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The Impact of the Poso Energy Hydropower Plant on Lake Poso Aquatic Ecosystem in Central Sulawesi

Dampak PLTA Poso Energi terhadap Ekosistem Perairan Danau Poso di Sulawesi Tengah

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ABSTRACT

The Poso Energy Hydropower Plant (PLTA) operation and various industrial, agricultural, and domestic waste disposal activities could impact the Lake Poso aquatic ecosystem. However, no documented reports have been detailing the impact of the PLTA. Therefore, this research aimed to analyze the characteristics of the Lake Poso aquatic ecosystem, focusing on physical (TSS, odor, color, turbidity), chemical (pH, DO, BOD, COD, NO3-N, total phosphate), and biological (fecal coliform, plankton diversity) parameters. Water samples were collected at six points in the area before, surrounding, and after the PLTA from July to September 2022. Analyzing the sample data using the analysis of variance (ANOVA) revealed significant differences in physical, chemical, and biological parameters among the six sample points. Additionally, the results showed that the PLTA impacted the characteristics of the Lake Poso aquatic ecosystem, particularly affecting parameters such as TSS, DO, COD, NO3-N, color, and total phosphate. An environmentally sound waste management strategy is urgently needed to support Lake Poso's aquatic ecosystem conservation.

INTISARI

Pembangkit Listrik Tenaga Air (PLTA) Poso Energi serta berbagai kegiatan pembuangan limbah industri, pertanian, maupun domestik dapat menurunkan karakteristik ekosistem perairan Danau Poso. Namun, hingga saat ini, belum ada studi mengenai dampak yang ditimbulkan oleh PLTA Poso Energi terhadap karakteristik ekosistem perairan. Tujuan dari penelitian ini adalah untuk mengevaluasi karakteristik ekosistem perairan Danau Poso yang meliputi parameter fisik (TSS, bau, warna, kekeruhan), kimia (pH, DO, BOD, COD, NO_3-N, total fosfat), dan biologi (fecal coliform, keanekaragaman plankton). Pengambilan sampel air dilakukan pada enam titik lokasi yang mencakup area sebelum air masuk ke PLTA, pada PLTA, dan setelah air keluar dari PLTA pada periode Juli hingga September 2022. Data dianalisis secara statistik dengan ANOVA. Hasil menunjukkan bahwa parameter fisik, kimia, serta biologi menunjukkan nilai yang berbeda nyata secara signifikan pada enam titik sampel. Keberadaan PLTA memberikan dampak perubahan pada karakteristik ekosistem perairan Danau Poso yaitu pada parameter TSS, DO, COD, NO_3-N, warna, dan total fosfat. Strategi pengelolaan limbah perlu lebih mengakomodasi faktor lingkungan untuk mendukung konservasi sumber daya perairan Danau Poso.

Introduction

Lake Poso in Poso Regency, Central Sulawesi, spans 32 km in length and 16 km in width, covering an area of 32,000 ha. It boasts a water discharge depth of 148 m^3/s and a depth of 510 m, making it the third-deepest lake in Indonesia. The lake holds significant potential for electricity generation, with an estimated capacity of 75,000 MW (ESDM 2015; Mamondol 2018). This energy production could effectively supply the electrical demands of Central Sulawesi Province and the surrounding areas for the foreseeable future, leading to plans for the construction of a power plant (Kayupa 2015).

The government has constructed various power plants, including the Hydropower Plant (PLTA), in response to the increasing and essential demand for electricity (Kayupa 2015). According to research by Rahayu & Windarta (2022), PLTA is considered an environmentally friendly option. Using renewable energy sources and producing no greenhouse gas emissions, PLTA is a beneficial alternative to traditional fossil fuel-based power generation (Detrina et al. 2019; Sibagariang 2021). Additionally, the government has authorized private entities like the Kalla Group to participate in the development of the Poso Energy PLTA.

The operations of the Poso Energy PLTA have caused various environmental impacts in different areas. It is crucial to recognize the effects of PLTA operations on water sedimentation and the deterioration in the physical, chemical, and biological quality of water (Wahid 2007; Detrina et al. 2019). Additionally, the operations have increased environmental maintenance costs and potentially decreased fish biota (Wahyudiana 2019; Ramadani 2021). Despite this, the impact of Poso Energy PLTA activities on the characteristics of the aquatic ecosystem still needs to be explored. This research aimed to investigate and assess the affected aquatic ecosystem, providing a valuable scientific basis for developing a management plan for Poso Energy PLTA and ensuring sustainable operations.

Methods

Time and Location

This research was carried out in Poso Regency, Central Sulawesi Province, to examine the characteristics of the Lake Poso aquatic ecosystem by collecting six samples in the North Pamona Sub-district (Figure 1). PLTA Poso Energy has three main power generation facilities: Poso 1 PLTA, Poso 2 PLTA, and Poso 3 PLTA. The sampling points included the Lake Outlet (Pamona Village), before entering the Poso 1 PLTA (border between Sulewana Village and Saojo Village), before entering Sulewana Village, before entering the Poso 2 PLTA (Sulewana Village), before entering the Poso 3 PLTA (border between Sangira Village and Sulewana Village), and after passing the Poso 2 Extension PLTA (Sulewana Village). Sampling was conducted at these locations five times each for three days, from July 14 to September 14, 2022.

Measurement of the Characteristics of the Lake Poso Water Ecosystem

Water samples were collected in the morning and afternoon simultaneously over three days and placed in 1500 ml sample bottles. Observations were made at each location on the key parameters of the aquatic ecosystem, encompassing physical (TSS, odor, color, and turbidity), chemical (pH, DO, BOD, COD, NO_3-N, and total phosphate), and biological parameters (fecal coliform and plankton diversity).

Turbidity

The Secchi disc, with a standard diameter of 20 cm and divided into alternating white and black quadrants, was employed to assess water turbidity. The measurement process began by lowering the disk into the water until it became invisible. The depth at which this occurred indicated the water's clarity level. The measurement process was performed five times, and the average value became the parameter estimate of water clarity, offering valuable insights into aquatic ecosystems and water quality.

Total Suspended Solid (TSS)

The gravimetric method was used to test for Total Suspended Solids (TSS). The process began with the preparation of 10 μm diameter filter paper, which was folded, rinsed, and heated in the oven for an hour at 100-110°C. Following heating, the filter paper was placed in a desiccator for 10 minutes and weighed. The

Figure 1. Research sampling location map

process was repeated three times to ensure a constant weight. The TSS was measured by pouring 50 ml of sample water through the filter. The subsequent process was similar to the preparation of the filter.

Degree of acidity (pH)

This research used pH sticks to measure the acidity (pH) degree by immersing the pH stick in a water sample for three minutes. Subsequently, the resulting color matched the standard listed on the pH box.

Dissolved oxygen (DO)

Dissolved oxygen (DO) was measured using an oxygen meter and a 500 ml water sample. The sensor tip of the meter was dipped into the sample, the "power" button was pressed, and the reading was taken in mg/l.

Biochemical Oxygen Demand (BOD)

Water samples were collected and stored in bottles before being incubated in the laboratory. Although the overall oxidation of organic materials was a time-consuming process, it was considered complete after 20 days. In this research, Biochemical Oxygen Demand (BOD) values were measured based on five days of incubation instead of the full 20 days. This adjustment not only reduced the time required for analysis but also minimized the impact of ammonia oxidation using oxygen. During the five-day incubation period, approximately 70-80% of the organic material was estimated to have undergone oxidation. The BOD measurements commenced with the determination of a representative sample volume, followed by the addition of reagents to support the growth of microorganisms responsible for the oxidation of organic materials. Dissolved oxygen (DO) levels were measured before and after the five-day incubation, and the difference in concentration was applied to calculate the BOD. Optimal environmental conditions and aeration were maintained throughout the incubation process, and the laboratory equipment was appropriately calibrated. Ultimately, these measurements provided an estimate of water quality and organic pollution levels.

Chemical Oxygen Demand (COD)

Each water sample was placed in a vial with 2 ml of Chemical Oxygen Demand (COD) reagent and gently shaken. After mixing, the samples were heated at 150°C for 120 minutes using a HACH plate. After cooling the samples to room temperature, the COD parameters were measured using a UV-Vis spectrophotometer, and the resulting values were recorded.

NO_3-N

To prepare the sample, 25 ml of the solution was diluted with ammonium-EDTA solvent to a total volume of 100 ml. The solution was then passed through a Cu-Cd column at a 7-10 ml/minute flow rate to reduce the nitrite content. A total of 1 ml of buffer color reagent solution was added to 25 ml of the reduced product in a measuring flask. The mixture was allowed to stand for 10 minutes before measuring the absorbance at a wavelength of 540 nm.

Total Phosphate

The sample was stirred and then transferred into a test tube with a volume of 15 ml. Subsequently, 0.1 gram of ammonium persulfate and 0.2 ml of sulfuric acid were added. After heating the solution to 100°C for 30 minutes, 2.4 ml of a mixed reagent was added. Following thorough mixing and a 10-minute incubation period, the mixture was cooled and combined with a few drops of Phenolphthalein (PP) indicator and 10N NaOH until a pink color developed. Finally, the absorbance was determined using a UV-Vis spectrophotometer at a wavelength of 880 nm.

Odor and Color

The color of the water was visually assessed using the sense of sight. The observation results were compared to the clean water quality standards set by the Minister of Health regulations. Additionally, the odor was evaluated using the sense of smell and compared with established clean water odor standards.

Plankton Diversity

Plankton's microscopic size presented challenges for observing and calculating its types and abundance. Researchers utilized a plankton net and additional tools such as flacon bottles and measuring buckets to address this. The procedure involved attaching the net's end to the flacon bottle's end and pouring the water sample into the bottle to filter the plankton. The resulting solidified plankton sample was examined in the laboratory to determine its abundance.

Fecal Coliform

A trisalt solution was prepared by dilution within the range of 10^{-1} to 10^{-3}, then shaken until homogeneous. Additionally, nine Lauryl Triptose Broth (LTB) tubes were arranged, each containing a Durham tube for each sample. Approximately 1 ml of sample water was added to tube 10^{-1} and vortexed until homogeneous. From tube 10^{-1}, 1 ml was transferred to tube 10^{-2}, and 1 ml of tube 10^{-2} was transferred to tube 10^{-3}. Next, 1 ml of solution from each dilution was transferred using a sterile pipette to each of the three LTB tubes. This process was repeated for the six samples. The tubes were then incubated at 35°C for 24-48 hours. The tube that produced bubbles in the Durham tube was considered to have a positive result.

Results and Discussion

Characteristics of the Lake Poso Aquatic Ecosystem

Turbidity

Water with a high concentration of suspended particles was considered murky, giving it a visibly dirty appearance. This turbidity was attributed to mud, well-dissolved organic matter, and other suspended particles (Rachmansyah et al. 2014). The One-Way ANOVA test results for the turbidity parameters indicated significant differences (sig. <0.05), indicating that the turbidity parameters at the six selected locations varied significantly (Table 1). In this research, the average turbidity value fell within the

Table 1. One-way ANOVA test results for turbidity parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	0.345	5	0.069	204.077	0.000
Within Group	0.008	24	0.000		
Total	0.353	29			

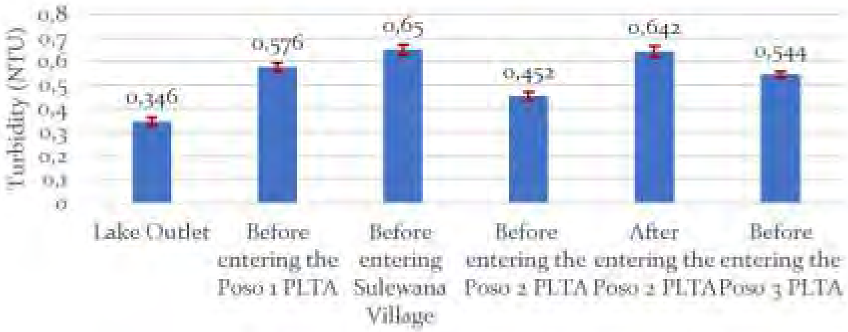

Figure 2. Average (blue bars) and standard deviation (red lines) values of turbidity parameter

normal range of less than 5 Nephelometric Turbidity Unit (NTU) (Figure 2), with the highest value occurring at the location before entering Sulewana Village. This sample point was near a residential area, leading to an increase in organic and inorganic substances from household and industrial waste. Consequently, the elevated levels of waste entering the water resulted in higher turbidity and reduced clarity, inhibiting sunlight penetration and limiting the photosynthesis zone (Patty et al. 2021).

Total Suspended Solid (TSS)

Total Suspended Solid (TSS) is an insoluble material that causes turbidity in water and cannot settle directly. TSS mainly consists of particles with smaller size and weight than sediment, such as clay, various organic materials, and microorganism cells (Ariebowo et al. 2020). The One-Way ANOVA test results (Table 2) for TSS indicated a significant difference (sig. <0.05). This analysis highlighted significant differences in TSS parameters at the six selected locations. The research findings (Figure 3), revealed fluctuations in TSS values. TSS levels increased at the location before entering the Poso 1 PLTA, Sulewana Village, and the Poso 2 PLTA, then decreased after entering the Poso 2 Extension PLTA and before entering the Poso 3 PLTA. The increase in TSS levels before entering the Poso 1 PLTA, Sulewana Village, and the Poso 2 PLTA resulted from significant domestic and industrial waste disposal. The lack of vegetation cover contributed to high values at these locations, as rainwater is converted into run-off, and dense soil inhibits the infiltration process. The decrease in TSS levels after entering the Poso 2 Extension PLTA and before entering the Poso 3 PLTA occurred due to sediment deposition in the riverbed.

pH

The measurement of acidity (pH) is a crucial tool for assessing the acidity and alkalinity of water determined by the pH value (Djoharam et al. 2018). This measurement is applied to gauge the pollution index by considering the levels of acidity or alkalinity. A neutral pH is achieved at a value of seven, with alkalinity and acidity represented by values above and below seven, respectively. The pH value indicates the balance of chemical elements and nutrients that are vital for the survival of aquatic vegetation and support the diverse biotic life in aquatic ecosystems. Generally, water with a pH below 4.8 or above 9.2 is considered polluted (Supriatna et al. 2009). In this research, the One-Way ANOVA test results (Table 3) for the pH parameter indicated significant differences (P<0.05), indicating that the pH parameter at the six selected locations varied significantly. The findings indicated a decrease in the pH value before the Poso 1 PLTA and an increase before entering Sulewana village. The highest average value was recorded at the Lake Outlet location and after entering the Poso 2 Extension PLTA, while the lowest was before entering the Poso 2 PLTA, at

Table 2. One-way ANOVA test results for TSS parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	2453.467	5	490.693	129.130	0.000
Within Group	91.200	24	3.800		
Total	2544.667	29			

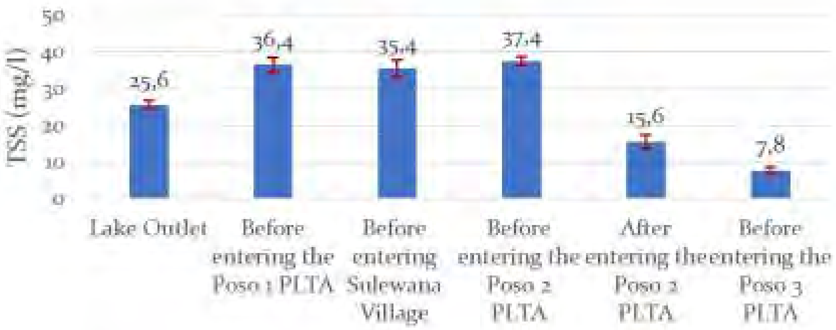

Figure 3. Average (blue bars) and standard deviation (red lines) values of TSS parameter

Table 3. One-way ANOVA test results for pH parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	0.892	5	0.178	4.564	0.005
Within Group	0.938	24	0.039		
Total	1.829	29			

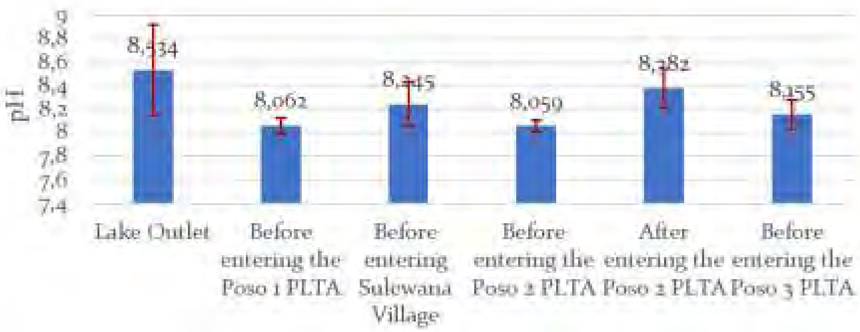

Figure 4. Average (blue bars) and standard deviation (red lines) values of pH parameters

8.059 (Figure 4). All sampling points maintained an average pH value within the normal range of quality standards, essential to support diverse aquatic life and freshwater biota, ideally ranging from 6.8 to 8.5 (Tatangindatu et al. 2011). The average pH value at the six sample points was within the range but exceeded 7.0, indicating alkaline conditions. This alkaline condition was attributed to household waste, such as detergent and solvent ions from the surrounding soil or rocks, leading to an elevated pH (Kristanto 2002).

Dissolved Oxygen (DO)

Oxygen is a gas with no smell or taste and limited water solubility. Both plants and animals in aquatic environments rely on dissolved oxygen (DO) for survival, making it an essential factor in evaluating water quality. Organisms can survive in water when the DO content is at least 5 ppm/l. Other factors affecting their survival include organism resistance, activity level, presence of pollution, and water temperature. DO is generated through the photo-synthesis process of aquatic plants and originates from the atmosphere at a specified rate (Kristanto 2002). The One-Way ANOVA test results for the DO parameters (Table 4) indicated significant differences ($p<0.05$), suggesting that the DO parameters at the six sample points varied significantly. The findings indicated that the average dissolved oxygen (DO) level exceeded the quality standard at several locations, including the lake outlet, before entering Poso 1 PLTA, Sulewana Village, and Poso 2 PLTA, indicating that the water in these points was suitable for use and beneficial for the aquatic ecosystem. However, at the location after entering the Poso 2 Extension PLTA and before entering the Poso 3 PLTA, the average DO value was below the quality standard (Figure 5), indicating water pollution that could harm the aquatic ecosystem (Aruan & Siahaan 2017). Low DO concentrations could lead to the death of fish and other oxygen-dependent aquatic organisms. In contrast, high DO concentrations could accelerate corrosion by forming a hydroxide layer on metal surfaces. Additionally, excessive heavy metals in water could adversely affect the respiratory systems of aquatic organisms (Kristanto 2002).

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) refers to the quantity of oxygen microorganisms require in water for the aerobic breakdown or degradation of organic waste materials (Santoso 2018). Several factors, including temperature, plankton density, the presence of microbes, and the type and quantity of organic matter, influence variations in BOD content. Although BOD measures the amount of dissolved oxygen (DO) needed by organisms to decompose and oxidize organic waste materials in water, it does not directly indicate the quantity of organic matter. However, the high oxygen consumption indicated by the decrease in DO suggests a high content of waste materials (Pour et al. 2014). The results of the One-Way ANOVA test for the BOD (Table 5) parameters revealed significant differences ($p<0.05$), indicating that the BOD parameters at the six sample points differed significantly. The results indicated that the average Biochemical Oxygen Demand (BOD) content at the six sample points ranged from 0.322 to 1.281 mg/l (Figure 6), well below the 3 mg/l quality standard. In comparison, the Dissolved Oxygen (DO) values at these locations ranged from 3.419 to 7.699 mg/l, indicating lower levels, suggesting a low presence of waste materials requiring oxygen and suitable to support aquatic life, as they fall within the range of 0.5 to 7 mg/l. Any water with BOD values exceeding 10 mg/l is considered polluted (Amit and Yashodhara 2012).

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is a technique used to measure the amount of oxygen in organic and inorganic substances in a water sample that a powerful chemical oxidizing agent, such as bichromate, can oxidize. This method is commonly used to evaluate oxidizable organic and inorganic materials levels in various water sources, including natural waters and domestic and industrial waste. In unpolluted surface

Table 4. One-way ANOVA test results for DO parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	103.288	5	20.658	1140.910	0.000
Within Group	0.435	24	0.018		
Total	103.723	29			

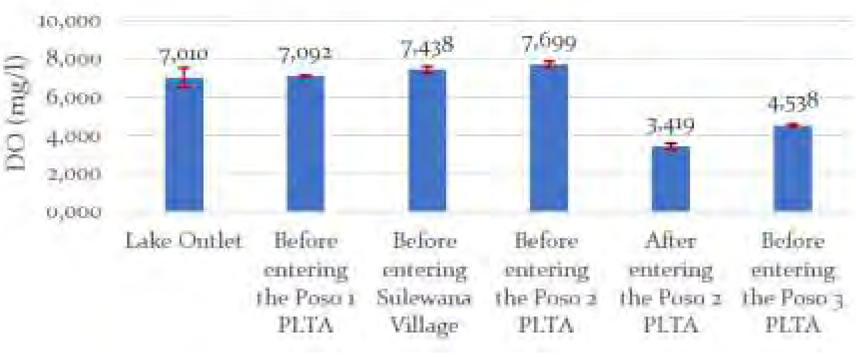

Figure 5. Average (blue bars) and standard deviation (red lines) values of DO parameters (mg/l)

Table 5. One-way ANOVA test results for BOD parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	4.654	5	0.931	511.727	0.000
Within Group	0.044	24	0.002		
Total	4.697	29			

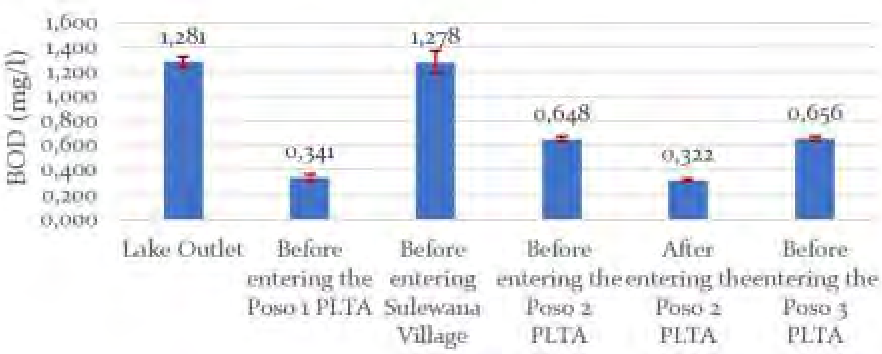

Figure 6. Average (blue bars) and standard deviation (red lines) values of BOD parameters (mg/l)

Table 6. One-way ANOVA test results for COD parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	2155.828	5	431.166	7330.297	0.000
Within Group	1.412	24	0.059		
Total	2157.239	29			

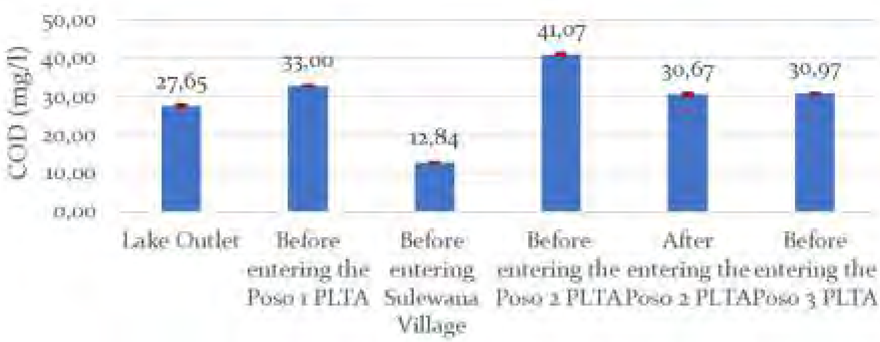

Figure 7. Average (blue bars) and standard deviation (red lines) values of COD parameters (mg/l)

water, the observed concentration is around 20 mg/l, while bodies of water receiving waste have a 200 mg/l value. Wastewater from industrial sources could have COD values ranging from 100 to 60,000 mg/l (Sitepu et al. 2021). The results of the One-Way ANOVA test for the COD content parameters (Table 6) revealed significant differences ($p<0.05$), indicating that the COD parameters at the six sample points exhibited significant differences. The Indonesian Government Regulation No. 82 of 2001 sets 25 mg/l as the standard quality for COD. The findings from six sample points varied (Figure 7). Four locations: before entering Poso 1 PLTA, before entering Poso 2 PLTA, after entering Poso 2 Extension PLTA, and before entering Poso 3 PLTA, exhibited higher values than the quality standard. The COD at the sample point before entering the Sulewana village, specifically the lake outlet, showed an average value of 27.65, slightly below the quality standard. These findings suggested that unpolluted waters and those contaminated by domestic or industrial waste from residential areas displayed low and high COD values, respectively. Consequently, this underscores the pressing need for more significant efforts in organic matter degradation to address water pollution (Ramayanti & Amna 2019).

NO_3-N

Nitrate is an inorganic ion part of the nitrogen compound cycle, with the chemical formula NO_3 and a molecular mass of 62.0049 g/mol. Nitrogen is found in various organic and inorganic compounds in the natural environment, including urea, protein, nucleic acids, ammonia, nitrate, and nitrite. High nitrate in drinking water can lead to digestive system issues (Amalia et al., 2021). The One-Way ANOVA test results (Table 7) for the NO_3-N parameter indicated significant differences (p,0.05), indicating significant variations in the NO_3-N parameter at six sample points. The quality standard for NO_3-N is ten, but the average value from six sampling locations was less than one, well below the standard limit. Before entering the Poso 3 PLTA, the sample point had the highest average nitrate value, approximately 1.615 mg/l (Figure 8). Accumulation of household waste, urine secretion, and fertilizer use along river flows contributed to the increased nitrate levels. Nitrate values tend to increase during the day as phytoplankton utilizes nitrate as a nutrient source in photosynthesis, which is facilitated by sunlight (Patriani 2016).

Total Phosphate

Phosphate is a pollutant that causes a decrease in the characteristics of aquatic ecosystems. Its excessive content in water led to eutrophication. Eutrophication is a natural process in which waters gradually age and become more productive for biomass growth (Sutamihardja et al. 2018). It could occur in a water area when the total phosphate concentration is 0.035-0.01 mg/l. The process takes thousands of years and can trigger algal blooms (explosion of phytoplankton populations), especially in calm, non-flowing waters, such as lakes, ponds, and the sea (Effendi 2003). The average value of total phosphate at the six sampling locations was below the quality standard of 0.2 mg/l. The presence of phosphate compounds in water significantly impacted the balance of aquatic ecosystems. Low phosphate concentration in water, such as in natural water (<0.01 mg/l), could inhibit the growth of plants and algae, and this condition is known as oligotrophy. At the six sampling points, only before entering Poso 3 did PLTA meet the total phosphate concentration for eutrophic waters (Figure 9), indicating suitability and fertility for aquatic ecosystems (Listantia 2020).

Odor and Color

The odor in water directly impacts consumers' perception and can significantly affect public acceptance of water quality. Tests conducted at the Donggala Environmental Service Laboratory revealed that the water from Lake Poso, utilized by the Poso

Table 7. One-way ANOVA test results for NO3-N parameters

	Total	df	*Mean Square*	F	Sig.
Between Group	10.138	5	2.028	4.564	0.000
Within Group	0.000	24	0.000		
Total	10.138	29			

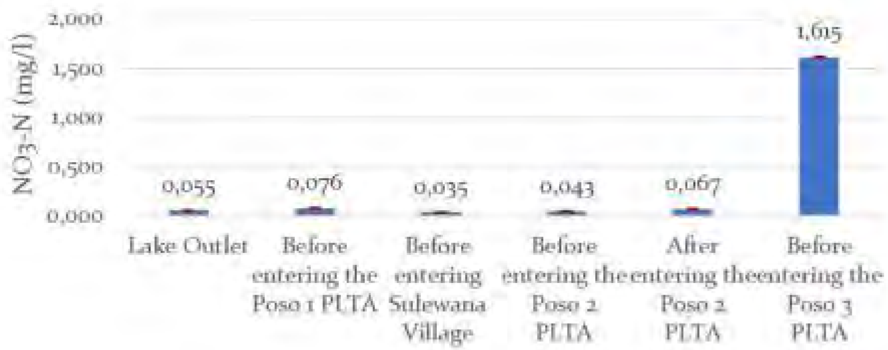

Figure 8. Average (blue bars) and standard deviation (red lines) values of NO_3-N parameters (mg/l)

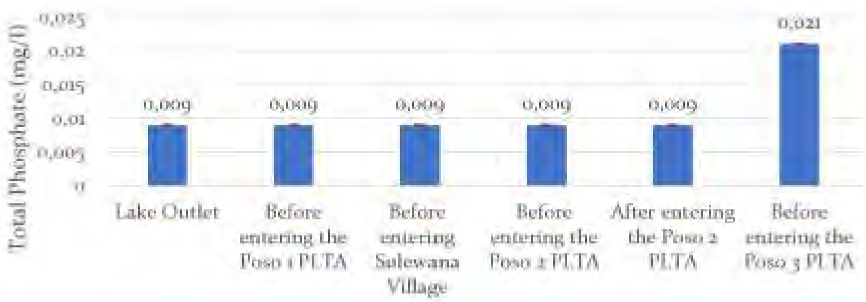

Figure 9. Average (blue bars) and standard deviation (red lines) values of total phosphate parameters (mg/l)

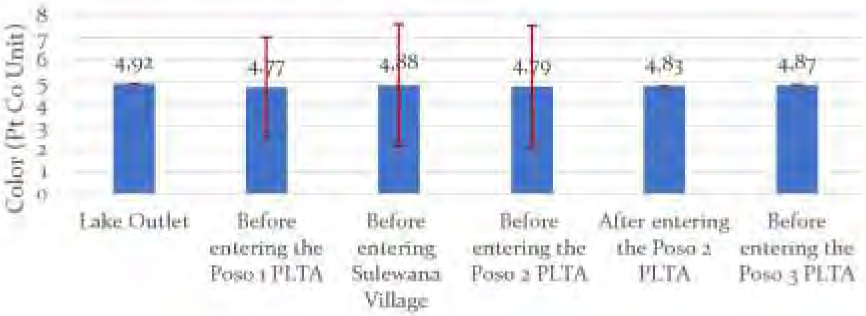

Figure 10. Average (blue bars) and standard deviation (red lines) values of color parameters (Pt-Co Unit)

Energy PLTA before entering the Poso 3 PLTA, exhibited no odor, in compliance with the drinking water quality standards outlined in the Republic of Indonesia Minister of Health Regulation No. 492/MENKES/PER/IV/2010. Odors such as metallic, fishy, or rotten can indicate poor water quality and potential health risks, often resulting from organic materials, specific organisms, and compounds such as phenol (Muzayana & Hariani 2019). The research findings confirmed the absence of odor at the six sample points, meeting the standard quality requirements.

The water color indicates the presence of particles from decomposing organic matter, natural metal ions like iron and manganese, plankton, humus, industrial waste, and aquatic plants. The reddish or blackish color can result from iron and manganese oxides, respectively (Effendi 2003). The standard quality for water color is 50 Pt-Co units. The laboratory test results indicated values below five at the six sampling locations, showcasing the water's compliance with color quality standards (Figure 10).

Plankton Diversity

The diversity of plankton has a significant impact on the primary productivity of aquatic environments. Plankton is a crucial natural food source for fish, providing up to 80% protein content (Aida 2008). Additionally, plankton is essential in breaking down organic material, including primary material from plant litter carried by river currents and secondary material from animals, into simpler compounds and elements accessible to aquatic plants (Wiryawan 2009). A sample testing revealed that the plankton in areas unaffected by Poso Energy PLTA (before entering Poso 3 PLTA, situated on the boundary of Sulewana Village and Sangira Village) consisted of three genera: Penium, Chlamydomonas, and Chorococcum. In contrast, plankton diversity in areas impacted by Poso PLTA included four genera: Penium, Conjugatae, Chlamydomonas, and Chorococcum. These findings suggested that the critical difference between the areas before and after use by Poso Energy PLTA was the presence of Conjugatae, which cannot adapt to unstable environmental conditions. The presence of conjugatae before entering Poso 2 PLTA in Sulewana Village indicated a lower pollution level. Moreover, this sample point also had a relatively high abundance of saprobic indicator species, including Spirogyra sp. and Zygnema sp. These phytoplankton

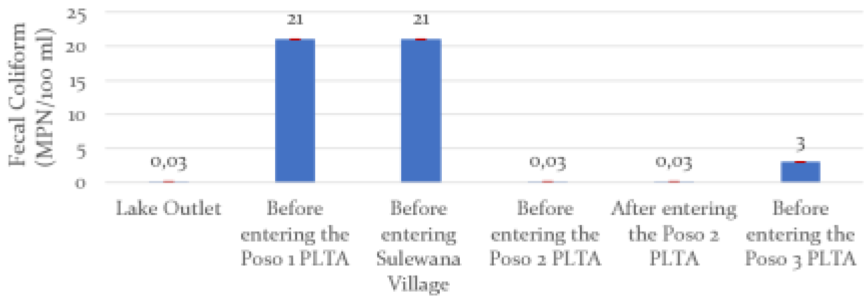

Figure 11. Average (blue bars) and standard deviation (red lines) values of Fecal Coliform parameters (MPN/100 ml)

types are typically found in waters with minimal or no organic matter pollution (Soegianto 2004).

Fecal Coliform

Fecal coliforms, found in feces, can be facultatively anaerobic, rod-shaped, gram-negative, and lacking spores. These bacteria typically originate from the small intestines of warm-blooded animals, including humans, and are one of the seven parameters used to assess wastewater. In laboratory tests, the presence of Escherichia coli is identified as an indicator of potential contamination by feces and the presence of other pathogenic microorganisms. The presence of fecal coliforms in water does not always indicate immediate danger and contamination by feces (Sianipar et al. 2022). The quality standard for fecal coliform is 1 MPN/100 ml. This research showed that the average fecal coliform levels before entering Poso 1 PLTA, Kampung Sulewana, and Poso 3 PLTA exceeded the quality standard (Figure 11), mainly due to direct waste dumping into the water, including domestic waste from residential areas, markets, shops, and surrounding public toilets. The high levels of fecal coliform bacteria led to the presence of other pathogenic bacteria due to the positive correlation between their properties (Widyaningsih et al. 2016). For instance, water contaminated by human feces or feces from warm-blooded animals contained pathogenic bacteria like E. coli, causing symptoms such as diarrhea, fever, stomach cramps, and vomiting (Bambang et al. 2014).

Conclusion

The research conducted on the effects of the Poso Energy Hydropower Plant (PLTA) on the Lake Poso aquatic ecosystem in Central Sulawesi has provided valuable insights into the environmental implications of renewable energy infrastructure development. The findings confirmed that hydropower activities affected various parameters, including TSS, DO, COD, NO_3-N, color, and total phosphate, highlighting the importance of adopting a holistic approach to planning and managing hydropower projects to mitigate environmental impacts. Further comprehensive investigation is required to fully comprehend the long-term consequences of hydropower development on aquatic ecosystems. Moreover, it is essential to develop management strategies that thoroughly consider environmental aspects when planning future projects, and this should involve collaboration among the government, project developers, and local communities.

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