Jurnal Mina Sains, 11 (2): 109-116, October 2025

Chlorophyll-a content around the floating needle cage damsite of the Koto Panjang Reservoir, Kampar Regency, Riau Province

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Abstrak

Waduk Koto Panjang dimanfaatkan sebagai sebagai tempat budidaya ikan dengan sistem Keramba Jaring Apung (KJA). Pengembangan KJA di Waduk Koto Panjang memberikan manfaat ekonomi bagi masyarakat namun juga berpotensi menyebabkan penurunan kualitas perairan. Penelitian ini bertujuan untuk menganalisis konsentrasi klorofil-a di sekitar waduk yang terdapat KJA. Metode survei digunakan untuk pengamatan pada 4 stasiun dengan 3 kali ulangan. Karakteristik pada empat stasiun berdasarkan variasi jumlah petak KJA: stasiun 1 (60 petak), stasiun 2 (tidak terdapat KJA), stasiun 3 (350 petak), dan stasiun 4 (600 petak). Penggambilan sampel dilakukan pada pagi hari pukul 08.00 hingga 12.00 WIB. Klorofil-a dianalisis dengan metode spektrofotometri. Konsentrasi klorofil-a di perairan Waduk Koto Panjang berkisar antara 7.693-12.927 µg/L, tergolong dalam kategori mesotrofik. Nilai tertinggi terdeteksi pada stasiun 4 (12,927 µg/L) dan terendah stasiun 2 (7,693 µg/L). Terdapat kecenderungan peningkatan konsentrasi klorofil-a sejalan dengan peningkatan jumlah petak KJA. Kualitas air di Waduk Koto Panjang berdasarkan pH, suhu, kecerahan, oksigen terlarut, karbondioksida bebas, dan Klorofil-*a* masih mendukung kehidupan organisme.

Kata Kunci: Budidaya ikan, Klorofil-a, kualitas air, mesotropik, phosphate

Abstract

Koto Panjang Reservoir is used as a fish farming site using the Floating Net Cage (KJA) system. The development of KJA in Koto Panjang Reservoir provides economic benefits for the community but also has the potential to cause a decline in water quality. This study aims to analyze the concentration of chlorophyll-a around the reservoir where KJA is located. The survey method was used for observations at 4 stations with 3 replications. The characteristics of the four stations were based on variations in the number of KJA plots: station 1 (60 plots), station 2 (no KJA), station 3 (350 plots), and station 4 (600 plots). Sampling was carried out in the morning from 08.00 to 12.00 WIB. Chlorophyll-a was analyzed using the spectrophotometric method. The concentration of chlorophyll-a in the waters of Koto Panjang Reservoir ranged from 7,693 to 12,927 µg/L, classified as mesotrophic. The highest value was detected at station 4 (12,927 µg/L) and the lowest at station 2 (7,693 µg/L). There was a tendency to increase chlorophyll-A concentrations in line with the increasing number of KJA plots. Water quality in the Koto Panjang Reservoir, based on pH, temperature, clarity, dissolved oxygen, free carbon dioxide, and chlorophyll-a, still supports the life of organisms.

Keywords: Chlorophyll-a, fish farming, mesotrophic, phosphate, water quality

Submitted: October 24, 2024; **Accepted**: October 30, 2025; **Published**: October 31, 2025

To cite this article: Alamsyah, F., Sumiarsih, E., & Yuliati. (2025). Chlorophyll-a content around the floating needle cage damsite of the Koto Panjang Reservoir, Kampar Regency, Riau Province. Jurnal Mina Sains. 11(2):109-116. https://doi.org/10.30997/jmss.v11i2.15921

Highlights

- An increase in water fertility is due to nutrient inputs from leftover feed and fish feces.
- The highest chlorophyll-a concentration was found at the location with the highest floating net density.
- Mesotrophic category reservoirs require attention in the management of cultivation activities to maintain ecosystem balance.

Introduction

Riau has abundant freshwater bodies, including rivers, swamps, reservoirs, and lakes, which play a vital role in supporting the lives of aquatic organisms and surrounding communities. Freshwater bodies, such as reservoirs and artificial lakes, are aquatic resources formed through the process of damming or obstructing river flow downstream. Damming these rivers will result in the habitat changing from flowing to stagnant (Gezie et al., 2023).

Koto Panjang Reservoir is located in Riau Province and is the result of damming from several rivers in Riau and West Sumatera, namely Kampar Kanan, Batang Mahat, Gulamo, Tapung Air Tiris, and Cunding. The area of inundation around the Koto Panjang reservoir reaches around 12,400 ha. Kampar Kanan River is the main river that flows into the Koto Panjang Reservoir and has an upstream component in West Sumatra (Hasibuan et al., 2017.

The reservoir plays a role as a power plant and flood control (Hasibuan et al., 2017). However, there have been significant changes in the land surrounding the reservoir, with forests being converted into agricultural land, plantations, settlements, and open land due to illegal logging activities. Meanwhile, people use the reservoir area for fishing activities, as a tourist attraction, and for cultivating fish within the floating net cages (KJA) system. In 2010, in the Koto Panjang reservoir, there were 900 KJA plots (Siagian, 2010). Then it increased in 2013 to 1,100 plots (Simarmata et al., 2013), and in 2014, the number of KJA increased to 1,200 (Sumiarsih, 2014). Furthermore, in 2018 there was a rapid increase so that there were 1,546 plots of KJA (Sihombing, 2018). This data indicates an annual increase in the number of KJA. Increasing number of KJA may impact water quality because KJA waste consists of uneaten feed and fish feces from the cultivated fish.

The utilization of the Koto Panjang Reservoir for KJA is primarily concentrated in the dam site area. Fish farmers use this area as a place to cultivate fish with a cage system. Although fish farming in KJA provides significant economic benefits, the existence of the KJA. This has a negative impact on the environmental conditions of the waters. This is due to the large production of organic and inorganic waste due to ineffective and inefficient feeding. The presence of KJA can degrade water quality due to the introduction of organic matter, such as fish feed and feces, into the water. According to Sumiarsih (2014), KJA activities in the Koto Panjang Reservoir contribute 19.28% of uneaten feed to the water. Residual feed and metabolism wasted into the waters in large quantities can cause eutrophication.

Eutrophication is the result of an increase in the amount of nutrients in a body of water. (Pratiwi et al., 2020). Plankton, which includes phytoplankton, partially utilizes nutrients that enter the waters. Phytoplankton, as primary producers, play a crucial role in waters. As primary producers, phytoplankton produce organic matter through the process of photosynthesis. With the help of chlorophyll, phytoplankton bind sunlight and utilize nutrients in the waters so that the process of photosynthesis takes place. One effort to maintain the sustainability of aquatic resources is knowing the fertility status of the waters by measuring the chlorophyll-a content. Chlorophyll-a, a pigment active in plant cells, plays an important role in the process of photosynthesis in water, and can be used as a measure of water fertility (Agung et al*.,* 2018).

Methods

This research was carried out in January-March 2024 in the waters of Koto Panjang Reservoir. The method used in the study is a survey method, namely by observing and taking data directly at the Koto Panjang Reservoir. The determination of purposive sampling research stations is carried out by looking at the conditions/characteristics of the research area so that the sampling station can represent the research area. The research station consists of 4 stations.

Station I: An area with a total of 60 plots of land at 0°25'4.0" N-100°86'91.4" E. Station II: an area without KJA activity, located at 0°16'32.4" N-100°52'17.8" E. Station III: an area with 350 KJA plots of land at 0°16'44.5" N-100°52'14.4" E. Station IV: an area with a total of 600 KJA plots of land located at 0°16'44.0" N-100°52'14.3" E (Figure 1).

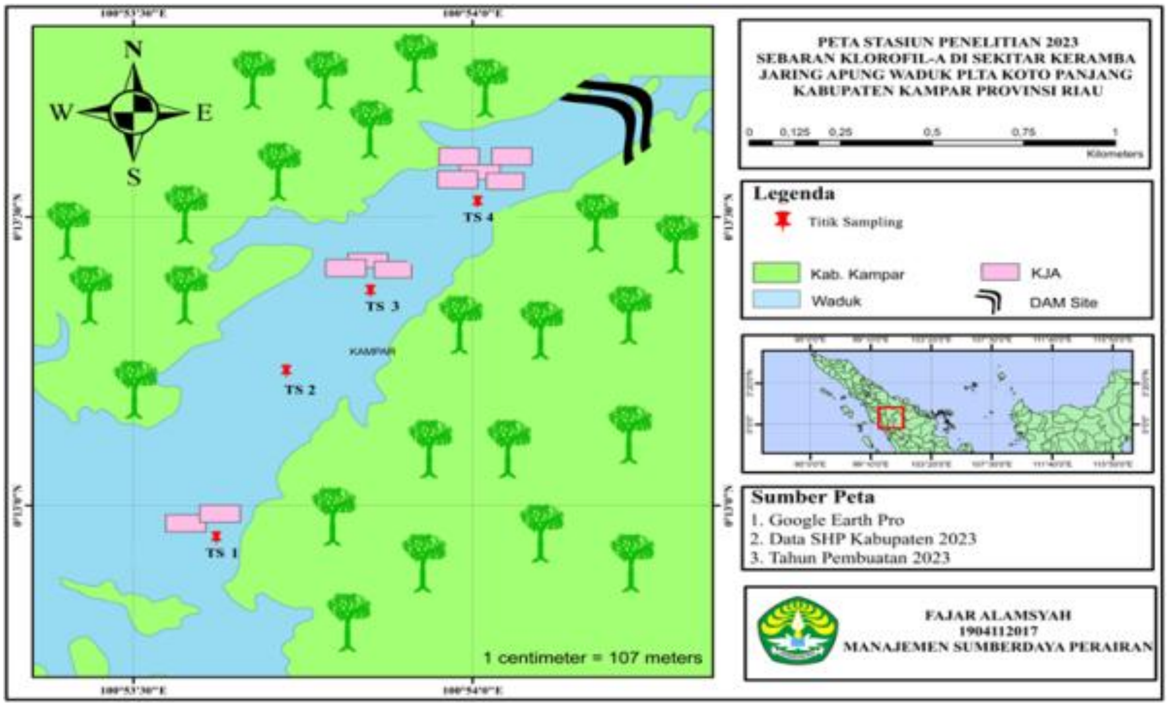

Figure 1. Research Station

Chlorophyll-a samples were collected using a one-liter water sampler in the morning between 8:00 AM and 12:00 PM WIB. Water samples were collected three times with a two-week interval. In addition to chlorophyll-a, water quality parameters were also measured, namely temperature, clarity, dissolved oxygen, free carbon dioxide, nitrate, and phosphate. Water samples were taken at three points at each station and then composited. Dissolved oxygen measurements used the Winkler method, while nitrate and phosphate refer to APHA 2012.

Chlorophyll-a was measured using a UV-Vis spectrophotometer. Chlorophyll-a concentration analysis was carried out by taking 500 ml of sample water, which was then filtered using Millipore paper. The milli pore paper containing chlorophyll-a is folded four times, then wrapped in aluminium foil and stored in the refrigerator for 1 night. The Millipore paper that has been stored in the refrigerator is put into a tissue grinder, then 90% acetone is added, as much as 3.5 ml, and then ground until it is evenly destroyed, and another 5 ml of acetone is added. The rubbed sample is placed into a test tube and centrifuged at a speed of 2,000 rpm for 10 minutes to separate the sediment from the supernatant (clear liquid). After centrifugation, the supernatant is poured into a cuvette, and its absorbance is measured at λ 750 nm and λ 665 nm. The concentration of chlorophyll-a in the cuvette was calculated using the Vollenweider formula in Boyd (1979) as follows:

$$\text{Chlorophyll-a } (\mu g/L) = 11.9\ (A665 - A750) \times V/L \times 1000/S$$

Remarks: A665 indicates the use of a spectrophotometer with a wavelength of 665 nm, A750 indicates the use of a spectrophotometer with a wavelength of 750 nm, V indicates the extraction of acetone (milli liter), S indicates the volume of the sample screened (milli liter), and 11.9 indicates a constant value (fixed).

Results and discussion

Chlorophyll-a

The results of the analysis of chlorophyll-a concentration ranged from 7,693 to 12,927 µg/L. The highest concentration of chlorophyll-a was found at Station 4, which was 12,927 µg/L, and the lowest chlorophyll-a concentration at Station 2 was 7,693 µg/L. The results of the chlorophyll-a concentration analysis are presented in Figure 2.

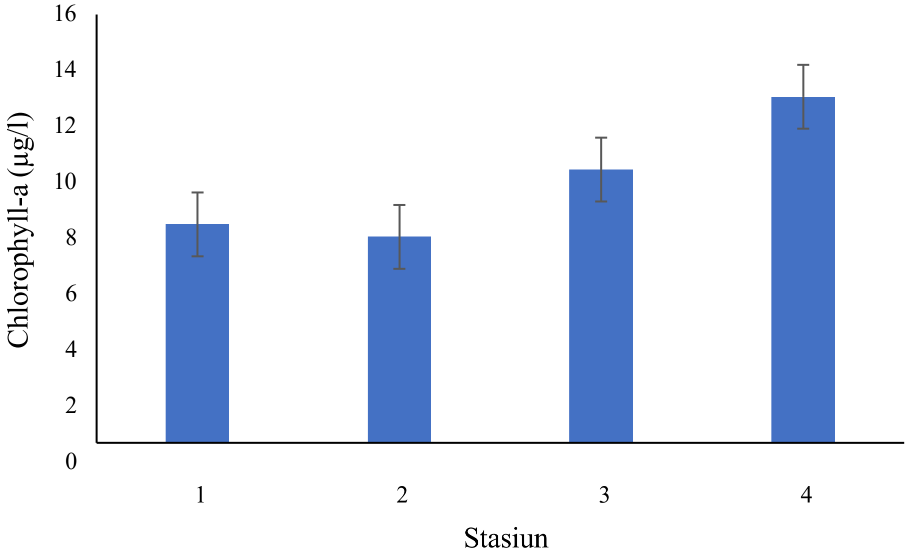

Figure 2. Chlorophyll-a analysis

Figure 2, there are variations in chlorophyll-a concentrations at four observation stations around the KJA. Chlorophyll-a concentrations ranged from 7.693 µg/L to 12.927 µg/L, with the maximum concentration detected at station 4 and the minimum at station 2. The data show a tendency for increasing chlorophyll-a concentrations in line with the increasing number of KJA plots. Station 4, with the largest number of KJA plots (600 plots), had the highest chlorophyll-a concentration (12.927 µg/L), followed by station 3 with 350 KJA plots (10.208 µg/L). Station 1, with the fewest number of KJA plots (60), showed a chlorophyll-a concentration of 8.160 µg/L, while station 2, which did not have KJA, showed the lowest value (7.693 µg/L). This pattern shows that there is a positive relationship between the number of KJA and the amount of chlorophyll-a in the water. This phenomenon can be explained by the nutrient enrichment mechanism (eutrophication) that occurs due to fish farming activities in KJA. According to Pratiwi *et al.,* (2020), organic waste from cage systems, in the form of leftover feed and fish feces, will increase nutrient concentrations, especially nitrogen and phosphorus, in the water.

Based on the trophic status according to Wetzel (2001), chlorophyll-a concentrations at all observation stations were categorized as mesotrophic. This condition indicates significant nutrient enrichment in the waters. Rahman *et al.,* (2022) stated that mesotrophic status can trigger excessive phytoplankton growth, potentially leading to harmful algal blooms. High chlorophyll-a concentrations, especially at stations with high cage densities (stations 3 and 4), require attention in reservoir management. Karimah *et al.,* (2023) emphasized that an increase in phytoplankton biomass as reflected in chlorophyll-a values can cause a decline in water quality, depletion of dissolved oxygen, and disruption to the balance of aquatic ecosystems.

Water quality

Water quality measurements at the Koto Panjang Reservoir are presented in Table 2.

Table 2. Water quality measurement results at the Koto Panjang reservoir.

No	Parameters	Unit	Station				Quality Standards (PP 22/2021, class II)
			1	2	3	4	
	Physical						
1	Temperature	°C	31	31	32	33	Dev 3*
2	Brightness	cm	128	130	127	126	60-90**
	Chemistry						
3	pH	-	5	5	5	6	6-9*
4	Dissolved Oxygen	mg/L	4,20	3,91	4,78	5,07	3*
5	Free Carbon Dioxide	mg/L	5,94	4,62	6,60	7,26	25*
6	Nitrate	mg/L	0,090	0,088	0,104	0,109	-
7	Total Phosphate	mg/L	0,066	0,063	0,069	0,071	0,03*
	Biology						
8	Chlorophyll-a	µg/L	8,160	7,693	10,208	12,927	-

Temperature during the study were relatively stable, ranging from 31°C to 33°C. The temperature range was relatively similar because the temperature measurements were carried out in fairly similar weather and conditions. Agustiningsih (2012) stated that high and low water temperatures are influenced by ambient air temperature, the density of surrounding vegetation, and sunlight intensity, which are influenced by factors such as cloud cover, season, and time of day. Temperature increases as more sunlight reaches the water body's surface. Temperature is one of the environmental factors that plays a very important role, because basically temperature affects the chemical reaction of water and affects the adaptation of aquatic biota, including farmed fish (Khaliq *et al.,* 2024). The normal temperature in fish farming ranges from 28 to 32ºC, while Effendi (2003) argues that the optimal temperature range for phytoplankton growth in waters is 20ºC–30ºC. This analysis shows that the water temperature at each station still meets water quality standards according to its designation.

Brightness value ranges from 126 to 130 cm. According to Heiskanen et al., (2010), low brightness affects the entry of sunlight into the water so that it can interfere with the photosynthesis process. Level of light penetration will be different in every aquatic ecosystem. The process of photosynthesis carried out by phytoplankton is highly dependent on sunlight. If this process is disrupted, the availability of oxygen in the waters will also be affected. These changes will negatively impact the life of aquatic organisms.

Value of acidity (pH) ranges from 5 to 6. The highest pH value is found at Station 4, which is 6, while at other stations it has a pH value of 5. The pH value in the reservoir waters is categorized as low and acidic, thought to be due to decomposing fish feed waste. The pH range is good for aquatic life and is included in the optimal range. This is in line with the opinion of Boyd (1982), who stated that if the pH value of water is less than 5 or greater than 9, then the waters have been heavily polluted, resulting in the life of aquatic biota being disturbed.

Concentration of DO ranges from 3.91 to 5.07 mg/L. Highest concentration of dissolved oxygen is found at Station 4, which is 5.07 mg/L, while the lowest is found at Station 2, which is 3.91 mg/L. The levels of high and low dissolved oxygen are influenced by the photosynthesis process carried out by phytoplankton; specifically, a greater abundance of phytoplankton leads to increased organic matter production. In addition, an increase in dissolved oxygen levels in waters occurs as light intensity increases, which plays an important role in photosynthesis (Saraswati et al., 2017).

The concentration of free carbon dioxide ranges from 5.49 to 7.26 mg/L. The highest free carbon dioxide is found at Station 4 (7.26 mg/L) and the lowest at Station 2 (4.62 mg/L). Carbon dioxide levels in waters can decrease or even decrease and can be lost due to the process of photosynthesis, evaporation, and agitation of water (Effendi 2003). Based on the results of the free carbon dioxide measurements obtained, can still support the life of aquatic organisms.

Nitrate ranges from 0.088 to 0.109 mg/L, while the total phosphate ranges from 0.063 to 0.071 mg/L. The highest nitrate and phosphate concentration is found at Station 4, while the lowest is found at Station 2. The high concentration of nitrate and phosphate at Station 4 is because there are relatively dense KJA activities there. Therefore, the remaining feed and metabolic residue at this station contribute more nutrients to the waters. The high amount of nutrients coming from leftover food that is not consumed by fish in the KJA causes high nitrate levels (da Silva Cacho *et al.,* 2020). According to Wetzel (2001), nitrate and phosphate levels in the Koto Panjang reservoir are classified as oligotrophic. However, according to Government Regulation of Indonesia Republik (No. 22/2021), phosphate levels have exceeded quality standards. This indicates that the reservoir waters have been enriched with phosphate.

Conclusion

The Koto Panjang Reservoir shows an increase in chlorophyll-a content along with the increase in KJA, where the highest concentration was found at the station with the highest density of floating net cages (12,927 µg/L). This study indicates a positive relationship between fish farming activities in floating net cages and increased water fertility due to nutrient input from leftover feed and fish feces that trigger the eutrophication process. Although several water quality such as temperature, DO, and free of CO_2 are still within the quality standard limits, the pH value tends to be acidic, and the phosphate levels exceed the threshold, indicating ecological pressure on the reservoir ecosystem. Overall, the waters of the Koto Panjang Reservoir are classified as mesotrophic, which indicates that there has been an increase in water fertility that requires attention in the management of cultivation activities to maintain ecosystem balance and water quality**.**

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