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WATER QUALITY STATUS OF SITU TLAJUNG HILIR ASSESSED BY THE STORET METHOD

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ABSTRACT

Situ Tlajung Hilir is a small lake in Wanaherang Village (Gunung Putri, Bogor Regency) that supports irrigation, recreational fishing, and small-scale aquaculture for the surrounding community. After reports of severe pollution in late 2021, when blackened and malodorous water accompanied by fish kills was linked to domestic and industrial discharges, its present condition warranted re-assessment. This study evaluated the lake's water-quality status using the STORET method against the Class II criteria of Government Regulation No. 22 of 2021. Samples drawn from three representative points (Points 1–3) on a single sampling occasion (19 March 2023) were examined for temperature, TDS, TSS, pH, COD, BOD, DO, total phosphate, sulphate, dissolved cadmium and lead, and fecal coliform, following the relevant Indonesian National Standards (SNI) and Standard Methods (23rd ed.) through gravimetric, titrimetric, spectrophotometric, ICP-OES, and Most Probable Number techniques. Averaged over the three points, the physical indicators and the dissolved metals stayed within Class II limits, whereas COD (27.35 mg/L), BOD (5.43 mg/L), DO (4.2 mg/L), total phosphate (0.10975 mg/L), and fecal coliform (2000 MPN/100 mL) each breached their thresholds. Summing the penalty scores produced a STORET value of –90, classifying the lake as Class D (heavily polluted), with organic and microbial loading from domestic and adjacent land-use activities as the dominant drivers.

ABSTRAK

Status Mutu Air Situ Tlajung Hilir Gunung Putri Kabupaten Bogor dengan Metode STORET

Situ Tlajung Hilir merupakan danau kecil di Desa Wanaherang (Gunung Putri, Kabupaten Bogor) yang dimanfaatkan untuk irigasi, pemancingan, dan budidaya ikan skala kecil oleh masyarakat sekitar. Setelah laporan pencemaran berat pada akhir 2021, ketika air menghitam dan berbau disertai kematian ikan yang dikaitkan dengan buangan domestik dan industri, kondisi terkininya perlu dikaji ulang. Penelitian ini mengevaluasi status mutu air danau menggunakan metode STORET terhadap kriteria mutu air Kelas II dalam Peraturan Pemerintah No. 22 Tahun 2021. Sampel dari tiga titik representatif (Titik 1–3) pada satu kali pengambilan (19 Maret 2023) diperiksa untuk parameter suhu, TDS, TSS, pH, COD, BOD, DO, total fosfat, sulfat, kadmium dan timbal terlarut, serta fecal coliform mengikuti SNI dan Standard Methods (ed. ke-23) melalui teknik gravimetri, titrimetri, spektrofotometri, ICP-OES, dan Most Probable Number. Dirata-ratakan atas tiga titik, indikator fisika dan logam terlarut berada dalam batas Kelas II, sedangkan COD (27,35 mg/L), BOD (5,43 mg/L), DO (4,2 mg/L), total fosfat (0,10975 mg/L), dan fecal coliform (2000 MPN/100 mL) melampaui ambangnya masing-masing. Penjumlahan skor penalti menghasilkan nilai STORET sebesar –90 sehingga danau tergolong Kelas D (tercemar berat), dengan beban organik dan mikroba dari aktivitas domestik dan tata guna lahan sekitar sebagai pemicu utama.

Kata kunci: fecal coliform; Kabupaten Bogor; metode STORET; mutu air; status pencemaran

INTRODUCTION

Freshwater underpins nearly every facet of daily life, yet its quality is increasingly strained by the combined pressures of industrial growth, agriculture, and rising domestic demand (Zulhilmi *et al.*, 2019). A large share of municipal and industrial effluent worldwide still reaches receiving waters with little or no treatment, progressively eroding aquatic quality and, ultimately, public health (Lin *et al.*, 2022; Xu *et al.*, 2022). Degradation sets in once the incoming pollutant load surpasses a water body's natural assimilative capacity (Barang & Saptomo, 2019).

Among inland waters, a *situ* a shallow Indonesian lake or pond—is particularly vulnerable because inflow typically exceeds outflow, so contaminants tend to accumulate rather than flush away (Ratnani, 2011). Such basins provide valuable services as water reserves and recharge zones, but they are commonly threatened by sedimentation, eutrophication, land-use conversion, and uncontrolled waste disposal (Kementerian Negara Lingkungan Hidup, 2007). Safeguarding their quality is therefore central to local pollution control (Dewanti & Naryanto, 2018), and prior regional studies have likewise applied chemical monitoring to inform raw-water management in the Bogor area (Dwiputri *et al.*, 2021).

Situ Tlajung Hilir, located in Wanaherang Village, Gunung Putri, Bogor Regency, is used for plantation irrigation, angling, and water-based recreation. Local reports in late 2021 described blackened, foul-smelling water attributed to wastewater carried into the lake during rainfall (*Bogor Update*, 2021). The concern is reinforced by Latief (2022), who recorded Fe, Cu, and Mn concentrations in tilapia (*Oreochromis mossambicus*) from the same lake that exceeded WHO limits, rendering the fish unsafe to eat. This evidence of heavy-metal accumulation in fish that are routinely harvested for consumption raises concern that the water column itself may be impaired, and indicates that a systematic assessment of the lake's water quality is warranted, which motivated the present study.

The STORET method has been applied widely in Indonesia to characterise the pollution status of inland and estuarine waters, including the neighbouring Situ Gunung Putri in the same regency (Aristawidya *et al.*, 2020), the Sermo Reservoir (Dewi *et al.*, 2020), the Ayung River (Widyasari & Putra, 2022), and the estuarine waters of Socah (Yusnita & Triajie, 2021). Most of these studies, however, characterise a single water body on the basis of limited sampling and seldom relate the water-quality status to the condition of the biota that the water supports. For Situ Tlajung Hilir specifically, published work has so far addressed only heavy-metal bioaccumulation in fish (Latief, 2022) rather than the status of the water column itself, and no STORET-based assessment has been reported following the 2021 pollution episode. This leaves a clear gap: the present condition of the lake water, and its suitability for the irrigation, fishing, and aquaculture on which the surrounding community depends, remains undocumented. The present study addresses this gap by providing the first STORET-based water-quality status assessment of Situ Tlajung Hilir after the reported pollution event, and by interpreting the water-column condition alongside the previously documented contamination of its fish.

Water quality is judged by comparing measured values with the standards laid out in Government Regulation No. 22 of 2021. Two approaches dominate status assessment in Indonesia: the Pollution Index and the Storage and Retrieval (STORET) method (Aristawidya *et al.*, 2020). STORET was selected here because it is highly sensitive across all measured parameters—every additional exceedance lowers the score and worsens the rating (Yusnita & Triajie, 2021). Accordingly, this study set out to establish the water-quality status of Situ Tlajung Hilir by means of the STORET method, referenced to the Class II standard. Although the survey was conducted in 2023, no STORET-based water-quality assessment of Situ Tlajung Hilir has been published before or since, so these data provide the first documented post-2021 baseline and remain the only available reference for the lake's status

MATERIALS AND METHODS

Materials and Instruments

The principal sample was lake water. Reagents comprised distilled water, Whatman filter paper, potassium hydrogen phthalate (KHP), a microbial seed suspension, nutrient solution, a 1000 mg/L multi-element stock, HNO_3, H_2SO_4, CH_3COOH,

$K_2Cr_2O_7$, $HgSO_4$, Ag_2SO_4, glucose, glutamic acid, starch indicator, $MnSO_4$, alkaline iodide-azide, $Na_2S_2O_3$, $BaCl_2$, potassium peroxodisulphate, ammonium molybdate, ascorbic acid, *Lauryl Tryptose Broth*, and *EC medium*. The main instruments were a Mettler Toledo MS204TS analytical balance, a Hach DR3900 spectrophotometer, an Agilent 5800 ICP-OES, and a Metrohm 632 pH meter, supported by an oven, autoclave, incubator, desiccator, water bath, and standard reflux, titration, and glassware sets.

Methods

Fieldwork and analyses ran for seven months (January–July 2023). The data were collected in March 2023, and the status reported here reflects the lake's condition at that time; conditions may have changed since, so the results are best read as a baseline against which future monitoring can be compared. Sampling was carried out at Situ Tlajung Hilir, while the physical, chemical, and microbiological measurements were performed at the Chemistry Laboratory of Universitas Nusa Bangsa, Bogor. Sampling followed SNI 6989.57:2008 at three purposively selected points (Widyasari & Putra, 2022): Point 1 near the inlet, where plantation work and angling occur; Point 2 beside a main road and a vehicle-washing business; and Point 3 closest to the outlet, adjoining settlements and the road. All samples were collected on 3 point with temperature and pH read on site and the remaining samples preserved as prescribed by the relevant SNI.

Parameters were determined under SNI and *Standard Methods* (23rd ed.). TDS and TSS were measured gravimetrically (SNI 6989.27:2019; SNI 06-6989.3:2019), pH with a calibrated meter (SNI 6989.11:2019), and temperature with a thermometer (SNI 06-6989.23:2005). COD was read spectrophotometrically by closed reflux (SNI 6989.2:2019), BOD titrimetrically (SNI 6989.72:2009), and DO by the azide-modified iodometric method (SNI 06-6989.14:2004). Total phosphate was quantified spectrophotometrically with ascorbic-acid reduction (SNI 6989.31:2021) and sulphate by turbidimetry (SNI 6989.20:2019). Dissolved Cd and Pb were analysed by ICP-OES (SM Ed. 23rd 3120.B; 3030.B/3030.E-2017), while fecal coliform was enumerated by the Most Probable Number procedure (SM Ed. 23rd 9221.E-2017) through presumptive and confirmatory tests. Each parameter was determined in three analytical replicate(s) at every sampling point, so that three point-values were obtained per parameter (one per point, Points 1 - 3), and the value reported for each point is the mean of its replicate determinations; these point-values formed the dataset used in the STORET computation. Each parameter was determined in triplicate at every sampling point, and the value reported for each point is the mean of these three replicate determinations; with twelve parameters measured at three points, this yielded a total of 108 determinations. The resulting point-values formed the dataset used in the STORET computation.

Water-quality status was assigned by the STORET method following Ministerial Decree No. 115 of 2003. Each measured value was checked against the Class II limit of Government Regulation No. 22 of 2021: a compliant parameter scored 0, whereas a non-compliant one received a penalty based on the scoring system (Table 1). The cumulative score maps onto the US-EPA classification—Class A (0, meets the standard), Class B (–1 to –10, lightly polluted), Class C (–11 to –30, moderately polluted), and Class D (below –30, heavily polluted).

Table 1. STORET scoring system for water-quality status (number of parameters ≥ 10)

Number of samples	Value	Physical	Chemical	Biological
≥ 10	Maximum	–2	–4	–6
	Minimum	–2	–4	–6
	Mean	–6	–12	–18

Source: Ministry of Environment Decree No. 115 of 2003.

RESULTS AND DISCUSSION

Overview of the Study Site

Situ Tlajung Hilir is located in RT 01 RW 03, Wanaherang Village. The lake and the positions of the three sampling points are shown in Figure 1. Point 1 (–6.412901, 106.936081) borders the inlet, plantations, and housing; Point 2 (–6.411627, 106.936822) lies very close to the road and a vehicle-washing operation; and Point 3 (–6.410651, 106.937480) is nearest the outlet, settlements, and the road. Because residents fish and raise tilapia here for consumption, the lake's quality has direct public-health relevance. The complete set of measurements is summarised in Table 2.

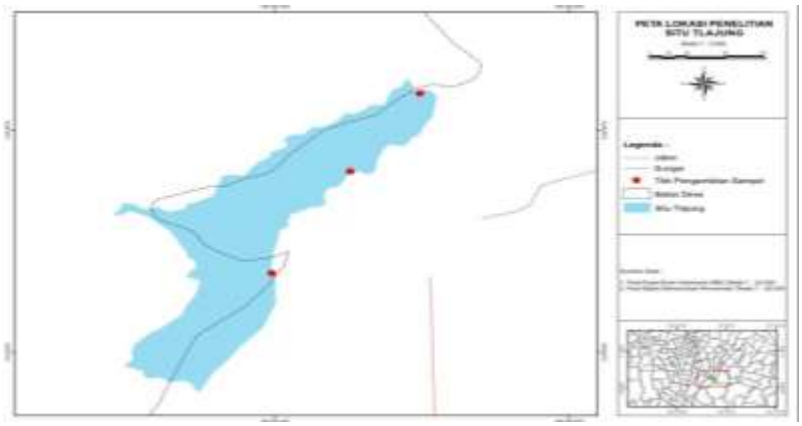

Figure 1. Location of Situ Tlajung Hilir and the three sampling points (Points 1–3), Wanaherang Village, Gunung Putri, Bogor Regency.

Table 2. Water-quality measurements at Situ Tlajung Hilir

Parameter	Unit	Standard	Point 1	Point 2	Point 3	Mean
Physical						
Temperature	°C	Dev. 3 °C	29.0	30.5	31.5	30.3
TDS	mg/L	1000	148	170	140	153
TSS	mg/L	50	8.2	7.6	7.8	7.9
Chemical						
pH	–	6–9	6.8	7.7	6.9	7.1
COD	mg/L	25	27.46	31.42	23.17	27.35
BOD	mg/L	3	5.38	5.58	5.32	5.43
DO	mg/L	min. 4	4.7	2.4	5.5	4.2
Total phosphate	mg/L	0.03	0.15918	0.13250	0.03756	0.10975
Sulphate	mg/L	300	4.47	3.06	3.28	3.60
Cadmium (Cd)	mg/L	0.01	0.0049	0.0019	0.0009	0.0026
Lead (Pb)	mg/L	0.03	0.0025	0.0052	0.0148	0.0075
Microbiological						
Fecal coliform	MPN/100 mL	1000	2300	2300	1400	2000

Note: values in bold do not meet the Class II standard (Government Regulation No. 22 of 2021). "Dev. 3 °C" denotes the maximum permitted deviation of 3 °C from the natural background water temperature, as specified for Class II waters in Government Regulation No. 22 of 2021.

Physical Parameters

Water temperature ranged from 29.0 to 31.5 °C (mean 30.3 °C) and complied with the standard (a deviation of 3 °C from the ≈30 °C lake norm). The gradual rise toward Point 3 reflects its sparse canopy and proximity to housing and the road, which speed solar heating of the water, compounded by sampling later in the morning; the shaded inlet at Point 1 stayed coolest (Rosarina & Laksanawati, 2018). TDS (140–170 mg/L) and TSS (7.6–8.2 mg/L) likewise remained well within Class II limits. The TDS peak at Point 2 is most likely associated with soap- and detergent-laden runoff from the vehicle-washing business, where NaOH and KOH ionise to Na^+ and K^+ while detergents add surfactants and phosphate (Rinawati *et al.*, 2016; Fernianti *et al.*, 2017). The highest TSS, at Point 1, is likely derived from decaying roots, twigs, and leaf litter, easing downstream as material was carried away (Elvince & Kembarawati, 2021).

Chemical Parameters

All pH readings (6.8–7.7; mean 7.1) satisfied the 6–9 range. The slightly acidic inlet reflects organic decomposition that releases organic acids and raises H^+ (Syahidah & Hermiyanto, 2019), whereas the basic peak at Point 2 (7.7) is consistent with alkaline soap waste, whose hydrolysis liberates OH^- (Khotimah *et al.*, 2021). In contrast, the oxygen-related indicators fared poorly. COD reached 27.46 mg/L at Point 1 and 31.42 mg/L at Point 2 (mean 27.35 mg/L), surpassing the 25 mg/L ceiling; the Point 2 maximum is consistent with a heavy organic burden from domestic effluent, while feed residues from aquaculture may contribute to the elevated value at Point 1 (Dewi & Suseno, 2023). BOD exceeded the 3 mg/L limit at every point (mean 5.43 mg/L), with surfactant-rich domestic waste again likely associated with the Point 2 maximum (Padmanabha & Purnama, 2015). Consistent with these loads, DO fell to just 2.4 mg/L at Point 2, below the 4 mg/L minimum, because dissolved oxygen is consumed in breaking down organic matter (Susanto *et al.*, 2021); Points 1 and 3 remained compliant. Taken together, these three indicators are mutually consistent: the elevated COD and BOD reflect a high load of oxidisable organic matter, whose microbial breakdown consumes dissolved oxygen, which explains why the DO minimum coincides with the BOD and COD maxima at Point 2.

These parameters are best interpreted jointly, as they describe a single coupled process of organic enrichment rather than independent exceedances. Inputs of biodegradable organic matter and nutrients (notably the phosphate discussed below) stimulate microbial activity and primary production; the resulting decomposition raises COD and BOD and draws down DO, while the same domestic and faecal inputs elevate fecal coliform counts. The covariation observed here, namely high BOD and COD, depressed DO, elevated phosphate, and high fecal coliform, is characteristic of incipient eutrophication and organic pollution in a shallow, poorly flushed *situ*, consistent with the pattern reported for the neighbouring Situ Gunung Putri in the same regency (Aristawidya *et al.*, 2020).

Total phosphate breached the 0.03 mg/L limit throughout (mean 0.10975 mg/L), declining from inlet to outlet. The inlet maximum may be associated with combined inputs from plantation fertiliser, household detergent, and aquaculture, all of which can enrich the water with phosphorus (Listantia, 2020; Dewi *et al.*, 2020). Sulphate, by comparison, stayed far below its 300 mg/L threshold (mean 3.60 mg/L), peaking modestly at the inlet, which may reflect fertiliser and detergent residues (Hadiarti, 2015; Lamusu *et al.*, 2022).

Dissolved Heavy Metals

Both metals remained within Class II limits at every point. Cadmium (0.0009–0.0049 mg/L; mean 0.0026 mg/L) declined from inlet to outlet; this gradient may be associated with metal-bearing inputs such as fertiliser applied on the surrounding plantations, although the source was not directly verified in this study (Purnamawati *et al.*, 2015). Lead behaved oppositely, rising toward Point 3 (0.0025–0.0148 mg/L; mean 0.0075 mg/L). Because sedimentation would tend to remove lead from the water column rather than enrich it, this increase is more likely associated with continued human-derived inputs entering the lake near the densely settled, roadside outlet, such as traffic- and road-related runoff and domestic discharge, which may offset losses to settling at that point (Budiastuti *et al.*, 2016). Even at these low aqueous levels, the water cannot be assumed safe, since heavy metals partition into sediment and biota where they may concentrate over time (Yulis & Desti, 2019).

Fecal Coliform

Fecal coliform counts (1400–2300 MPN/100 mL; mean 2000 MPN/100 mL) exceeded the 1000 MPN/100 mL limit at all points. Such densities signal possible co-occurrence of other pathogens and point to household waste and faecal matter washed into the lake (Widyaningsih *et al.*, 2016). The finding is especially relevant because fish harvested here are eaten by nearby residents. Fecal contamination of this magnitude indicates the likely presence of enteric pathogens, and consuming fish or water from such a source can transmit gastrointestinal infections, including diarrhoea, dysentery, typhoid fever, cholera, and other enteric illnesses caused by organisms such as pathogenic *Escherichia coli*, *Salmonella*, and *Shigella*. The risk is greatest for children, the elderly, and people with weakened immunity, and is compounded where fish are eaten raw, undercooked, or after handling under poor hygiene. These counts therefore signal a public-health hazard, not merely a regulatory exceedance, and warrant caution in using the lake's fish and water until the contamination is controlled (Widyaningsih *et al.*, 2016). Taken together with Latief (2022), who reported heavy-metal accumulation in tilapia from the same lake, these findings indicate that residents who consume fish from Situ Tlajung Hilir face a dual exposure pathway, microbiological and heavy-metal, which reinforces the need for caution in using the lake's fish as a food source.

Water-Quality Status by STORET

Comparing every parameter with the Class II standard produced a cumulative STORET score of –90 (Table 3). The exceeding parameters COD, BOD, DO, total phosphate, and fecal coliform—supplied all of the penalty. Under the US-EPA scheme adopted in Decree No. 115 of 2003, any total below –30 falls in Class D, so Situ Tlajung Hilir is classed as heavily polluted. Because biological parameters carry a threefold weighting, fecal coliform contributed the single largest penalty (–30) (Aristawidya *et al.*, 2020).

Table 3. STORET status calculation for Situ Tlajung Hilir

Parameter	Max score	Min score	Mean score	Total
Physical				
Temperature	0	0	0	0
TDS	0	0	0	0
TSS	0	0	0	0
Chemical				
pH	0	0	0	0
COD	–4	0	–12	–16
BOD	–4	–4	–12	–20
DO	0	–4	0	–4
Total phosphate	–4	–4	–12	–20
Sulphate	0	0	0	0
Cadmium (Cd)	0	0	0	0
Lead (Pb)	0	0	0	0
Microbiological				
Fecal coliform	–6	–6	–18	–30
Total score				–90

Note: a total of –90 corresponds to Class D (heavily polluted) under Decree No. 115 of 2003.

Taken together, the non-compliance of COD, BOD, DO, total phosphate, and fecal coliform reflects sustained organic and microbial loading from domestic activity, decomposing plant litter, and nutrient inputs from poorly managed fertiliser use and fish farming. These pressures align with the November 2021 episode, in which high-organic effluent from a beverage plant reportedly entered the lake during the wet season, and with Latief (2022), whose detection of heavy-metal accumulation in tilapia underscores the need to treat fish from Situ Tlajung Hilir with caution.

The Class D status found here is consistent with reports from comparable Indonesian inland waters assessed by the same method. The neighbouring Situ Gunung Putri, in the same regency and subject to similar domestic and land-use pressures, was likewise classified as polluted using STORET (Aristawidya *et al.*, 2020), and organic and microbial exceedances of the type observed here have also driven reduced status in reservoir and river systems evaluated with STORET, such as the Sermo Reservoir (Dewi *et al.*, 2020) and the Ayung River (Widyasari & Putra, 2022). The convergence of these findings indicates that the impairment of Situ Tlajung Hilir reflects a broader pattern of organic and faecal loading in shallow, poorly flushed water bodies within densely used watersheds, rather than an isolated case, and strengthens the inference that domestic discharge and surrounding land use are the dominant drivers.

This study has limitations that should be considered when interpreting the results. Sampling was conducted on a single day with triplet methods at three points, so the findings represent the lake's condition at one point in time rather than its full annual variability. Water quality in such systems fluctuates with rainfall, seasonal change, discharge, and intermittent industrial and domestic activity, and a single day, three point survey cannot capture this temporal and spatial variation or distinguish episodic from chronic pollution. The status reported here should therefore be read as an indicative snapshot. Multi temporal sampling across wet and dry seasons, additional sampling points, and analysis of lake sediment would be needed to establish the lake's representative long term water quality status.

CONCLUSION

Assessed by the STORET method, Situ Tlajung Hilir returned a score of –90 and falls within Class D, indicating heavy pollution. The parameters failing the Class II standard of Government Regulation No. 22 of 2021 were COD, BOD, DO, total phosphate, and fecal coliform, with the impairment driven by industrial discharge, domestic waste, community activity, and surrounding plantations. As this assessment is based on a single sampling occasion at three points, it represents the lake's condition at one point in time; future work should therefore include multi-temporal sampling across seasons and additional points, and extend the analysis to lake sediment, for a fuller and more representative pollution picture. Community outreach is also advisable so that residents avoid consuming fish or water from the lake while it remains polluted and help curb the pollution sources.

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