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EUTROPHICATION OF DANAU BANGKAU PEATLAND BASED ON NITRATE-PHOSPHATE CONCENTRA-TIONS AND FISH DIVERSITY

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ABSTRACT
Danau Bangkau Peatland is one of the peatlands in which local community do fishing activities. In the dry season, agricultural farming activities are performed, while this area is also a residential area. Some of these anthropogenic activities also indicate eutrophication in this peatland. The purpose of this study was to determine the eutrophication of Danau Bangkau Peatland based on the nitrate-phosphate content and fish diversity. The parameters included analysis of nitrate and phosphate using spectrophotometric methods and on-site analysis of DO and pH to evaluate the level of eutrophication. In addition, the Shanon-Wiener method was used to determine fish diversity. The results showed the nitrate content was found low at center station and Peatland outlet (i.e. within 0.4-10 ppm). Inversely proportional to the phosphate parameter which was rather higher than Water Quality Standard (BMA) between 0.19 - 3.34 ppm, eutrophication occurred in the Danau Bangkau Peatland. DO parameter was very low (1.1 - 4 ppm), which is far from the Water Quality Standard. Surprisingly, the pH parameter was actually quite good at between 5.99 - 6.9. Fish diversity was low as only 6 species were found, namely Snakehead Fish (*Chana striata*), Giant Snakehead Fish (*Chana micropeltes*), Climbing Perch Fish (*Anabas testudineus*), Kissing Gourami (*Helostoma temminckii*), Snakeskin Gourami (*Trichogaster pectoralis*) and Three-spot Gourami (*Trichogaster trichopterus*). The high phosphate content in old peat Peatlands formed eutrophic conditions, in which only certain fish species were able to adapt. This condition made the fish diversity in Danau Bangkau Peatland very low.

KEY WORDS
Eutrophication, nitrate, phosphate, fish diversity, Danau Bangkau Peatland.

Danau Bangkau Peatland is an area included in the Regional Spatial Plan (RT / RW) of South Kalimantan Province which is planned to be prioritized for a conservation area for fisheries reservoirs (fish stocking) that needs to be protected and preserved. Danau Bangkau Peatland is covered by water all year round, making it recognized as a fish reserve from rivers in the western region of the Meratus Mountains, and it is a habitat for waterbirds that must be protected (Mahreda and Dekayanti, 2012).

Recently, some types of fish in Danau Bangkau Peatland are rather difficult to find and the size of the fish is relatively small, while the catch of fishermen has decreased (Yunita, 2012). The decrease was due to some factors, among which is exploitative fishing and water silting due to water weeds, such as water hyacinth (*Eichhornia crassipes*).

Waters area is regarded polluted if contamination of organic or inorganic substances into the water is found. The increase in trace elements (pollutant loads) such as nitrates and phosphates results in a continuous increase in nutrient concentrations in water bodies at large quantity makes water bodies become eutrophic and stimulates blooming in the form of eutrophication and deficit in dissolved oxygen concentrations (Arifin *et al*., 2016). Toxic compounds where microbes grow trigger degradation of fish resources, even death and shrinkage of water discharge. Pollution due to growth of certain organisms is called eutrophication that commonly occurs in land waters, including peatlands.

To the present, eutrophication is often associated with algae and macrofita blooming, but its relationship with fish diversity of fish catch is not yet clear. Therefore, it is necessary to conduct research on the eutrophication that occurred in Danau Bangkau Peatland seen from nitrate-phosphate content and fish diversity in order to determine the trophic status of the peatland. The determination of this status is necessary for policy makers in relation to the inclusion of the Peatland in the Regional Spatial Plan of South Kalimantan Province as a fish stocking conservation area that needs to be protected and preserved.

METHODS OF RESEARCH

This research was conducted in Danau Bangkau Peatland, Hulu Sungai Selatan Regency, South Kalimantan Province. Sampling was carried out three times within 10-day intervals from two locations which were purposively determined; the outlet area and the middle of the Peatland waters. Primary data include water quality parameters and fish diversity caught by fishermen.

Water sample for water quality test was obtained from the same location as fish sampling location, which location represented the overall characteristics of the waters. The water quality parameters regarded in this research were nitrate and phosphate, which were analyzed at the Water Quality and Hydro-Bioecology Laboratory using spectrophotometric method. The pH level and Dissolved Oxygen (DO) were analyzed on-site at the sampling location to be compared to the Water Quality Standard mentioned in Government Regulation No. 82 of 2001.

Fish samples were caught using gill net fishing gear within certain period of time to obtain a qualitative picture of on-site fishery conditions, including economic fish or non-economic fish. The fish caught were then identified in the field based on the fish identification book. If the identification was not possible, then fish samples were applied with formalin solution to be preserved and put in a plastic bag to be later identified at the Ichtiology Laboratory of the Faculty of Fisheries and Marine, ULM.

Fish diversity index was measured using Shannon-Wiener method as follows:

$$H' = -\sum P_i \ln P_i \qquad\qquad P_i = \frac{n_i}{N}$$

Where: H’ = Shannon Wiener’s Diversity Index; Ni = number of individuals of species number-I; N = total number of individuals from all species.

RESULTS AND DISCUSSION

Four water quality parameters were measured in this research including key parameters of freshwater quality, especially peat Peatland waters. Nitrate and phosphate are key parameters in research on eutrophication, while pH and DO are key parameters in peat Peatland waters.

Table 1 – Water Quality Parameters of Danau Bangkau Peatland Taken in 3 Different Samplings

No	Parameter	27 July 2020 T1 O1	6 August 2020 T2 O2	16 August 2020 T3 O3	PP No 82 2001 (Class 2)
1	Nitrate (ppm)	2.0 2.4	0.6 0.5	10 0.4	10
2	Phosphate(ppm)	0.19 0.37	3.34 0.49	0.2 0.46	0.2
3	DO (ppm)	1.1 2.0	2.0 1.1	4.0 1.5	4
4	pH	6.27 6.23	5.99 5.99	6.9 6.05	6-9

The pH concentration resulted from the analysis as presented in Table 1 and Figure 1 ranges from 5.99 – 6.9. This score shows that the concentration is close to normal condition for peatland water.

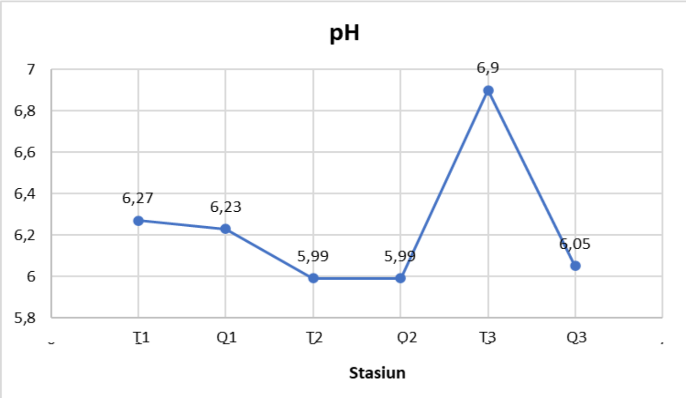

Figure 1 – pH Concentration of Each Sampling from Observation Station in 3-time Sampling

The average pH at the sampling location still met the Class II Water Quality Standard (BMA) based on Government Regulation No 82, ranging between 6 - 9. The measurement results that were slightly under the Water Quality Standard were obtained in the second sampling from T2 and O2 stations. Herliwati and Rahman (2011) also found the waters of Danau Bangkau Peatland, Hulu Sungai Selatan Regency also still met the water quality Standard, namely as the pH concentration ranged between 6.45 - 6.72. Similarly, Slamat (2015) in a monotonous research done in peatlands located in Hulu Sungai Utara Regency found normal pH levels based on the water quality standard of 6.5 - 7. However, Nugroho et al, in a research done in lebak swamp of South Sumatra found that the pH ranged from 3.3 to 5.6.

The pH concentration that is close to normal is quite surprising, considering that the peatland waters are associated with acid sulphate or pyrite soil conditions, which means that the waters should be acidic (Noor, 1996). Low pH levels will cause high solubility of Fe and Zn minerals but low Ca, P, and Mg minerals. The pH level greatly affects the level of toxicity. Taqwa (2010) stated that pH is a limiting factor for organisms living in waters. Too-high or too low pH levels will affect the survival of the organisms that live in it (Sofarini *et al*., 2019).

Dissolved oxygen (DO) concentration obtained from the analysis as shown in Table 1 and Figure 2 ranges from 1.1 - 4 ppm. The score is rather low, considering that the Danau Bangkau is a peatland. The highest value, which corresponds to the minimum limit of DO value in the waters, which was 4 ppm, was found at the T3 center station. Meanwhile, the lowest score which is far below the minimum limit of DO value of 1.1 ppm was found from the sample obtained from T1 center station and the O2 outlet station for peatland sampling.

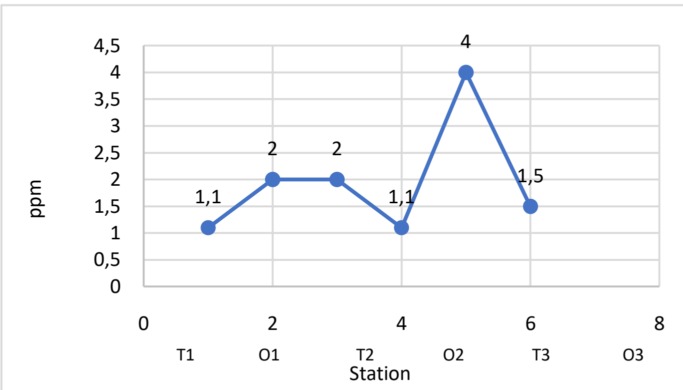

Figure 2 – DO Concentration DO (ppm) of Each Observation Station from 3 Samplings

The results of Dissolved Oxygen (DO) measurements in this study were lower than the results of DO measurements conducted by Herliwati and Rahman (2011) in Danau Bangkau Peatland, Hulu Sungai Selatan Regency, which results were within normal range between 6.45 - 6.73 ppm. Meanwhile, the results of research in the monotonous peatland in Hulu Sungai Utara Regency by Slamat (2015) showed DO values ranging between 3.0 - 4.8 ppm.

As a peatland waters, Danau Bangkau Peatland has quite weak water flow and very slow currents which cause low DO levels based as presented in Table 1 and Figure 2. In addition, the water stirring process is also rare due to the far distance between two stations from Nagara River, causing water runoff to inhibit water stirring. The decomposition of organic matters by aerobic bacteria continues, where the largest source of organic material come from the food chain cycle in the waters. The decomposition of organic matters will decrease the dissolved oxygen scores as organic matter will be decomposed by microorganisms that consume the available oxygen. According to Effendi (2003), dissolved oxygen decreases as the water temperature increases, preventing DO values from meeting the predetermined quality Standard.

In closed waters, DO supply depends on the sunlight penetration and the diffusion of oxygen from the air to the water. According to Herliwati and Rahman (2011), dissolved oxygen levels fluctuate daily (diurnal) and seasonally, depending on the mixture and movement of water masses, photosynthetic activity, respiration and waste entering water bodies.

Nitrate concentrations obtained from the analysis results listed in Table 1 and Figure 3 range between 0.4 –10 ppm. The highest value was found from the peatland sampling center station 3 (T3), and the lowest one was at the peatland sampling outlet 3 (O3).

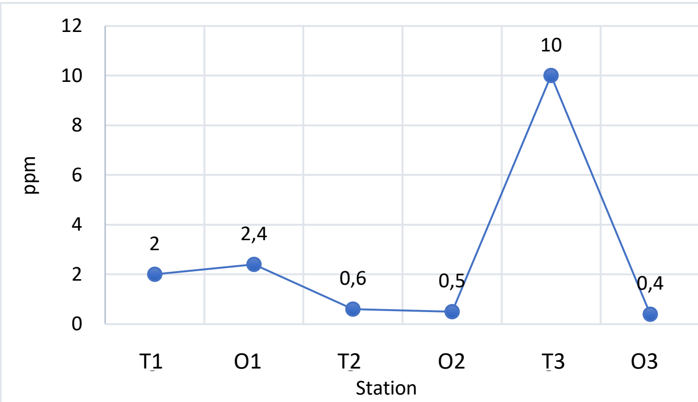

Figure 3 – Nitrate Concentrations (ppm) from Each Station in 3 Samplings

In general, nitrate concentrations in waters with good conditions (non-polluted waters) are within low range, even undetectable up to 10 ppm (Wetzel, 2001). Since the nitrate values were > 0.4 ppm, Danau Bangkau Peatland waters are classified as eutrophic (Goldman and Horne, 1983), which were slightly within similar range of nitrate values found in Limboto Lake (Krismono, 2010), Tempe Zu Lake (Directorate of Fish Resources, 2009) and Pening Swamp (Zulfia and Aisyah, 2013; Nugroho *et al*, 2014).

High nitrate content at the peatland center station might be due to nutrients from the agricultural waste around peatland waters (Fried et al., 2003). The nutrients are probably the cause of the overgrowth of algae and water plants which is also called eutrophication (Paytan and Mclaughlin, 2007). In addition, the peatland center station is a fishing area which indicates nutrient enrichment in these waters, because nitrate is one of the important nutrients for plants and algae, which indirectly feeds carnivorous fish in this lake (Effendi, 2003).

Low nitrate content was rather found in some parts of the water where water hyacinth grows well such as at outlet sampling station 3 (O3). The low nitrate value supports the growth of water hyacinth and phytoplankton plants. The slow water flow in Danau Bangkau

Peatland might occur as this peatland has only one outlet, namely the Nagara River. In addition, the number of aquatic plants such as water hyacinth (*Eichhornia crassipes*), kiambang (*Salvinia molesta*) and green algae (*Hydrilla verticilata*) will slow down the stream. This condition causes the water that enters the peatland stay longer. With the vastness of the peatland and the slow water flow, the mixing of the water in the peatland is less good. This condition results in stratification in peatland water quality including nitrate stratification.

Lewis (2000) reported that in tropical waters, limited nitrate is more common than low phosphate levels since nitrate tends to be lost internally due to the relatively high temperature. Wetzel (2001) also stated that nitrate in water can be eliminated through sedimentation and denitrification.

Nitrate is a macro nutrient needed by all types of plants. Plants absorb nitrates continuously for their metabolic needs in large quantities. The plants that live in the waters of Danau Bangkau Peatland are quite abundant. Brahmana *et al* (2010) stated that ammonium and nitrate compounds are widely absorbed by plants and algae for the growth process. The abundant water plants found in Danau Bangkau Peatland indicates that the absorption of nitrate is maximized, reducing the nitrate concentrations in the water.

The analysis done in this research showed phosphate concentrations as shown Table 1 and Figure 4 ranging between 0.19 - 3.34 ppm. The highest concentration was found at the middle Peatland sampling station 2 (T2), and the lowest one at the middle peatland sampling station 1 (T1).

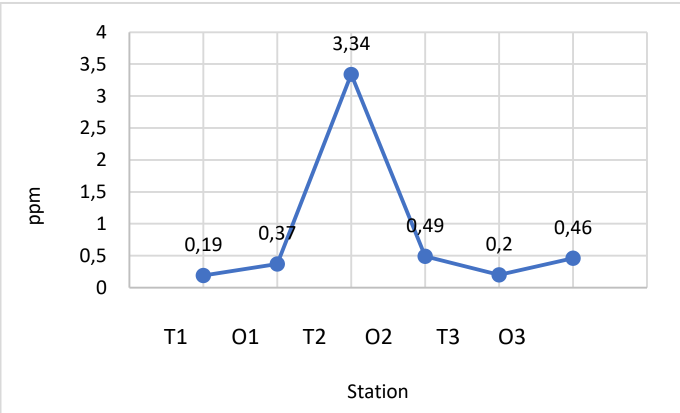

Figure 4 – Phosphate Concentration (ppm) in Each Sampling Station in 3 Samplings

The phosphate concentrations in this research have reached the maximum limit of the Standard as mentioned in Government Regulation No. 82 of 2001, namely 0.2 ppm for class II (water recreation, cultivation, growth). In Danau Bangkau Peatland waters, low phosphate concentrations were only found at the center station Peatland sampling 1 (T1) and the center station peatland sampling 3 (T3) of 1.9 ppm and 2 ppm. Water hyacinth and other plants make use of phosphate contents as there were more water plants in T1 and T2 stations than at T2 station (Attachment 2). Phosphate is known a form of phosphorus that benefit water plants (Tchobanoglous, 1991; Dugan, 1972 in Effendi, 2003; Romimohtarto and Juwana, 2005).

The highest concentration of phosphate was found at the center station peatland sampling 2 (T2) of 3.34 ppm. This phosphate content has exceeded the environmental quality standard threshold set in Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control, which is 0.2 ppm for group II water bodies. Therefore, Danau Bangkau Peatland is regarded a polluted waters. The concentration of nitrate is much lower than phosphate concentration because the phosphate settles and takes a long time to decompose (Arizuna et al., 2014).

Likewise, high concentrations of phosphate can be harmful to biota that live in water. As a result, the potential for eutrophication or algal blooming is very incraesed. According to Anhwange *et al*. (2012), the maximum recommended phosphate level for rivers and waters should be under 0.1 ppm. Waters with a phosphate concentration greater than 0.1 ppm are called eutrophic waters, in which the blooming of macrophages and phytoplankton commonly occurs (Subarijanti, 2005 in Kadim *et al*., 2017). This condition can then decrease the oxygen concentration in water bodies, causing higher fish mortality and phosphate to be re-deposited into the sediment pores through various processes, including sedimentation and adsorption (Carignan 1982 in Purnamaningtyas, 2014).

Phosphate compounds in Danau Bangkau Peatland are formed through biogeochemical cycle in the waters, especially the bottom of the waters, where the peatland waters are formed from weathering, plant litter and the of organic decomposition over a very long period of time. Other natural sources include soil erosion, waste from animals and phosphate minerals (Moriber, 1974 in Affan, 2010). In addition to natural process, the conditions around the research location where there is no industrial area show that the source of phosphate in the waters comes from river water runoff. In addition, human activities such as domestic waste disposal and other activities as well as water overflow from aquaculture activities that produce high phosphate concentration and agriculture activities can be possible sources.

Prior research have confirmed that phosphate is an important element in eutrophication (Dillon and Rigler, 1974; Fried *et al*., 2003). Its existence is associated with algal growth as it was first confirmed in 1968 (Fried *et al*., 2003). In fact, eutrophication is a natural process by which lakes gradually age and become more productive for biomass growth. It takes thousands of years reach eutrophic state. This natural process is affected by humans and modern activities which accelerate the process to only several decades or even a few years.

Eutrophication refers to an increase in the rate of nutrients accumulation in a water system that usually occurs due to anthropogenic activities (Sutcliffte and Jones, 1992; Nebel and Wright, 1993; Schnoor, 1996). In short, eutrophication can be defined as the process of enriching waters (the process of becoming more productive) with inorganic matter (nutrients) (Welch, 1992). Straskraba (1993) stated eutrophic waters have a brightness of below 2 meters. Low brightness can occur due to high suspended particles in water bodies. In addition, blooming phytoplankton populations also cause increased turbidity which will inhibit light penetration into water bodies. These particles can come from pieces of water plants or the roots of water hyacinth (Eichhornia crassipes), or from sediment that is carried into the water bodies through rivers around Danau Bangkau Peatland.

Fish are quite vulnerable to changes in the aquatic environment due to their adaptation system to the physical and chemical environment. Sufficient food availability good water quality will accelerate the growth of fish. On the other hand, even with sufficient food, poor water quality will inhibit fish growth, disrupt the reproductive cycle and increase fish mortality rate. Diversity of fish species, abundance and structure of fish schools in waters depend on habitat conditions, water volume, the presence of predators and competition for food (Simanjuntak, 2012; Jackson et al., 2001).

Table 2 – Fish Species Caught in this Research

Filum	Kelas	Ordo	Famili	Genus	Spesies	Indonesian General Name
Chordata	Actinopterygii	Perciformes	Channidae	Channa	*Channa micropeltes*	Toman
					Channa striata	Gabus
			Osphronemidae	Trichogaster	*Trichogaster pectoralis*	Sepat siam
					Trichogaster trichopterus	Sepat rawa
			Helostomatidae	Helostoma	*Helostoma temminckii*	Tambakan
		Anabantiformes	Anabantidae	Anabas	*Anabas testudineus*	Betok

Source: Primary Data, 2020.

Eutrophication does not only cause algae blooms and macrophites, but it also affects fish diversity. In this research, it can be seen that the phosphate levels are very high, reaching 3.34 ppm from the permissible limit according to PP No. 82/2001 for class 2, which is 0.2 ppm. The high levels of phosphate trigger eutrophication in Danau Bangkau Peatland. Furthermore, the fish in the peatland must adapt to these extreme conditions. The DO levels were relatively low because eutrophication also triggers chemical reactions in phosphate and it is used to decompose organic matter in water. Increased decomposition activity will increase the rate of dissolved oxygen consumption by decomposer microbes (Barus, 2002). Only fish that are classified as black fish or primitive fish groups are able to withstand such extreme conditions.

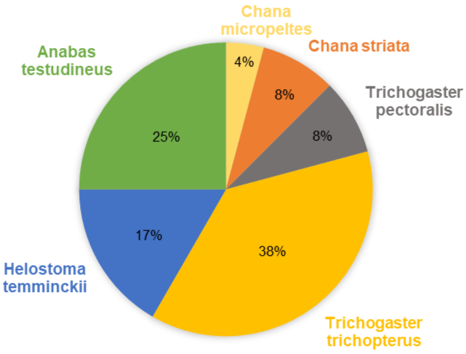

Figure 5 – Fish Species Composition in Danau Bangkau Peatland

Nurnaningsih (2004) revealed that human activities around fish habitats will affect fish diversity. For sustainable growth and reproduction, fish need to adapt to the environmental conditions. Furthermore, Anwar *et al*., (1984) explained that the composition and distribution of fish is strongly influenced by physical, chemical and biological changes. The fish caught in this research were Snakehead Fish (*Chana striata*), Giant Snakehead Fish (*Chana micropeltes*), Climbing Perch Fish (*Anabas testudineus*), Kissing Gourami (*Helostoma temminckii*), Snakeskin Gourami (*Trichogaster pectoralis*) and Three-spot Gourami (*Trichogaster trichopterus*). Most of these fish have labyrinth as a means of breathing assistance in oxygen-poor conditions. Eutrophic conditions cause very low fish diversity. The low fish diversity in Danau Bangkau Peatland is most likely due to the relatively high content of nitrate and phosphate, which cause high oxygen consumption by aerobic bacteria during decomposition process and ultimately reduce dissolved oxygen levels.

Both on-site and ex-site, Danau Bangkau Peatland is at a eutrophic condition. At least this condition is shown in the water column which enters the euphotic zone. Different conditions may occur at the bottom of the water, with dynamics that are more complex and varied.

CONCLUSION

Water samples at central stations and peatland outlet showed low nitrate concentration (i.e. in the range of 0.4 –10 ppm). On the contrary, phosphate concentrations tend to be high, exceeding the predetermined Water Quality Standard of within 0.19 - 3.34 ppm. Such conditions cause eutrophication to occur in Danau Bangkau Peatland. The DO levels were relatively very low (between 1.1 - 4 ppm) which could not meet the Water Quality Standard. However, as peatland waters, the pH parameter is surprisingly quite good at between 5.99 - 6.9. Fish diversity was found low, as only 6 species were found, namely Snakehead Fish (*Chana striata*), Giant Snakehead Fish (*Chana micropeltes*), Climbing Perch Fish (*Anabas testudineus*), Kissing Gourami (*Helostoma temminckii*), Snakeskin Gourami (*Trichogaster pectoralis*) and Three-spot Gourami (*Trichogaster trichopterus*). The high phosphate content in peatlands, which are also classified as old marshes, causes eutrophic conditions and only certain types of fish are able to adapt to these conditions. The fish diversity in Danau Bangkau Peatland is very low. Both in-site and ex-site, Danau Bangkau Peatland is at a eutrophic condition.

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