driven by various anthropogenic and natural factors (Faruq et al., 2026).

Laboratory wastewater serves as a significant pathway for microorganisms (Teuscher et al., 2024). This wastewater typically originates from residual laboratory chemicals, equipment rinse water, and testing sample residues (Amri & Wesen, 2015). Laboratory waste is heterogeneous in nature,

containing organic and inorganic compounds as well as reactive chemicals that can cause environmental pollution if not properly treated (Nurhayati et al., 2018). Failure to manage this wastewater can degrade the quality of water bodies and increase the risk of environmental pollution in the surrounding area (Sutrisno et al., 2025).

Based on land-use data (Das, 2025) for the Lampung State Polytechnic area, the site is dominated by practical training grounds (± 9.48 ha), academic and laboratory buildings (± 4.18 ha), aquaculture ponds (± 0.40 ha), and a reservoir (± 0.50 ha) serving as the area's water storage. At the Smart Food Technology Building, greywater from sinks mixes with laboratory wastewater and is discharged directly into the drainage system without any wastewater treatment (Sihombing et al., 2025). This mixed wastewater flows directly into the reservoir, potentially affecting the water quality of the reservoir within the campus grounds.

Laboratory waste has more complex characteristics than domestic wastewater, as it potentially contains concentrations of organic chemicals (Mehari et al., 2015), chemical compounds, and heavy metals. This content can increase Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels, as well as impact aquatic organisms (Fransiscus & Simangunsong, 2021). Various physical, chemical and biological variables are considered detrimental to the water environment, especially if present in excessive amounts (Banda & Kumarasamy, 2021). Water pollution can occur due to physical, chemical, and biological contaminants (Bouchareb et al., 2025), and metals released by industries and universities (Lewoyehu et al., 2022). Such pollution can often be visually identified through changes in the water's color and odor resulting from a decline in water quality (Rosid et al., 2025).

One of the most important aspects of public health is maintaining water quality. Both the campus environment and public health may suffer from a drop in water quality (Marselina et al., 2025). Accurate water quality assessment requires the collection and analysis of a number of characteristics of wastewater (Gaviria et al., 2024). This can serve as a basis for developing wastewater treatment systems tailored to the characteristics of wastewater in a specific region (Rismiyati et al., 2023).

The water pollution index is an approach that significantly reduces data volume and simplifies the presentation of water quality status (Effendi, 2016). Furthermore, a water quality index-based approach combines various characteristics into a calculation-based indicator, thereby facilitating the understanding of water quality (Mallick et al., 2026). This can serve as a basis for decision-making regarding sustainable environmental management (Prameswari et al., 2023). The quality of wastewater in the campus building's drainage channels has not yet been assessed; therefore, an evaluation using a water quality index method is required.

The determination of water quality status is based on water quality parameter measurements compared with quality standards for the intended use (Afifah et al., 2025). Physical, chemical, and biological water quality criteria are frequently used to describe the degree and state of water contamination (Omer, 2019).

The Pollution Index (IP) and STORET methods are two water quality index techniques that can be used to evaluate the state of the water (Romdania et al., 2018). The IP approach compares measured water quality indicators with relevant quality requirements to calculate pollution levels (Natasha & Adharini, 2024). Based on the degree of contamination and the degree to which water quality measures meet predetermined quality requirements, the STORET technique is used to evaluate water quality conditions (Samudra et al., 2024).

Most previous studies have applied water quality index methods to receiving water bodies such as rivers and lakes (Syed et al., 2023). In contrast, their application to mixed domestic and laboratory wastewater from educational institution buildings remains limited. The characteristics of mixed wastewater combining laboratory chemical residues with domestic organic loads have the potential to elicit a different response regarding standard water quality indices compared to natural water bodies (Ceron-Aramburo et al., 2026).

Previous studies have guided the development of the Smart Food Technology Building by proposing the use of Anaerobic Filter (AF) technology to reduce organic pollutant loads (Sari et al., 2026); however, this recommendation was not based on actual wastewater quality data from the building's drainage system. To address this issue, this study aims to determine the level of wastewater pollution in the campus building's drainage channels and assess the water quality status of the receiving reservoir water body using the Pollution Index (IP) and STORET methods.

2. METHOD

a. Existing Conditions

The Lampung State Polytechnic (Polinela) campus covers a total area of 35 hectares, spanning both Bandar Lampung City and South Lampung Regency (Phelia et al., 2026). One of the facilities located on the campus is the Smart Food Technology Integrated Laboratory Building, which supports educational and research activities and has a total building area of approximately 6,523.99 m². The building houses 37 laboratory rooms that have been constructed and are currently in use. In addition to laboratories, the building features lecture rooms and restrooms on every floor to support students' practical work and research activities. The location of the Smart Food Technology Integrated Laboratory Building is shown in Figure 1.

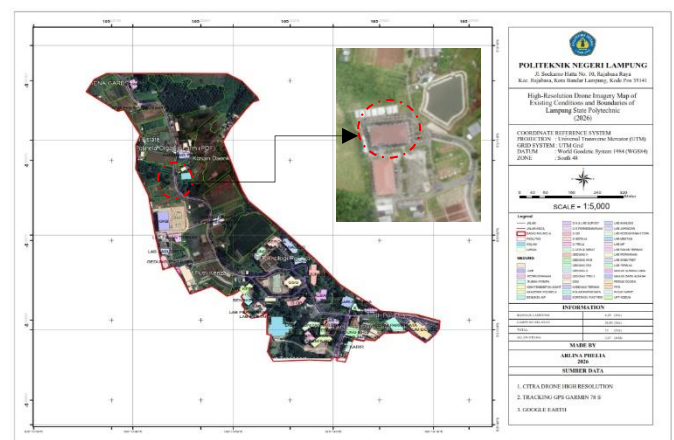


Figure 1. Location map of the Smart Food Technology Integrated Laboratory Building.

The wastewater management system in this building currently relies on septic tanks to treat domestic waste (greywater and blackwater) generated by restroom activities. Meanwhile, liquid waste from laboratory operations is still discharged directly through the building's drainage system into the campus reservoir without prior treatment, posing a potential risk of environmental pollution in the surrounding area.

b. Sample Point Collection

Sampling was conducted in the campus drainage channels and reservoir. Sampling points were determined based on the pollutant load present in the drainage channels (Nurhalimah et al., 2023). The details regarding the sampling points are as follows:

1. Drainage Channel 1

Sampling point 1 is located on the right side of the building. Sampling at this point was conducted at 08:00 a.m., at coordinates 5°21'15.78"S; 105°13'44.07"E. The area surrounding this point is adjacent to the restrooms, the Soil and Water Laboratory, and the Animal Science Laboratory, and features wastewater that is a mixture of sink drainage and effluent from practical activities.

2. Drainage Channel 2

Sampling point 2 is located on the left side of the building. Sampling at point 2a was conducted at 4:30 p.m., at coordinates 5°21'16.32"S; 105°13'42.02"E. The area surrounding point 2 is adjacent to the restrooms, food technology laboratory, plant pathology laboratory, and animal science laboratory; the wastewater there is a mixture of sink drainage and effluent from laboratory practical work.

3. Reservoir Area

Sampling point 3 is located at the campus reservoir, which receives a mixture of liquid waste from laboratory practical activities and sink wastewater (greywater). Samples were collected at two times: in the morning at 08:30 WIB and at 4:55 p.m. WIB. This reservoir is classified as a Class II water body, given its designated use for aquaculture and agricultural irrigation within the campus grounds.

The locations and times of the sampling points are presented in Table 1 and Figure 2.

Table 1. Locations and timing of research sample collection.

No.	Sample Number	Coordinates	Time	Volume	Description
1	1	5°21'15.78"S; 105°13'44.07"E	08:00	2000 ml	Wastewater Testing
2	1	5°21'16.32"S; 105°13'42.02"E	16:30	2000 ml	Wastewater Testing
3a	2	5°21'15.16"S; 105°13'45.74"E	08:30	2000 ml	Water Quality Testing
3b		5°21'15.39"S; 105°13'45.52"E	16:55	2000 ml	(Reservoir)

Sources: Observation Results, 2026

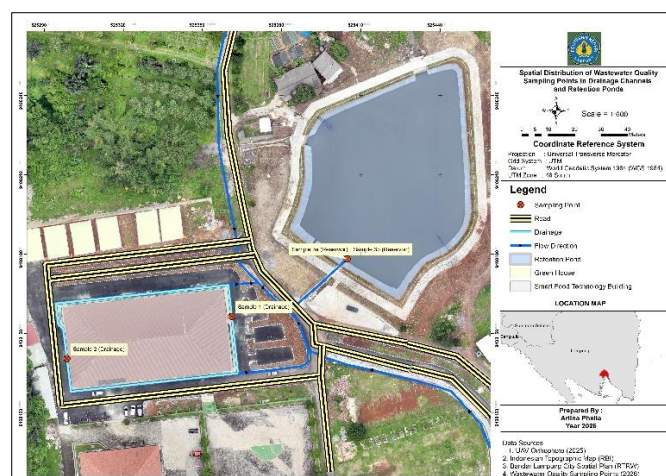


Figure 2. Sampling Point.

Seven parameters were observed and measured (Rahmadi et al., 2025) : pH, DO, TDS (Total Dissolved Solids) (Ma'ruf et al., 2025), COD, BOD, Total Coliform, and TSS (Total Suspended Solids). These seven parameters were used to assess the pollution level of the laboratory building's wastewater within the drainage system and to determine the water quality status of the reservoir serving as the receiving water body. The reference methods for laboratory analysis of the wastewater samples are presented in Table 2.

Table 2. Reference Methods for Wastewater and Reservoir Water Analysis in the Laboratory

No.	Parameter	Unit	Wastewater Testing Reference Method	Reservoir Water Testing Reference Method
1	pH	-	SNI 6989.11-2019	SNI 6989.11-2019
2	DO	mg/L	SNI 06-6989.14-2004 (Iodometri/Winkler)	SNI 06-6989.14-2004 (Iodometri/Winkler)
3	TDS	mg/L	SNI 06-6989.27-2005 (Gravimetri)	SNI 06-6989.27-2005 (Gravimetri)
4	TSS	mg/L	SNI 6989.3-2019	SNI 6989.3-2019
5	BOD	mg/L	SNI 6989.72-2009	SNI 6989.72-2009
6	COD	mg/L	MU.SS-UJI.90 (Spektrofotometri)	IK.MS-UJI.LA 13 (Spektrofotometri)
7	Total Coliform	MPN/100 mL	SM 9221 B, 23 rd Edition:2017	SM 9221 B, 23 rd Edition:2017

Sources: BSPJI Laboratory Results, 2026

c. Data Processing and Analysis

The laboratory test results were subsequently processed and analysed based on national water quality standards applicable in Indonesia (Firdaus et al., 2014). Data from wastewater testing in the drainage channels (Point 1 and Point 2) were compared against domestic wastewater quality standards, in accordance with the Regulation of the Minister of Environment and Forestry (Permen LHK) No. 68 of 2016, to determine the compliance status of each parameter.

Meanwhile, data from testing the water in the reservoir (Point 3), which serves as the receiving water body, were compared against the Class II Water Quality Standards for Lakes and Similar Water Bodies (as per Government

Regulation [PP] No. 22 of 2021). This classification applies to water suitable for water based recreational facilities, freshwater fish farming, livestock operations, crop irrigation, and other uses requiring equivalent water quality (Anwar et al., 2018). Finally, the data were processed using the Pollution Index (IP) and STORET methods to determine the water quality status. The following is an explanation of the two methods to be employed.

1. STORET Method

This method is used to determine water quality status based on scores derived from comparisons involving various measured water quality variables (Wisha et al., 2025). These scores are obtained by comparing water quality parameters against the quality standards stipulated in the Decree of the Minister of Environment Number 115 of 2003 concerning Guidelines for Determining Water Quality Status (Tallar & Suen, 2015), as presented in Table 3.

$$\text{Score STORET} = \Sigma \text{ quality parameter score} \quad (1)$$

Table 3. Score Based on the STORET Method

No	Value	Parameter		
		Physics	Chemistry	Biology
< 10	Max	-1	-2	-3
	Min	-1	-2	-3
	Average	-3	-6	-9
≥ 10	Max	-2	-4	-6
	Min	-2	-4	-6
	Average	-6	-12	-18

Source : Environment Minister's Decree No. 115 of 2003

2. Pollution Index (IP) Method

Water quality status was determined using the Pollution Index method (Wardhani & Rachmanita, 2022), to assess water pollution based on water quality parameters relative to established quality standards. This method is used to classify water quality according to applicable standards (Sampe et al., 2018). The Pollution Index (IP) calculation employs the following equation:

$$P_{ij} = \frac{\sqrt{\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R}}{2} \quad (2)$$

Where:

P_{ij} = Pollution index

C_i = Observed water quality parameter concentration

L_{ij} = Water quality parameter concentration specified by the applicable standard

M = Maximum value of C_i/L_{ij}

R = Average value of C_i/L_{ij}

Water quality assessment was conducted by calculating the maximum and average values of each parameter's concentration relative to the quality standard (Aji et al., 2025). The maximum pollution load refers to the permissible pollution load for a water body; in this case, a small reservoir, based on its

designated use (Rahayu et al., 2018). Table 4 below presents the water quality status based on the Pollution Index (IP) value.

Table 4. Water Quality Status Based on IP Values

No.	Pollution Index	Quality Status
1	$0 \leq IP \leq 1$	Satisfies Quality Standards (Good)
2	$1 \leq IP \leq 5$	Lightly Polluted
3	$5 \leq IP \leq 10$	Moderately Polluted
4	$IP > 10$	Highly Polluted

Source : Environment Minister's Decree No. 115 of 2003

3. RESULTS AND DISCUSSION

3.1 Wastewater Pollution Levels in Drainage Channels

The measured wastewater quality parameters at Point 1 and Point 2 of the drainage channel included pH, TSS, COD, BOD, and Total Coliform. The level of wastewater pollution was analysed by comparing these parameter values against the quality standards outlined in the Regulation of the Minister of Environment and Forestry Number 68 of 2016 concerning Domestic Wastewater Quality Standards (Rahsia et al., 2025). The analysis of these parameters was necessary to determine the wastewater quality and the level of pollution within the drainage channel (Rismiati et al., 2023). The laboratory test results are presented in Table 5.

Table 5. Wastewater Quality Data for Drainage Channels and Comparison with Quality Standards.

No	Sam pling Point	Unit	Test Result		Quality Standa rd	Regulation	Description
			S 1	S 2			
1	pH	-	6.9	7.36	6 – 9	Minister of Environment and Forestry Regulation Number 68 of 2016	Compliant
2	TSS	mg/L	25.83	26.67	30		Compliant
3	COD	mg/L	310	114	100		Non- Compliant
4	BOD	mg/L	147.97	67.14	30		Non- Compliant
5	Total Colif orm	MPN/ 100mL	24000	35000	3000		Non- Compliant

Note : S1 = Sample Testing at 08:00, 2026

S2 = Sample Testing at 16:30, 2026

Based on wastewater quality testing results for the Smart Food Technology Building, several parameters exceeded quality standards: Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), and Total Coliform (Sari et al., 2026). High COD and BOD values indicate a significant presence of organic matter in the wastewater, originating from laboratory equipment wash water, leftover test samples, or residues from practical work chemicals.

The organic load entering the drainage channel is positively correlated with the level of laboratory activity in the vicinity of the sampling point. High Coliform bacteria counts in the drainage channel indicate wastewater contamination (Hasibuan et al., 2022) originating from sink wastewater and potential seepage from toilets near the sampling site.

3.2 Water Quality of Reservoir Based on Pollution Index (IP) and STORET Methods

Water quality reflects the level of pollutants that may impact the campus environment (Apriliasi et al., 2023). Water in the reservoir is classified as polluted if one or more parameters exceed surface water quality standards. The quality of reservoir water must be monitored because the water body receives liquid waste from the drainage system of the Smart Food Technology Building. This assessment aims to determine how the waste affects the aquatic system surrounding the campus. Laboratory test results for the reservoir are presented in Table 6.

Table 6. Water Quality Laboratory Test Data for Reservoirs

No	Sampling Point	Unit	Test Result		Quality Standard Class II	Regulation
			S 3a	S 3b		
1	pH	-	6.84	6.55	6-9	Government Regulation of the Republic of Indonesia Number 22 of 2021
2	DO	mg/L	5.5	8.9	4	
3	TDS	mg/L	848	117	1.000	
4	TSS	mg/L	10.50	6.40	50	
5	COD	mg/L	32	12	25	
6	BOD	mg/L	15.58	4.79	3	
7	Total Coliform	MPN/100mL	24000	140	5.000	

Note : S3a = Sample Testing at 08:30, 2026
S3b = Sample Testing at 16:55, 2026

Activities around the small reservoir increase the pollutant load, and aerobic microorganisms decompose organic matter inefficiently during the morning hours, leading to elevated levels of COD, BOD, and total coliforms. This occurs because dissolved oxygen (DO) levels are lower in the morning than in the afternoon, as photosynthesis does not take place overnight. By afternoon, phytoplankton photosynthesis raises DO levels, thereby optimising the self-purification process regarding pollutants and reducing the influx of bacteria (Rahadi et al., 2019). The following section presents an assessment of the water quality status of the reservoir using two methods: the Pollution Index (IP) and the STORET method.

a. Water Quality Index Based on the Parameter Index (IP) Method

The Pollution Index is a calculation derived from several water quality parameters (Mada et al., 2023). This method allows for the comparison of measured water quality parameters against established water quality standards (Fadhil et al., 2025). Table 7 below presents the results of the reservoir water quality analysis using the Pollution Index (IP) method.

Table 7. Pollution Index (PI) Calculation Results.

No.	Parameter	Lij	Cij 3a	Cij 3b	Ci/Lij 3a	Ci/Lij 3b	Ci/Lij new 3a	Ci/Lij new 3b
1	pH	6-9	6.84	6.55	0.44	0.63	0.44	0.63
2	DO	4	5.5	8.9	0.18	0.11	0.18	0.11
3	TDS	1.000	848	117	0.85	0.12	0.85	0.12
4	TSS	50	10.5	6.4	0.21	0.13	0.21	0.13

No.	Parameter	Lij	Cij 3a	Cij 3b	Ci/Lij 3a	Ci/Lij 3b	Ci/Lij new 3a	Ci/Lij new 3b
5	COD	25	32	12	1.28	0.48	1.54	0.48
6	BOD	3	15.58	4.79	5.19	1.60	4.58	2.02
7	Coliform	5000	24000	140	4.80	0.03	4.41	0.03
Maximum							4.58	2.02
Average							1.74	0.50
Pij							3.46	1.47
Pij Rata-rata							2.47	

Sources: Observation Results, 2026.

Calculations using the Pollution Index (PI) method indicate that the Pij value at point S3a is 3.46 and at point S3b is 1.47, with an average Pij value of 2.47. Based on water quality status classifications, this value falls within the range of $1.0 < Pij \leq 5.0$, meaning the reservoir water quality is categorized as lightly polluted. Parameters such as total coliform, COD, and BOD exceeded quality standards, indicating the presence of polluting waste (Zuandi & Normagiat, 2024) in the reservoir.

b. Water Quality Index Based on the STORET Method

To determine water quality status using the STORET method, the data obtained from measuring the small reservoir's water quality must be processed by calculating the maximum, minimum, and average values for each parameter (Haliska et al., 2026). Table 8 below presents the calculations using the STORET method.

Table 8. STORET Method Calculation Results.

No.	Parameter	Quality Standard	Max	Score	Min	Score	Average	Score	Total Score
1	pH	6-9	6,8	0	6,6	0	6,7	0	0
2	DO	4	8,9	0	5,5	0	7,2	0	0
3	TDS	1.000	848	0	117	0	482,5	0	0
4	TSS	50	10,5	0	6,4	0	8,5	0	0
5	COD	25	32	-2	12	0	22,0	-6	-8
6	BOD	3	15,6	-2	4,8	-2	10,2	-6	-10
7	Coliform	5000	24000	-3	140	0	12070	-9	-12
Result									-30

Sources: Observation Results, 2026.

Based on calculations using the STORET method, a total score of -30 was obtained, classifying the small reservoir's water quality as moderately polluted. Water quality status was determined using time-series data (morning and afternoon) from the same sampling locations (Saraswati et al., 2014).

This pollution value is influenced by several parameters that exceed quality standards specifically Total Coliform, BOD, and COD. Calculations using the STORET method allow rapid determination of water quality status based on observations, with results driven by parameters that exceed established standards (Putra et al., 2023). This method is highly sensitive to changes in water quality; the greater the number of parameters failing to meet standards, the poorer the resulting water quality status (Asuhadi & Manan, 2018).

3.3 Relationship between Wastewater Pollution Levels from the Laboratory Building and the Water Quality Status of the Reservoir

The two methods differ in their classification due to their scoring systems. The IP method only considers the ratio of maximum and average concentrations to quality standards, whereas STORET assigns a cumulative negative score, making it more sensitive to the number of parameters exceeding those standards (Santika, 2024). A summary of the three methods is presented in Table 9.

Table 9. Summary of Reservoir Water Quality Results

No.	Method	Score	Classification	Description
1	STORET	-30	Moderately Polluted	The water quality of the reservoir has deteriorated due to several parameters exceeding quality standards.
2	Pollution Index (IP)	2,47	lightly Polluted	The index value indicates that the water in the reservoir is beginning to show signs of pollution, with parameters exceeding quality standards.

Sources: Analysis Results, 2026.

Differences in classification arise from the characteristics of each method: IP utilises single data points from a specific observation time (maximum and average Ci/Lij), whereas STORET employs a time-series approach incorporating cumulative penalties based on maximum, minimum, and average values, making it more sensitive to parameters that consistently exceed quality standards (Hoya et al., 2020). Both methods are also known to be more sensitive to parameters with concentrations that far exceed quality standards relative to others (Aristawidya et al., 2020); this is evident in the case of Total Coliform, which contributed the highest penalty in the STORET method (-12) and yielded the second-highest Ci/Lij value in the IP method (4.41).

COD, BOD, and Total Coliform consistently remain key parameters for reservoir pollution across both methods; notably, these same parameters exceed the domestic wastewater quality standards applicable to the drainage channel of the Smart Food Technology Building (Minister of Environment and Forestry Regulation No. 68 of 2016). This indicates a link between the pollutant load from laboratory wastewater and the degradation of water quality in the reservoir, which serves as the receiving water body underscoring the importance of managing wastewater at the source to maintain the reservoir's water quality in compliance with Class II standards (Government Regulation No. 22 of 2021).

4. CONCLUSION

The study concludes that the wastewater in the drainage channel of the Smart Food Technology Building is polluted, as evidenced by COD, BOD, and Total Coliform levels exceeding the domestic wastewater quality

standards set by Minister of Environment and Forestry Regulation Number 68 of 2016. Regarding the receiving water body, the water quality status of the reservoir is categorized as lightly polluted according to the Pollution Index (IP) method (average IP of 2.47) and moderately polluted according to the STORET method (score of -30); in both methods, COD, BOD, and Total Coliform consistently exceeded the Class II quality standards (as per Government Regulation No. 22 of 2021). These findings indicate a link between the pollutant load from laboratory wastewater and the deterioration of the reservoir water quality; therefore, managing wastewater at the source must be a primary priority to safeguard the reservoir water quality in the future.

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