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Abstract. Koto Panjang Reservoir, located in Riau Province, has multiple uses including hydroelectric power, irrigation, clean water sources, tourism, and fisheries. The high activity inside and outside the reservoir has increased the concentration of nitrate (N) and phosphate (P) so that it has an impact on water fertility. The high concentration of N and P causes a decrease in water quality which results in the low carrying capacity of the waters for floating net cage cultivation activities. This study aims to determine the dynamics of nitrate and phosphate as an indicator of water fertility in the Koto Panjang Reservoir. This research was conducted from 2016 to 2020 and sampling was conducted in March, June, September, and December. Sampling was carried out at 10 points and the determination of sampling points was based on purposive sampling. Water samples were taken from the surface of the water (1 m) using a water sampler and put into a 250 ml plastic bottle. Sampling, preservation, transportation, and sample analysis were carried out based on the standard methods of Standard Methods for The Examination of Water and Wastewater (APHA 2005). The data from the analysis results were tabulated and analyzed descriptively. The results of water quality data analysis show that the biological oxygen demand (BOD_5) and chemical oxygen demand (COD) values exceed the permitted quality standards, while temperature, conductivity, pH, turbidity, and dissolved oxygen (DO) are still below the quality standard. The nitrate concentration value ranged from 0.37 - 0.56 mgL^{-1} while the phosphate concentration at each station ranged from 0.14 - 0.56 mgL^{-1}. The value of nitrate and phosphate during the study fluctuated but the values for each sampling location were not much different. The concentration of N and P values in the Koto Panjang reservoir decreased with increasing numbers of cages. This shows that the high value of nitrate and phosphate in the Koto Panjang Reservoir does not only come from floating net cage activities but also from other activities such as plantations, agriculture, settlements, and tourism.

Key Words: dynamics, Koto Panjang reservoir, nitrate, phosphate, trophic, water fertility.

Introduction. Koto Panjang Reservoir is one of the 324 reservoirs in Indonesia that were completed in 1997 (Siagian & Simarmata 2018), and is the second largest in Southeast Asia as a multi-functional reservoir, being used for hydroelectric power, irrigation, tourism and fisheries. This reservoir is supplied with water from the Kampar Kanan, Kapau, Tiwi, Takus, Gulamo, Mahat, Osang, Cunding, Arau Kecil, and Arau Besar rivers (Warsa et al 2008) with a total inflow of 535.47 m3/second and a total outflow of 295.99 m3/second. The area of this reservoir is ± 124 km^2 with an effective inundation capacity of ± 1.545 million km^3 and an active water holding capacity of ± 1.040 million m^3 (Haryanto et al 2013).

The Koto Panjang Reservoir is used daily as a source of livelihood for 400 fishermen (Warsa et al 2008). The current use of the Koto Panjang reservoir for fisheries is not only for capture fisheries but also for floating net cage cultivation. Raising fish using the floating net cage system is mostly concentrated around the dam site in the reservoir. In 2003, the number of floating net cages (FNC) operating around the dam site was of 196 compartments (Nur 2006) and in 2006 the number of floating net cages (FNC) was of 513 compartments and in 2009 the number of floating net cages (FNC) increased to 900 plots (Siagian 2010). Furthermore, according to Simarmata et al (2013), the number of fish cages in the Koto Panjang reservoir increased to 1,100 plots by 2013, and according to PLN (2019), by March 2019 the number of cages operating around the dam site was of 1,204 plots with an area of 30,744 m^2. Based on the data above, it can be argued that there has been an increase in the number of floating net cages in the Koto Panjang reservoir until 2019 (PLN 2019). Thus, the increase in the number of plots from 2009 to 2019 is 304 plots.

The main problem in the development of fisheries in reservoir waters is the degradation of the quality of the aquatic environment caused by pollution loads, both organic and inorganic originating from the upstream area and the reservoir itself as well as changes in aquatic habitat from flowing waters (rivers) to stagnant waters (reservoirs). The main source of pollution comes from activities in the watershed (DAS) because of activities in the industrial sector, settlement, agriculture, livestock, and human activities in the waters of the reservoir itself, such as intensive fish farming activities in floating net cages, which do not consider the carrying capacity of the body of waters (Kartamihardja 2014).

The uncontrolled number of floating net cages also has an impact on the quality of drinking water for the Kampar Regency. Many FNC fish farms can cause changes in the water quality of this reservoir. The increasing number of floating net cages in the Koto Panjang Reservoir has made fertility in the waters to also change. The resulting waste will disturb the water condition and it will disturb the life of the surrounding organisms. The water quality conditions are generally bad.

Research conducted by Sumiarsih (2014) shows that the remaining fish feed wasted in the Koto Panjang Hydroelectric Reservoir is 19.28%. Other studies have also shown that after the fishes eat, there is around 25-30% wasted feed (Chen et al 2011). Thus, large amounts of food waste and metabolic waste that are wasted in the waters will have the potential to pollute the aquatic environment. The large number of fish cages operating and the high activity of plantation and agriculture around the reservoir have increased the fertility of the waters of the Koto Panjang reservoir. Increasing fertility of waters can cause various problems, one of which is the decline in water quality which has an impact on the unsustainability of fish farming in cages. Purnomo et al (2016) states that FNC activity produces waste such as feed residue and metabolic waste such as feces and urine which, if in large quantities, will reduce the quality of water in the reservoir, by reducing oxygen content and increasing toxic elements concentrations, such as nitrogen (N) and phosphorus (P). This study aims to determine the dynamics of nitrate and phosphate concentrations in waters as an indicator of water fertility in the Koto Panjang reservoir.

Material and Method

Description of the study sites. This research was conducted in the Koto Panjang Reservoir, Riau Province, Indonesia from 2016 to 2020 and sampling was conducted in March, June, September, and December. The sampling locations were divided into 10 stations, namely: Tanjung Balit Village (Station 1), Tanjung Village (Station 2), Batang Mahat Village (Station 3), Koto Tuo Village (Station 4), Batu Besurat Village (Station 5), Bridges 1 (Station 6), Jembatan 2 (Station 7), dam site (Station 8), dam site outlet (Station 9) and Rantau Berangin bridge (Station 10), presented in Figure 1. This research uses survey methods and the determinations from the sampling stations, carried out purposively, which include the conditions of the upper river (upstream), puddle (reservoir) and the river bottom (downstream). Analysis of samples from the field were carried out at the Laboratory of the Faculty of Fisheries and Marine Affairs, Riau University and the Regional Health Laboratory (Labkesda) of Riau Province.

Data types. Water quality parameters (physical and chemical) that are measured as indicators of the trophic status of water are temperature, brightness, turbidity, pH, dissolved oxygen (DO), biologycal oxygen demand (BOD_5), chemical oxygen demand (COD), nitrate and phosphate. The parameters of temperature, brightness (secchi disc), pH (Adwa AD 132), turbidity (Martini Mi415) and DO (Lutron DO-5510) were measured directly in the field, except for the analysis of the concentration of parameters BOD_5, COD, nitrate and phosphate at the Regional Health Laboratory (Labkesda) Riau Province. Secondary data comes from literature studies in the form of results, research reports and technical reports from various government agencies and universities.

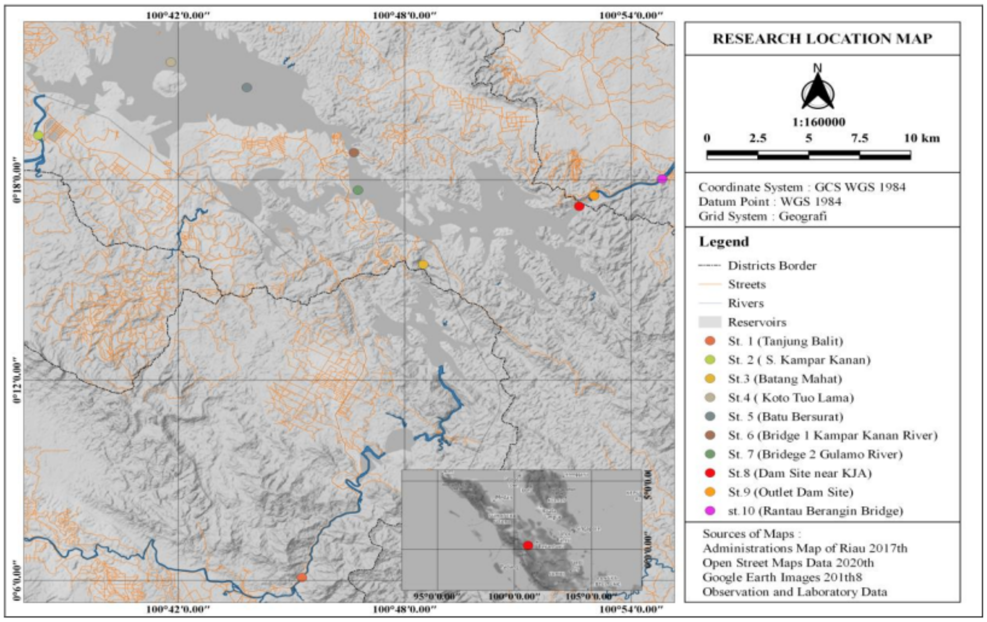

Figure 1. Sampling stations location in the Koto Panjang Reservoir, Riau Province, Indonesia.

Sampling, preservation and analysis. Reservoir water samples were taken using a Kemmerer water sampler at a depth of 1 m from the surface then put into a plastic bottle with a volume of 1000 ml. The sample water is stored in a cool box at about 4°C and taken to the laboratory for analysis. Sampling, transport and sample analysis were carried out based on the standard methods of Standard Methods for The Examination of Water and Wastewater (APHA 2005). Measurements and samplings are carried out at all predetermined stations and each year they are conducted 4 times with intervals of 3 months. The observed water quality parameters (physical and chemical) are presented in Table 1.

Table 1

Water quality parameters, methods and sample analysis

No.	*Parameters*	*Unit*	*Method*	*Measurement*
1.	Temperature	°C	Expansion	In-situ
2.	Brightness	m	Reflection of light	In-situ
3.	Turbidity	NTU	Light scattering	In-situ
4.	pH	-	Electrometric	In-situ
5.	DO	mg / L	Electrometric	In-situ
6.	BOD_5	mg / L	Azide modification	Laboratory
7.	COD	mg / L	Closed reflux spectrophotometry	Laboratory
8.	Nitrate	mg / L	Colorimetric	Laboratory
9.	Phosphate	mg / L	$SnCl_2$	Laboratory

Data analysis. Water quality measurement data including temperature, turbidity, pH, DO, BOD5, COD, nitrate and phosphate were analyzed descriptively by comparing them with surface water quality standards (Government Regulation of the Republic of Indonesia No. 82 of 2001), except for brightness values. Nitrate and phosphate concentrations as determinants of water fertility were compared with aquatic fertility classifications based on nitrate and phosphate (Goldman & Horne 1983).

Results and Discussion

Results. The results of water quality measurements in the Koto Panjang Reservoir can be seen in Table 2. The average temperature during the study ranged from 25.5±0.1°C to 29.8±0.1°C, where the lowest average temperature was found at station 1 and the highest at station 5. The average conductivity value (DHL) ranges from 36.7±4.5 μS to 58.9±13.2 μS, where the lowest average temperature is found at station 10 and the highest is at station 2. The turbidity value of each location ranges from 2.1±0.1 NTU to 4.2±2.5 NTU, with the lowest value at station 6 and the highest at station 2. The pH value of the waters ranges from 6.4±0.1 to 7.0±0.04 and the values are not much different for each station. The oxygen value of each study location was quite high, ranging from 6.3±0.1 mgL^{-1} to 6.8±0.1 mgL^{-1} and these values did not differ much for each station. For the BOD_5 value of each study location ranged from 3.5±0.4 mgL^{-1} to 6.6±0.3 mgL^{-1} while the COD value ranged from 16.1±0.8 mgL^{-1} to 26.2±2,1 mgL^{-1}. Based on Government Regulation No. 82 of 2001 concerning Water Quality Management and Pollution Control for second-class water quality standards, the value of water quality in Koto Panjang reservoir is still in good condition but the values of BOD_5 and COD are above the threshold.

Table 2

Results of Measurement and Analysis of Water Quality in Koto Panjang Reservoir

Station	*Temperature (°C)*	*Turbidity (NTU)*	*pH*	*DO (mgL^{-1})*	*BOD_5 (mgL^{-1})*	*COD (mgL^{-1})*
1	25,5 ± 0,1	3,6 ± 2,0	6,9 ± 0,1	6,6 ± 0,1	5,6 ± 0,5	21,4 ± 3,4
2	25,8 ± 0,2	4,2 ± 2,5	6,8 ± 0,1	6,5 ± 0,1	5,6 ± 0,6	22,3 ± 3,2
3	29,7 ± 0,1	2,3 ± 0,2	6,9 ± 0,1	6,7 ± 0,1	3,8 ± 0,3	17,9 ± 1,2
4	29,7 ± 0,1	2,3 ± 0,2	6,9 ± 0,1	6,7 ± 0,1	3,8 ± 0,3	17,9 ± 1,2
5	29,8 ± 0,1	2,2 ± 0,1	6,9 ± 0,1	6,8 ± 0,1	3,5 ± 0,4	16,8 ± 1,3
6	29,2 ± 0,2	2,1 ± 0,1	7,0 ± 0,04	6,7 ± 0,1	3,9 ± 0,2	16,1 ± 0,8
7	29,2 ± 0,2	2,2 ± 0,1	6,9 ± 0,1	6,4 ± 0,1	4,3 ± 0,4	18,2 ± 1,2
8	29,2 ± 0,1	2,4 ± 0,1	6,9 ± 0,04	6,4 ± 0,02	5,9 ± 0,3	23,0 ± 0,9
9	27,5 ± 0,2	3,9 ± 0,5	6,4 ± 0,1	6,3 ± 0,1	6,6 ± 0,3	26,6 ± 2,1
10	28,1 ± 0,2	3,8 ± 0,5	6,6 ± 0,1	6,5 ± 0,1	6,3 ± 0,2	26,0 ± 1,4

The results of the analysis of water samples obtained show that the average nitrate value during the study ranged from 0.42±0.01 mgL^{-1} to 0.56±0.02 mgL^{-1}. The lowest nitrate values were found at stations 1 (2017) while the highest values were found at stations 8 and 10 in 2016 (Figure 2). The high nitrate value at stations 8 and 10 is due to the location, where there are fish farming activities in floating net cages. Even though the nitrate value fluctuates every year, the nitrate concentration of each station does not differ much. The nitrate value during the last five years (2016-2020) is still below the class I quality standard (<10 mgL^{-1}).

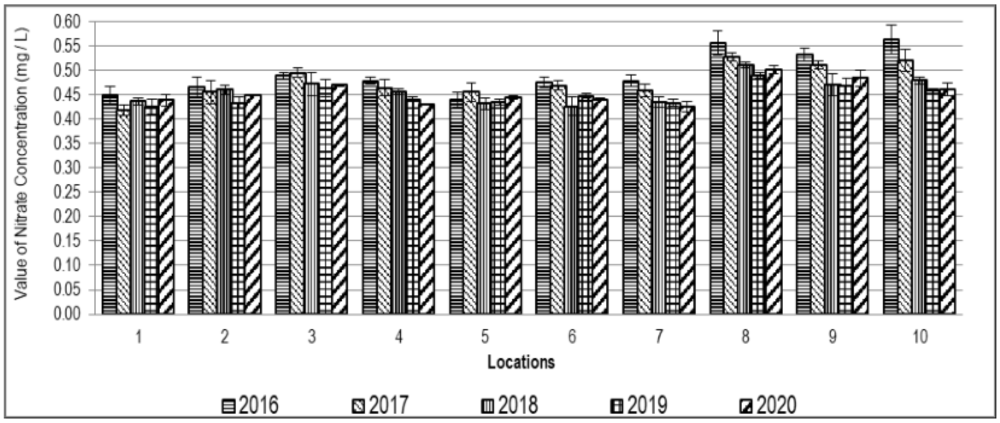

Figure 2. Nitrate concentration values of each Koto Panjang Reservoir station in 2016-2020.

The concentration of phosphate values at each station is presented in Figure 3 and the values range from 0.41±0.01 mgL^{-1} to 0.56±0.02 mgL^{-1} with the highest average phosphate concentration found at station 8 in 2016 and the lowest at station 1 at 2020. The highest average phosphate value of each observation station was found in 2016 and is thought to not only come from fish farming in cages, but also from other activities such as agriculture and plantations using phosphate fertilizers around the Koto Panjang reservoir, so that it has an impact on water quality. However, over time, the phosphate value of each station tends to decrease. The phosphate concentration during the last five years (2016-2020) was still above the Class II quality standard (0.2 mgL^{-1}).

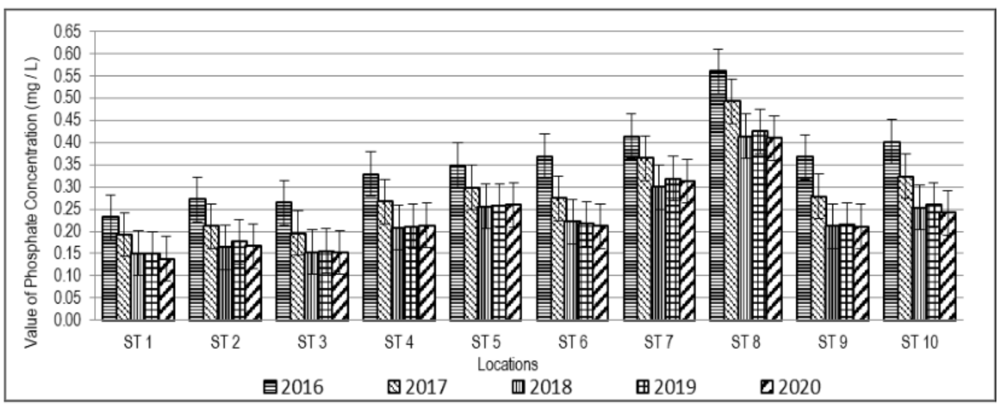

Figure 3. Value of phosphate concentration for each Koto Panjang Reservoir station in 2016-2020.

The relationship between the number of cages and the concentration of nitrate and phosphate at each station is presented in Figure 4. From Figure 4 the number of floating net cages operating in 2016 and 2017 is less, namely: 1,153 plots compared to 2018, 2019 and 2020 with 1,176, 1,194 and 1,204 plots respectively, with the highest distribution of floating net cages, around 70%, are at station 8 and the rest at station 7. Since 2016 to 2020 there has been an increase in the number of cage units (mapped) by 51 plots or an increase as much as [illegible]%. On the other hand, it can also be seen that the concentration of N and P values in the Koto Panjang Reservoir decreases with the increase in the number of cages. This shows that the high value of nitrate and phosphate in the Koto Panjang Reservoir does not only come from floating net cage activities but also from other activities such as plantations, agriculture, housing, and tourism.

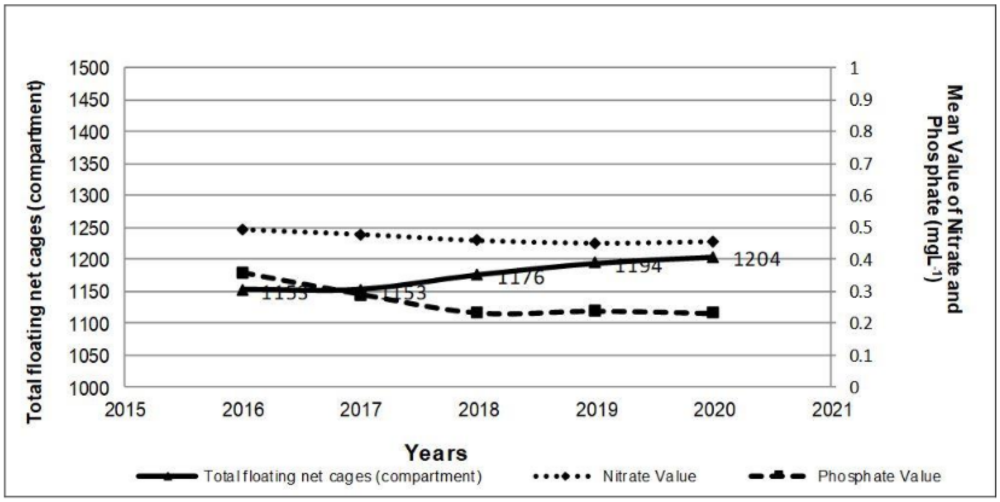

Figure 4. The relationship between the number of cages and the average value of nitrate and phosphate concentrations in the Koto Panjang Reservoir.

Discussion. The water quality of the Koto Panjang Reservoir has begun to experience degradation due to human activities inside and outside the reservoir. This can be seen from the BOD5 and COD values of each location, where BOD_5 values range from 3.5±0.4 mgL^{-1} to 6.6±0.3 mgL^{-1} while the COD values range from 16.1±0.8 mgL^{-1} to 26.2±2.1 mgL^{-1}. Based on Government Regulation number 82 of 2001 concerning Water Quality Management and Pollution Control for second class water quality standards, the values of BOD5 waters are <2 mgL^{-1} and COD <10 mgL^{-1}. The high BOD_5 and COD values indicate that the Koto Panjang reservoir has experienced degradation due to organic matter pollution.

According to Nugroho and Mahmud (2005) that BOD_5 shows the amount of dissolved oxygen needed by living organisms to decompose or oxidize waste materials in water. Then Barus (2004) states the factors that influence BOD_5, namely the content and type of organic matter, temperature, plankton density, dissolved oxygen, pH value, and the presence of microbes. If the BOD_5 content is high, it will result in a shrinkage of dissolved oxygen through the process of decomposing organic matter under aerobic conditions and a decrease in the pH value in water.

According to Boyd (1982) that COD or Chemical Oxygen Demand is the amount of oxygen needed to break down all organic material contained in water. This is because the organic material is deliberately broken down chemically using a strong oxidizer of potassium bichromate under hot and acidic conditions with silver sulfate as a catalyst, so that all kinds of organic materials, both those that are easily biodegradable and complex and difficult to decompose, will be oxidized. If the BOD and COD values are high and exceed the quality standard, then it can be suspected that there are indications of organic matter contamination (Atima 2015).

Nitrate and phosphate are important elements for the growth and development of phytoplankton in the waters so that their existence is a limiting factor. Lack of nitrate and phosphate for phytoplankton can disrupt the growth and development of phytoplankton in reservoir waters. According to Asriyana and Yuliana (2012), optimal phytoplankton growth requires a nitrate content ranging from 0.9 - 3.5 mgL^{-1} and orthophosphate content ranging from 0.09 - 1.08 mgL^{-1}. Naturally, the availability of phosphorus in waters is due to the weathering of the host rock and the decomposition of organic matter. The existence of household waste, industrial waste, and agricultural waste contributes to increased phosphorus in surface waters. Chapman and Chapman (1993) states that phosphorus binds to organic matter and basic sedimentary minerals and can be mobilized by bacteria and released into the water column. Phosphorus, in the form of orthophosphate, and nitrate can be directly absorbed and utilized as nutrients by aquatic plants and algae (Effendi 2003).

Mustofa (2015) states that the most nutrients needed by phytoplankton are N and P. Phytoplankton requires N and P elements in making body fat and protein. N and P elements are often limiting factors in the primary productivity of phytoplankton. These elements can only be used by phytoplankton directly if they are in the form of nitrate and orthophosphate. So that in its utilization, phytoplankton requires a chemical process of nitrification from the N element to be converted into nitrate, while the phosphate in the water itself is mostly in the form of orthophosphate and polyphosphate, it can be used by phytoplankton.

The average nitrate value in the waters of the Koto Panjang reservoir is still below the permitted quality standards (<10 mgL^{-1}). The average nitrate value of each observation station ranged from 0.42±0.01 to 0.56±0.02 mgL^{-1}, this value being categorized as high enough for reservoir waters. The results of research by Hasibuan et al (2017) showed that the concentration of nitrate in the Koto Panjang Reservoir was 0.326 to 1.467 mgL^{-1} while Sari et al (2015) in Ir. H. Djuanda (Jatiluhur) obtained nitrate values ranging from 0.21 to 0.86 mgL^{-1} and Kartamihardja and Krismono (2016) the nitrate content in the Saguling Reservoir ranged from 0.03 to 1.063 mgL^{-1}. Compared to the research of Hasibuan et al (2017), Sari et al (2015), and Kartamihardja and Krismono (2016), the nitrate value in this study is still in the same range.

According to Goldman and Horne (1983), water fertility is based on nitrate concentrations, namely less fertile or oligotrophic (nitrate concentration 0.0 – 0.1 mgL^{-1}), moderate or mesotrophic water fertility (nitrate concentration 0.1 - 0.2 mgL^{-1}) and high or eutrophic water fertility (nitrate concentration >0.2 mgL^{-1}). Based on the data above, the nitrate concentration in this study was above > 0.2 mgL^{-1}, so the fertility level of the Koto Panjang waters was high (eutrophic). Sari et al (2015) stated that nitrogen nitrate levels of more than 0.2 mgL^{-1} can result in eutrophication (enrichment) of water, which in turn stimulates the rapid growth of algae and aquatic plants (blooming). Kusriani and Widjarnako (2017) stated that all reservoir waters will experience eutrophication after 1–2 years of inundation (water replenishment due to decomposition of organic matter). The increase in the fertility of the waters of the Koto Panjang Reservoir is not only from the decomposition of inundation time but also from human activities inside and outside the reservoir after inundation.

When viewed from the phosphate value, the average phosphate value is above the permissible water quality standard. The average phosphate value of each observation station ranged from 0.14±0.01 to 0.56±0.02 mgL^{-1}. Goldman and Horne (1983) classified aquatic fertility based on phosphate into five levels, namely low or ultra-oligotrophic fertility (phosphate levels 0,000-0,020 mgL^{-1}), moderate or oligotrophic fertility (phosphate levels 0.021 to 0.050 mgL^{-1}), moderate or mesotrophic fertility (phosphate levels 0.051 - 0.100 mgL^{-1}), fertility is particularly good, or eutrophic (phosphate levels 0.101 to 0.200 mgL^{-1}) and the waters are too fertile or hypertrophic (phosphate levels > 0.200 mgL^{-1}). Based on the above values, the level of fertility of the Koto Panjang Reservoir waters based on the phosphate value is classified as eutrophic to hypereutrophic.

Sari et al (2015) found that the phosphate value in Djuanda Reservoir was 0.2-0.36 mgL^{-1} (eutrophic-super eutrophic), while Hasibuan et al (2017) obtained the following phosphate concentrations during his study in the Koto Panjang Reservoir, namely 0.068 to 0.416 mgL^{-1} during the rainy season and 0.131 to 0.352 mgL^{-1} during the dry season. The results of research by Utomo et al (2012) showed that the phosphate value in the Gajah Mungkur Reservoir ranged from 0.098 to 0.27 mgL^{-1} and Kartamihardja and Krismono (2016) showed that the phosphate content in Ir. H. Djuanda ranged from 0.04 to 0.43 mgL^{-1}.

When compared with the phosphate values at several other locations, the phosphate values in the Koto Panjang Reservoir are still in the same range. According to Sulaiman et al (2020), the waters of lakes and reservoirs that are too fertile (eutrophic - hypereutrophic) are not suitable to be selected as locations for floating net cages cultivation because of the chance of upwelling is quite high. The eutrophic level can also be an indication that the carrying capacity of water has been exceeded to support aquaculture activities.

Most of the sources of phosphorus in the reservoir are from floating net cage cultivation activities, mainly from leftover feed and fish feces. Phosphorus will be used by fish according to their body needs and phosphorus that cannot be utilized will be excreted in the form of feces and urine (Lestari et al 2015). Goldfish (*Carassius auratus*) and tilapia (*Oreochromis niloticus*) need feed containing phosphorus ranging between 0.6 - 0.7% and 0.8 - 1.0%, respectively, while fish feed used in aquaculture contains phosphorus 1.27 - 1.66% (1.50%), the excess being excreted (Ardi 2013).

Usually, feed with high total P will release phosphorus which dissolves in water and accumulates in water. Sukadi (2016) states that the higher the P content in the feed, the higher the release of P into water media. The release of P to water media is influenced by pH, temperature, oxygen, turbulence, and microbial activity. The rate of release of nutrients from feed becomes higher at high temperatures (Kibria et al 1997).

According to Mayunar (1995) safe and good phosphate levels are 0.2 mgL^{-1} to 0.5 mgL^{-1} and according to the Ministry of Marine Affairs and Fisheries (DKP 2002), which provides a limit value of 0.2 mgL^{-1} - 0.3 mgL^{-1}. Based on Government Regulation No. 82 of 2001 concerning Water Quality Management and Pollution Control for second-class water quality standards, the P content, in this case, the total phosphorus is 0.2 mgL^{-1}. The results of Siagian (2010) research showed that the phosphate value of the Koto Panjang reservoir ranged from 0.11 mgL^{-1} to 0.14 mgL^{-1}. However, the results of this study obtained phosphate values ranging from 0.14 to 0.56 mgL^{-1}, when compared with values above the value of phosphate in this study was higher.

The distribution of floating net cages in the Koto Panjang Reservoir is only found at the dam site, Bridge I (Kampar River), and Bridge II (Gulamo River). However, seen from the concentration of N and P sediment in each location, it should be assumed that the locations where there are no floating net cages for N and P supply come from agriculture, plantations, tourism, and settlements. Agricultural activities and rubber and oil palm plantations usually use fertilizers with high concentrations. Nurdin et al (2017) stated that the largely agricultural area around the Koto Panjang Reservoir is ± 32,296 ha, oil palm, and rubber plantations are ± 11,548.57 ha and settlements are ± 1,243.11 ha. The same thing was also conveyed by Hasibuan et al (2017) that the temperature of nitrate deposition in the waters of the Koto Panjang reservoir is thought to have come from the input of household waste activities originating from settlements around the Kampar River waters to reservoirs and FNC waste in these waters.

The relationship between the number of floating cages net and the concentration of N and P in the Koto Panjang Reservoir was not positively correlated. The addition of the number of cages did not follow the concentration of N and P values in the water. This shows that the increase in N and P values does not only come from floating net cages but also from other activities. According to Siagian (2010) that the carrying capacity of the Koto Panjang reservoir for aquaculture activities in FNC ranges from 611 ha - 1,047 ha or 19,559 - 33,515 plots. Based on the results, this study found around 1,204 floating net cage plots operating in Koto Panjang Reservoir. Thus, based on the results of Siagian (2010) research, the current number of cages is still within the permitted carrying capacity of the reservoir.

Conclusion. The average value of nitrate and phosphate concentrations in the Koto Panjang Reservoir has fluctuated since 2016 to 2020 but the concentrations of nitrate and phosphate in each research station did not differ much. The value of nitrate for the last five years (2016-2020) is still below the water quality standard, while phosphate is above the permissible water quality standard. The concentration of N and P values in the Koto Panjang Reservoir decreased along with the increasing number of cages which indicated that the high value of nitrate and phosphate in the Koto Panjang Reservoir did not only come from floating net cage activities but also from other activities such as housing, agriculture, plantations, and tourism.

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