Assessment of water quality and pollution load in Logung reservoir, Indonesia

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Abstract. The Logung Reservoir in Central Java Province is one of 18 new reservoirs developed to support the National Food and Water Security Program. Despite fully operating recently, its water quality is potentially degraded due to existing human activities surrounding this reservoir. Therefore, we conducted a study to assess water quality in this reservoir (from November 2019 to January 2020) and biological productivity status using the Trophic Level Index (TLI) based on the value of brightness, chlorophyll-a, total nitrogen, and total phosphate. The STORET technique with Class II water quality criteria is used to determine water quality based on physical, chemical, and biological characteristics. This study indicates that general water quality status is classified as class C (moderate) or moderately polluted, with a score of -18 to -20. Parameters that exceed the threshold are Biochemical Oxygen Demand (BOD) and total P, possibly due to high organic matter from residential and agricultural areas. As for biological productivity, the analysis shows that the waters of Logung Reservoir can be categorized as oligotrophic, with TLI values ranging from 2.6 to 2.8. This study should be conducted regularly since its results are useful for reservoir managers in formulating strategies to improve and maintain water quality standards so that the reservoir can function properly. **Keywords**: Logung Reservoir, trophic level index, water quality.

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1 Introduction

The Logung Reservoir in Central Java Province is one of 18 new reservoirs developed to support the National Food and Water Security Program. It has an important function to support Kudus Regency's inhabitants which frequently experiences drought, and during the rainy season, the Kudus Regency frequently experiences flooding due to overflowing rivers whose upstream originates from the Muria Mountains [1]. The Logung Dam is located on the slopes of the Muria Mountains and is expected to reduce flooding in the Kudus Regency and surrounding areas [2].

The Logung Dam is planned to fulfill irrigation water requirements for a maximum potential land area of 5,296 ha in the Kudus Regency region, comprising of an existing 2,805 ha and development irrigation of 2,491 ha, and increased crop production, especially rice crops. Logung Dam can fulfill irrigation water for maximum potential land needs of ± 2,180 ha and increase rice crops in Kudus Regency, provide raw water needs for drinking water in the Logung Dam area of up to 200 liters per second for urban and rural locations, also used as PLTMH (Microhydro Power Plant) and produce 0.50 MW of electricity. Indirectly, Logung Dam can be utilised for tourism/recreation. The utilization of the Logung Dam is also in the form of tourism in the inundation area of the Logung Dam or Logung Reservoir area. The development of tourism in the reservoir area, namely, several speed boats are already operating that are used for tourism in the Logung Reservoir [3].

During the rainy season, Kudus Regency often experiences flooding due to the overflow of the Logung River in the lower reaches and drought during the dry season [4]. The Logung Dam construction is expected to alleviate flood disasters in the Kudus Regency and neighboring areas [5]. It will indirectly improve the local community's standard of living by providing water that may be used collectively [6].

These activities are expected to influence the river's water quality, as well as the water quality of the Logung Reservoir watershed both from excessive use of fertilizers from agriculture activities and domestic practices like overusing detergents [7].

Changes in water quality conditions in river flows are the impact of land use discharges around the river [8]. The quality of major rivers in Indonesia has deteriorated, as evidenced by rising BOD, COD, and TOC levels [9][10]. Upstream of the Logung Reservoir Catchment Area (DTA) in the Muria Mountains, the land use of the catchment area of Logung Reservoir is dominated by agricultural and residential areas. The catchment area of Logung Reservoir is located in Kudus Regency and Pati Regency, with an area of 3898.27 ha. Meanwhile, brightness, nutrients (orthophosphate), and chlorophyll-a reached eutrophic status during the rainy season. The picture of chlorophyll-a content shows increased water fertility from year to year. The continuous increase in fertility is feared to result in undesirable impacts on the sustainability of the reservoir function, siltation, decreased water quality, and threats to the survival of biota inhabiting the waters [11]. All activities in and around the reservoir, as well as garbage carried by the flow in the Logung Reservoir Catchment Area, are likely to contribute to waste discharges that will cause changes in the aquatic environment's quality. If these activities grow from year to year, it is feared that they will cause pollution of the reservoir waters. Therefore, we conducted a study to assess water quality and biological productivity status using the Trophic Level Index (TLI) based on the value of brightness, chlorophyll-a, total nitrogen, and total phosphate in this reservoir. It is expected that the result are useful for reservoir managers in formulating strategies to improve and maintain water quality standards so that the reservoir can function properly.

2 Material and methods

2.1 Time and study area

This research was conducted from November 2019 - January 2020 located in the Logung Reservoir Catchment Area (DTA). Sampling was carried out using the purposive sampling method. Water sampling is more directed at the centers of population activities as a source of pollutants entering reservoir waters such as settlements, plantations, and tourism sites, namely at five sample points determined based on the Logung Reservoir catchment area (DTA) activity location. The research location can be seen in Figure 1.

It was choosing locations for water sampling along rivers while considering that the water sample sites may be the source of waste flowing into reservoir waters from various human activities. Furthermore, to determine the position of the research sample points using the Global Positioning System (GPS), it was determined that the water sampling locations taken were considered representative of the waters of the DTA reservoir and Logung Reservoir. Samples were taken at five locations as follows :

- Sample Point 1: Located in the upper reaches of the Gajah River.
- Sample Point 2: Located in the Elephant River, upstream of the Logung Reservoir inundation area.
- Sample Point 3: Located on the Elephant River in the inundation area of the Logung Reservoir (downstream).
- Sample Point 4: Located on the Logung River in the Logung Reservoir inundation area (downstream).
- Sample Point 5: Located in the middle of the Logung River, the upstream of the Logung Reservoir inundation area.
- Sample Point 6: Located in the upper reaches of the Logung River.

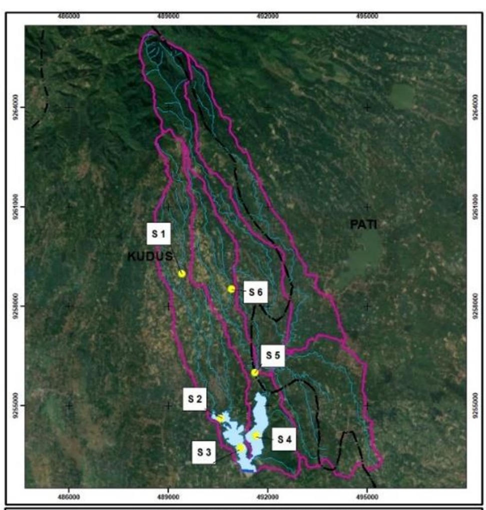

Figure 1. Research Location

2.2 Research tools and materials

GPS, roller meters, secchi disks, float bottles, and ArcGIS 10.3 software are used to collect data for this investigation. The use of these tools provides accuracy and continuity in information collection. In addition, the main data sources for this study included 2019 satellite imagery, a landform map of Kudus District, and an administrative map of Kudus District. Integrating these tools and data sources allows for comprehensive and relevant analyses to produce a deep understanding of the research objectives.

2.3 Methodology

2.3.1 Sampling of river water quality

The sampling was done using the purposive sampling method, which is a sampling procedure based on numerous factors stated by the researcher. Sampling in the upstream area is based on the consideration that in the upstream area, no activities provide pollution loads. In contrast, sampling in the mid-river area is based on the number of activities that are thought to contribute to the occurrence of pollution in the Logung Reservoir DTA. Water sampling in the river was done once in December 2019 in the center of the river at a depth of 0.5 (half) the depth from the river's surface using a grab sample. This sample only describes the characteristics during sampling [12].

2.4 Data analysis

The data analysis includes water quality analysis, pollutant load analysis, water quality identification, and water pollution control measure analysis.

2.4.1 Water quality analysis

An examination of the water quality of the Logung Reservoir DTA using tests for water pollution parameters like temperature and total suspended solids (TSS), chemical and physical parameters like dissolved oxygen (DO), chemical and biochemical oxygen demand (BOD), pH, NH^3-N (ammonia), PO^4-P (phosphate), and biological parameters like chlorophyll a.

2.4.2 Pollutant load analysis

This analysis is carried out by calculating river water discharge and estimating the pollution burden, including river, domestic, and agricultural pollution loads. Calculation of discharge, calculated using the formula:

$$Q = v \; x \; A \tag{1}$$

Information:
Q = water discharge (m^3/sec)
v = current speed (m/sec)
A = cross-sectional area of the river (m^2)

River Pollution Load, calculated using the formula:

$$BP = Q \; x \; C \tag{2}$$

Information:
BP = Pollution Load (kg/hr)
Q = River Debit (m^3/dt)
C = Concentration of i-th Parameter (mg/L)

To convert the waste load into kg/day multiplied by

$$10^{-3} \times 3600 \times 24 \quad (3)$$

2.4.3 Water quality status

The STORET technique was used to determine the water quality in the Logung Reservoir watershed by comparing water quality data collected throughout the study to Class II and Class III water quality requirements [14]. Class II quality standards apply to tourism or water leisure activities, while Class III quality standards apply to freshwater fishing activities [13]. This approach can identify values that still meet or exceed water quality criteria. Furthermore, the value assigned (score) indicates if the water quality is good, lightly polluted, or poor. The "US-EPA (United States Environmental Protection Agency)" value system is used to determine the status of water quality by categorizing water quality into four classifications, namely:

1. Class A : excellent score = satisfies quality standards
2. Class B: a good score of -1 to -10 indicates that the area is lightly polluted.
3. Class C: medium polluted score = -11 to -30
4. Class D: poor performance = -31 highly polluted

If the measurement results do not exceed water quality criteria, it is given a score of 0; otherwise, it is given a score of 1, as shown in Table 1.

Table 1. Determination of a value system for water quality status

Sample	Value	Parameter		
		Physical	Chemical	Biology
	Maximum	-1	-2	-3
<10	Minimum	-1	-2	-3
	Average	-3	-6	-9

2.4.4 Estimation of fertility status of Logung reservoir waters

The Trophic Level Index was developed by [15]. TLI is a development of TSI, but TLI includes total nitrogen parameters in the calculation. Average TLI range values Table 3. Mathematically, the TLI value is calculated using the following equation:

$$TLI_{chl} = 2.22 + 2.54\,log(Chl)$$

$$TLI_{S} = 5.10 + 2.60\,log\left(\frac{1}{s} - \frac{1}{40}\right)$$

$$TLI_{TP} = 0.218 + 2.92\,log(TP)$$

$$TLI_{TN} = -3.61 + 3.01\,log(TN)$$

$$\text{Average TLI} = \frac{TLI_{chl} + TLI_{s} + TLI_{TP} + TLI_{TN}}{4}$$

Information:
TLI_{Chl} = TLI value for chlorophyll-a
TLI_{S} = TLI value for Secchi disk depth
TLI_{TP} = TLI value for total phosphate
TLI_{TN} = TLI value for total nitrogen

Table 2. Trophic level and range of values of each parameter for trophic level index analysis [15]

Stasus trophic level	Enrichment categories Nutrients	TLI	Klorofil-a (mg/m^3)	Brightness (m)	Total Phosphate (mg/m^3)	Total Nitrogen (mg/m^3)
Ultra Mikrotrofik	Element crisis nutrient	0,0 – 1,0	0,13 – 0,33	31 – 24	0,84 – 1,8	16 – 34
Mikrotrofik	Very low	1,0 – 2,0	0,33 – 0,82	24 – 15	1,8 – 4,1	34 – 73
Oligotrofik	Low	2,0 – 3,0	0,82 – 2,0	15 – 7,8	4,1 – 9,0	73 – 157
Mesotrofik	Moderate	3,0 – 4,0	2,0 – 5,0	7,8 – 3,6	9,0 – 20	157 – 337
Eutrofik	High	4,0 – 5,0	5,0 – 12,0	3,6 – 1,6	20 – 43	337 – 725
Supertrofik	Very High	5,0 – 6,0	12,0 – 31,0	1,6 – 0,7	43 – 96	725 – 1558
Hipertrofik	Saturation	6,0 – 7,0	> 31	< 0,7	>96	> 1558

In the laboratory, the physical, chemical, and biological characteristics of water are measured. The water quality parameter calculation refers to and compares to PP Number 82 of 2001 about Class II and Class III water quality standards.

3 Result and discussion

3.1 Water quality of Logung Reservoir catchment area

3.1.1 Physical parameters

a. Temperature
The findings of the first water temperature sampling on November 23, 2019, and the second sampling on January 6, 2020, starting from sampling point 1 in the upper reaches of the Gajah River to sampling point 6 located in the lower reaches of the Logung River, did not have a significant difference, which ranged from 28 - 33°C. Such temperatures are nevertheless within the range of water quality criteria established by government regulations, water quality management, and water pollution control. Normal water temperatures must deviate by three degrees Celsius from natural temperature conditions in the local area, according to the quality criteria for water bodies of classes I, II, and III [12].

b. TSS (Total Suspended Soil)
The measurement results of the TSS parameter of the Logung Reservoir Water catchment area at sampling point 1 to sampling point 6 ranged from 6.53 - 455 mg/L. At sampling sites 2 and 5, the concentration of suspended solids (TSS) increased from upstream to downstream and exceeded the quality limits for class II river water based on PP No. 82 of 2001. This phenomenon indicates the influence of sand mining activities, mostly found around the middle area of the river (samples 2 and 5), on the increase in suspended solids. The value of suspended solids increased from upstream to downstream. Although not harmful, abundant suspended material can raise turbidity, which further inhibits sunlight penetration into the water column and, as a result, affects photosynthesis in the water [16]. Based on [12], the suitability of waters for fisheries

based on the value of suspended solids (TSS), the suspended solids (TSS) content of Logung River water has little effect (6.53-455mg/L) on the ecological importance of fisheries.

3.1.2 Chemical Parameters

a. Ph

The measurement results of the pH parameter of the Logung Reservoir Catchment Area at sampling point 1 to sampling point 6 ranged from 7.05 - 7.82. Fluctuations in pH values are influenced by organic and inorganic waste discharged into the Logung and Gajah Rivers. The highest measurement at sampling point 5 was 7.82, which was influenced by agricultural activities. Referring to Presidential Decree No. 82 of 2001, the pH of Logung River is still under water quality criteria for all classifications of water bodies. Based on the findings of pH measurements in Logung River, which are regarded as normal, aquatic biota life is still in relatively good condition [12].

b. Dissolved Oxygen

Based on the water quality monitoring results at sampling points, as shown in the table above, the quality of dissolved oxygen has declined from upstream to downstream. The values range from 4.05 mg/L to 3.82 mg/L for the Gajah Hulu River (sample 1) to the Gajah Hilir River (sample 3). It indicates an increase in the process of organic matter decomposition and inorganic material oxidation due to increased waste disposal, particularly tourism activities in the Lower Gajah River location (sample 3). According to the value of dissolved oxygen content, the water quality of the Gajah River has dropped from upstream to downstream, or there is pollution. This value follows [17] statement that polluted environmental water has a very low oxygen content.

c. COD (Chemical Oxygen Demand)

The COD measurements were performed on November 23, 2019, and the second sampling date was January 6, 2020. As demonstrated in Table 28, the concentrations range from 10.42 to 48.32 mg/L. COD parameter levels increase from upstream to downstream and surpass Group II water quality criteria at testing locations 1 and 6. The COD measure is one indicator of organic waste-related water contamination. COD is the total quantity of oxygen required to chemically oxidize organic material, both biodegradable and non-biodegradable, to CO_2 and H_2O. At stations 3 and 4 of the study area, various activities produce organic and inorganic waste including tourism (domestic activities) and agriculture.

d. Biochemical Oxygen Demand (BOD)

From the findings of BOD measurements in the first sampling on November 23, 2019, and the second sampling on January 6, 2020, the BOD values ranged from 3.23 - 14.98 mg/L. The BOD value has an upward trend from upstream to downstream. The results showed that water quality with the BOD parameter exceeded the threshold value of class II river water quality standards at all sampling points and the threshold of class III river water quality standards at all sampling points 1 to sample 6. The increase in BOD levels indicates an increase in the discharge of organic waste into the river body. Organic waste is generated from various activities in the segment, including livestock and settlement activities. Large volumes of organic materials decompose in water, absorbing oxygen and diminishing the amount of dissolved oxygen (DO). The BOD value at sampling point 3 was 14.98 mg/L, but the DO value was just 3.82 mg/L. The increase in the BOD value of the Logung River from upstream to downstream shows that the river water quality has deteriorated or that pollution has occurred in the downstream portion [18].

e. Nitrate
During observations in the Logung Catchment Area, nitrate concentrations ranged from 0.008 to 9,629 mg/L, with the maximum result at Station 6 being 9,629mg/L. The high nitrate concentration at the station is assumed from agricultural activities around station 6. Nitrate concentrations the lowest is at station 3 at 0.088mg /L. Overall, nitrate concentrations at each sample station are within the specified quality limits. It is believed that household and agricultural practices near the watershed may raise the nitrate levels in the water column as high nitrate concentrations were found in both river bodies.

f. Nitrite
Based on the results during the observations, the highest nitrite concentration occurred at station 1 at 0.009 mg/L and station 4 at 0.007 mg/L. This value did not exceed the predetermined quality standard of <0.06 mg/L. The high nitrite content in the reservoir waters is assumed from household waste input because station 1 has a residential area around the Gajah Hulu River.

g. Total P
Total P measurement results on the first sampling is November 23, 2019, and the second sampling date, January 6, 2020 obtained the value of the Total P ranged from 0.531 - 3.911 mg/L. This sampling shows an increase from upstream to downstream and exceeds the Group II quality standard threshold at the point of all sampling. Contributions to increased phosphate (PO4-P) levels are indicated due to the presence of agricultural and agricultural activities that are abundant downstream.

h. Ammonia
$NH_3{}^{-N}$ concentration (Ammonia) measurement results in the table show the increase and sampling point 1 up to sampling point 6 (from upstream to downstream) and do not exceed group I water quality standards starting from the sampling point of all samples. Ammonia is indicated as a result of settlement, livestock, and agricultural activities.

i. Total nitrogen
Based on observations, the total concentration of N is 13.06 - 21.21 mg/L. The highest concentration is found in the Logung River, Station 4 in the middle of the Logung River and Station 5 downstream of the Logung River. The Gajah River has the lowest concentration in Station 3 downstream and Station 2 upstream. The high level of N in reservoir waters is caused by a waste load entering the water flow or by agricultural activities, as well as the accumulation of organic matter in the water.

3.1.3 Biology Parameters

a. Chlorophyll-a
Chlorophyll-a indicates phytoplankton abundance in waters that play a role in photosynthesis [20][21]. Phytoplankton has a significant role in determining primary productivity in water [22]. Primary productivity is a key measure of environmental health and marine resource management [23]. Based on observations of sample point 3 and sample point 4 in the Logung Reservoir Catchment Area, the chlorophyll-a concentration value is a parameter that indicates phytoplankton biomass in reservoir waters. Chlorophyll-a concentration determines the fertility level of a water body [24]. The observation results of the chlorophyll-a content value at 2.92-3.89 µg/L. These

results follow the determination of Eutrophication status, which is classified into four categories of trophic status, namely oligotroph, mesotroph, eutroph, and hypereutroph or hypertroph modified OECD 1982, MAB 1989; UNEP-ILEC, 2001 in MOE 2009 that chlorophyll-a value < 2. 0 µg/L is classified as oligotroph, < 5.0 µg/L mesotroph, < 15.0 µg/L eutroph and if = 200.0 µg/L is classified as hypereutroph or hypertroph.

3.2 Pollution load

3.2.1 Debit calculation

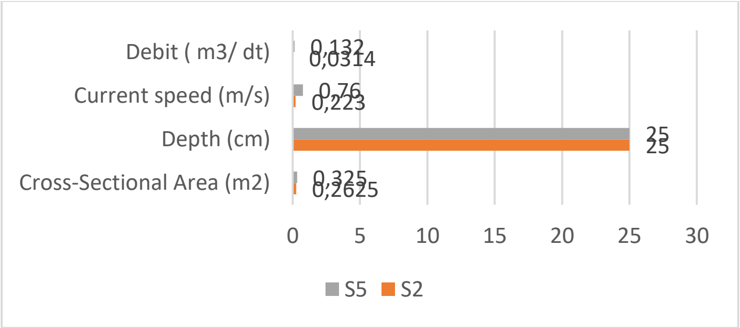

Figure 2. Results of discharge measurement and calculation November 23, 2019

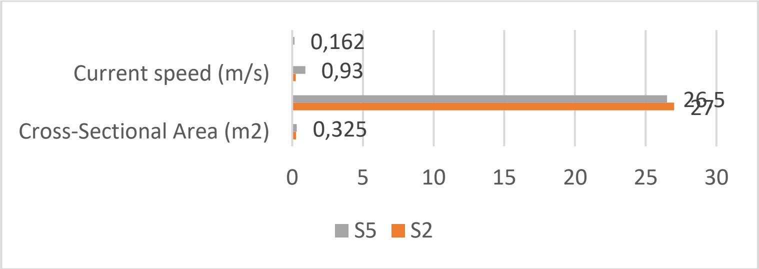

Figure 3. Results of discharge measurement and calculation January 6, 2020

Based on the calculation of the Logung Reservoir Catchment Area discharge downstream of the river, water discharge in downstream river area is greater. The discharge size is influenced by the current's speed and the waterway's cross-sectional area (river). The discharge size also affects the concentration of pollutants, if the discharge of river water is large / increases, the concentration of pollutants entering water bodies decreases due to the dilution process.

3.2.2 Non-point source pollution load

The amount of pollutants in the river's water flow determines the point source pollution load in the river, which is impacted by river water discharge. Table 3 shows the pollution load estimate for the Logung Reservoir Catchment Area. The highest pollution load entering the Logung Reservoir Catchment Area waters is the COD parameter, followed by BOD, and then P-Total. The Total N parameter does not have a big influence, especially the load generated by the Total N parameter.

Table 3. The calculation of the pollution load of DTA Logung Reservoir

Segment	Parameter	Potential Pollutant Load (Kg/day)			Amount (Kg/day)
		Domestics	Agriculture	Farming	
1	BOD	256,81	149030,5	865,23	150065,78
	COD	353,12	223545,8	1690,07	225569,88
	Total P	12,52	0	0	12,4
	Total N	1,35	0	0	1,33
2	BOD	89,95	138517,1	514,49	139107,94
	COD	123,68	207775,7	1006,56	208974,85
	Total P	4,39	0	0	4,33
	Total N	0,47	0	0	0,47
3	BOD	88,95	124186,2	776,53	124989,46
	COD	122,31	186279,3	1450,69	187919,65
	Total P	4,34	0	0	4,3
	Total N	0,47	0	0	0,46
4	BOD	71,82	114783,6	862,48	115634,97
	COD	98,75	172175,3	1617,73	173909,44
	Total P	3,50	0	0	3,48
	Total N	0,38	0	0	0,37
5	BOD	72,14	103073,1	542,80	103655,48
	COD	99,20	154609,6	1043,95	155751,74
	Total P	3,52	0	0	3,48
	Total N	0,38	0	0	0,37

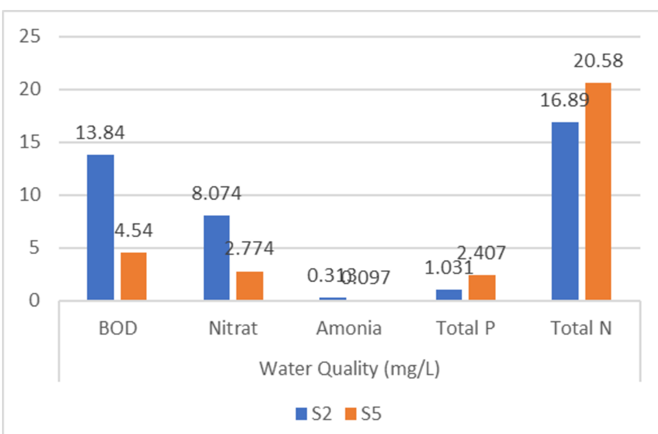

Figure 4. Water Quality *Point source* First Sampling in November 2019

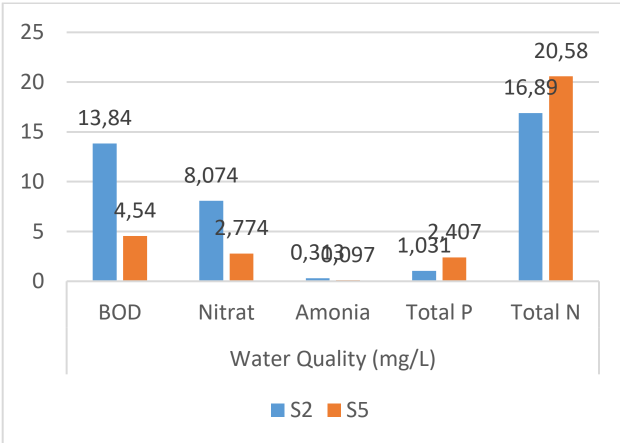

Figure 5. Water Quality Point source Second Sampling in January 2020

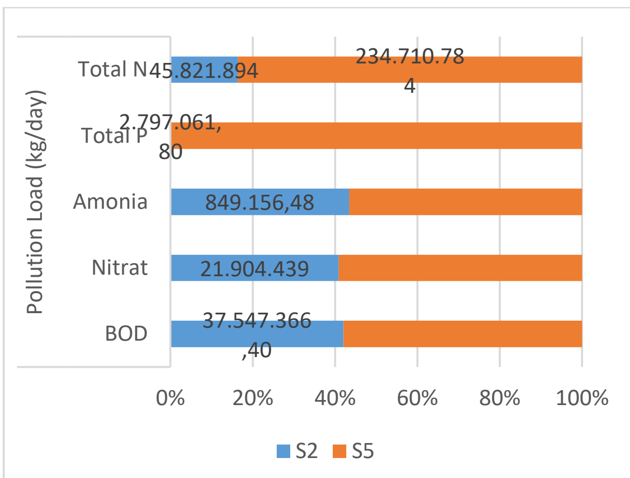

Figure 6. Point source *Pollution Load* First Sample Intake November 2019

The Logung Reservoir Catchment Area receives waste streams from community activities around the waters. The measurement results show that the largest pollutant load entering the Logung Reservoir Catchment Area waters is easily decomposable organic waste (BOD5), 71663616 kg/day. The magnitude of the pollution load derived from BOD5 is assumed from settlements and agricultural areas along the river. The total N pollution load is caused by activities around the waters of the Logung and Gajah rivers, mainly from agriculture that is almost along the river and runoff from agricultural areas that produce organic nitrogen in the waters.

3.3 Water quality status of Logung Reservoir Catchment Area

The status of water quality refers to the degree of contamination or good conditions in a water source at a certain period, as determined by comparison with the water quality standards that have been set [25]. Based on STORET method, sample point I received a total score of -18, sample point 2 received a total score of -20, sample point 3 received a total score of -20, sample point 4 received a total score of -18, sample point 5 received a total score of -18, and sample point 6 received a total score of -20 when compared to Class II quality standards. The Logung Reservoir Catchment Area's total water quality state is categorized as class C (medium), or moderately polluted, with a score of -18 to -20 for Class II quality criteria, according to the STORET method. Based on Class II quality requirements, the average measurement findings of water quality parameters in the waters of the Logung Reservoir Catchment Area during the study exceeded the necessary standards. Two measures that have surpassed the Class II quality requirements' threshold limit are BOD and Total P. The highest concentration of Total-P during the observation is in the presence of pollutant contributions at each sample point in these waters allegedly derived from domestic activities around the waters. For the BOD parameter at sample point 2 and sample point 6, It is assumed that the reason of the high organic matter at this sample site is residential and agricultural area, with the value above the Class II quality requirement.

Figure 7. Average measurement of water quality parameters in the waters of the Logung Reservoir Catchment Area

3.4 Fertility Status of Logung Reservoir DTA Waters

Analysis of water quality of the four parameters measured in the TLI calculation illustrates the dynamics of the condition of a reservoir [26]. The waters of the Logung Reservoir are categorized as mesotrophic based on the average TLI value of chlorophyll-a. These waters are classified as mesotrophic for the TLI value of the Secchi disk. In contrast, when viewed from the TLI value of total P, these waters are classified as ultramicrotrophic, and the TLI value of total N are classified as ultramicrotrophic.

Based on the calculation results by combining all parameters used in the calculation of fertility during this trophic level study, the analysis results show that the Logung Reservoir waters are all included in the oligotrophic category because the overall TLI value is 2.6 - 2.8. Trophic status is an indicator of a water body's fertility level that can be measured from nutrients and brightness levels and other biological activities that occur in a water body [27]. The calculation of TLI to determine fertility status is based on a calculation by combining all four parameters used: brightness, total nitrogen, total phosphate, and chlorophyll-a. The value of TLI ranges from < 1 to > 6. The higher TLI value found suggests that the reservoir's water quality is deteriorating, or vice versa [28].

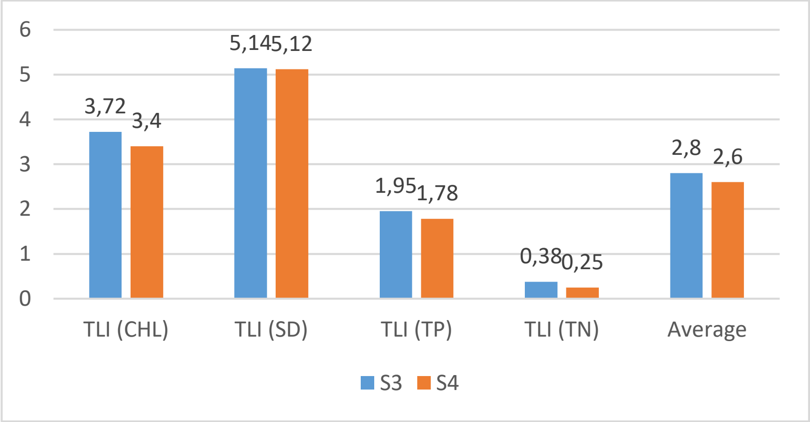

Figure 8. Distribution range of Logung Reservoir water fertility values

According to [29] eutrophic fertility status can describe the level of impact of human activities on a lake or reservoir. It is suspected that activities in the reservoir waters have impacted water quality conditions, especially the nutrient increase. This impact can be seen from the overall TLI calculation. Water conditions that have experienced eutrophic trophic levels due to activities also occur in Lake Batur, based on the research [29]. Based on fertility level research, Lake Batur shows that Lake Batur is classified as eutrophic, with indices ranging from 4.2 to 5.0. High residential areas, livestock, and agriculture activity cause this eutrophic category. If monitoring is not done properly, the negative impact that the low water quality conditions will cause will harm the development of the reservoir. Under these conditions, Logung Reservoir requires continuous monitoring to maintain the condition of the reservoir waters, considering the many benefits of these waters. It can be concluded that the waters of Logung Reservoir indicate that the reservoir waters are lightly polluted when related to water quality conditions.

4 Conclusion

Water pollution measures, including BOD and Total P, exceeded quality criteria at every monitoring station in the Logung Reservoir Catchment, indicating a decrease in water quality from upstream to downstream. According to the STORET method, the Logung Reservoir Catchment's overall water quality status is categorized as class C, or highly polluted. From upstream to downstream, these waters' pollution load increased significantly. The point source pollution load, particularly the BOD parameter, which reached 71663616 kg/day, and the non-point source pollution load, with the COD parameter of 225569.88 kg/day, had the highest values. Nevertheless, the water state of the Logung Reservoir is still classified as oligotrophic.

5 References

[1] Pontororing MEI, Pinontoan OR, Sumampouw OJ. 2019. Uji Kualitas Air Bersih Dari Pt. Air Manado Berdasarkan Parameter Biologi Dan Fisik Di Kelurahan Batu Kota Kota Manado. *J KESMAS*. 8(6):484–492.

[2] Balai Besar Wilayah Sungai (BBWS) Pemali Juana. 2012. Laporan: Review Desain Bendungan Logung Kabupaten Kudus

[3] Agustina Y, Atina A. 2022. Analisis Kualitas Air Anak Sungai Sekanak Berdasarkan Parameter Fisika Tahun 2020. *J Penelit Fis dan Ter*. 4(1):13. doi:10.31851/jupiter.v4i1.7875.

[4]Sasongko EB, Widyastuti E, Priyono RE. 2014. Study of Water Quality and Utility of Dug Well to the People around Kaliyasa Rivers Cilacap. *J Ilmu Lingkung*. 12(2):72–82.

[5]Revansyah Ma, Men Lk, Setianto S, F F, Safriani L, Aprilia A. 2023. Analisis Tds, Ph, Dan Cod Untuk Mengetahui Kualitas Air Di Desa Cilayung. *J Mater dan Energi Indones*. 12(02):43. doi:10.24198/jme.v12i02.41305.

[6]Setyowati RDN. 2015. Status Kualitas Air Das Cisanggarung, Jawa Barat. *Al-Ard J Tek Lingkung*. 1(1):37–45. doi:10.29080/alard.v1i1.32.

[7]Sari RN, Istirokhatun T, Sudarno. 2014. Analisis penentuan kualitas air dan status mutu Sungai Progo Hulu Kabupaten Temanggung. *J Tek Lingkung*. 1(1):1–9. https://media.neliti.com/media/publications/133559-ID-analisis-penentuan-kualitas-air-dan-stat.pdf.

[8]Tafangenyasha, C. and T. Dzinomwa. 2005. Land-use impacts on river water quality in lowveld sand river systems in south-east Zimbabwe. *Land Use and Water Resources Research* 5: 3.1-3.10.

[9]Sahabuddin H, Harisuseno D dan Yulianti E. 2014. Analisa status mutu air dan daya tampung beban pencemaran Sungai Wanggu Kota Kendari. *J. Teknik Pengairan.* 5 (1) : 19-28

[10]Irsanda P.g, Karnaningroem N, Bambang D. 2014. Analisis Daya Tampung Beban Pencemaran Kali Palayaran Kabupaten Sidoarjo Dengan Metode QUAL2Kw. *Surabaya : Institut Teknologi Sepuluh November*

[11]Alfatihah A, Latuconsina H, Prasetyo HD. 2022. Analisis Kualitas Air berdasarkan Parameter Fisika dan Kimia di Perairan Sungai Patrean Kabupaten Sumenep. *AQUACOASTMARINE J Aquat Fish Sci*. 1(2):76–84. doi:10.32734/jafs.v1i2.9174.

[12] Effendi H. 2003. Water Quality Study for Water Resources and Environmental Management. Yogyakarta (ID): *Kanisius*.

[13]Rohmawati Y, Kustomo K. 2020. Analisis Kualitas Air pada Reservoir PDAM Kota Semarang Menggunakan Uji Parameter Fisika, Kimia, dan Mikrobiologi, serta Dikombinasikan dengan Analisis Kemometri. *Walisongo J Chem*. 3(2):100. doi:10.21580/wjc.v3i2.6603.

[14] Peraturan Pemerintah Republik Indonesia No. 82 Tahun 2001 tentang Pengelolaan Kualitas Air dan Pegendalian Pencemaran Air. Presiden Republik Indonesia. (2001)

[15]Burns N, McIntosh J, Scholes P. 2005. Strategies for Managing the Lakes of the Rotura District, New Zealand. *Lake and Reservoir Management.* 21 (1): 61 –72. http://doi.org/b6mwqp

[16]Burhanuddin B. 2013. Analisis Kualitas Air Secara Fisik Dan Kimiawi pada Sistem Pemeliharaan Kima Sisik (Tridacna Squamosa). *Octopus J Ilmu Perikan*. 2(1):110–115.

[17]Wardhana, S. W. (1995). Dampak Pencemaran Lingkungan. *Penerbit Andi Offset*.

[18]Salmin. (2005). Oksigen Terlarut (DO) dan Kebutuhan Oksigen Biologi (BOD) Sebagai Salah Satu Indikator Untuk Menentukan Kualitas Perairan. *Pusat Penelitian Oseanografi-LIPI, Jakarta. Oseana*, 1(1), 21–26

[19]Makmur M, Haryoto K, Setyo SM, Djarot SW. 2012. Effect of Organic Waste and N / P Ratio on Phytoplankton Abundance in Cilincing Green Shell Cultivation Area. *Waste Management Technology.* 15 (2): 51-64

[20]Zhang, C., Han, M. 2015. Mapping chlorophyll-a concentration in Laizhou Bay using Landsat 8 OLI data. *Proceedings of the 36th IAHR World Congress. Netherland,* 12–17.

[21]Moses WJ, Gitelson AA, Berdnikov S, Povazhnyy V. 2009. Satellite estimation of chlorophyll-a concentration using the red and nir bands of Meris – the Azov sea case study. *IEEE Geoscience and Remote Sensing Letter.* Vol. 6, No.4.

[22]Lee Z, Marra J, Perry MJ, Kahru M. 2015. Estimating oceanic primary productivity from ocean color remote sensing: A strategic assessment. J. Mar. Syst. 149(December):50–59.doi:10.1016/j.jmarsys.2014.11.015.

[23]Behrenfeld, M. J., E. Boss, D. A. Siegel, and D. M. Shea. 2005. "Carbon-based Ocean Productivity and Phytoplankton Physiology from Space." Global Biogeochemical Cycles 19 (1). doi:10.1029/2004GB002299.

[24]Vidović M., Rodic M. M., Vidovic M. U., Trajkovic I. S., Jovanic S. Z., 2015 Assessment of the trophic status by monitoring of reservoir's water quality. *Journal of Water Resource and Protection* 7:1-13.

[25][KLH] Ministry of Environment. 2003. *Decree of the State Minister for the Environment Number 115 Year.*

[26]Pavluk T, Vaate A. 2013. Trophic Index and Efficiency. *Di dalam: Encyclopedia of Ecology*.

[27]Shen, S.Y. and Shaw, M.J. (2004) Managing Coordination in Emergency Response Systems with Information Technologies. *Proceedings of the 10th Americas Conference on Information Systems, New York,* 2004, 2110-2120.

[28]Radiarta IN, Sophia LS. 2012. Spatial Model of Aquatic Fertile in Lake Batur, Bangli Regency, Bali Province with Geographical Information System Application . *Aquaculture Research*. 7 (3): 499-508. Http://doi.org/cgpx

[29]Kagalaou, I.Latsiou,A. 2007. Investigating the local people's perceptions and attitude in a Greek protected area. *Proceed. of CEMEPE Conference, skiathos. Greece*