Assessment of spatial variations in water quality, plankton and macrozoobenthos diversity of Batanghari River, Indonesia

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Abstract. The Batanghari River, located in Sumatera, has experienced many anthropogenic pressures which caused sedimentation and changes in the river's water quality. Plankton and benthic communities are organisms that are very sensitive to changes in environmental quality. This study aimed to investigate and update the spatial variation of water quality, plankton, and macrozoobenthos diversity in the Batanghari River. The results show that nitrite, ammonia and total phosphorus concentrations are quite high in the waters with a low clarity level. The highest diversity index and abundance of phytoplankton were found in Batanghari Tabir. Bacillariophyceae dominated the phytoplankton found in the Batanghari River. Zooplankton found in this study came from Cladocera, Rotifera, and Protozoa. The highest diversity index and abundance were found in Batanghari Tebo. The most common type of macrozoobenthos came from the Oligochaeta group. In general, phytoplankton was categorized as of a moderate diversity. Even zooplankton's and macrozoobenthos's diversity was relatively low in diversity.
Key Words: diversity index, abundance, benthic, freshwater, Sumatra.

Introduction. The Batanghari River is one of the longest rivers in Sumatra, with a 1,740 km total length. This river flows from the upstream in West Sumatra Province to the downstream in the Province of Jambi. It has several main branches, including the Tembesi Batang, Tabir Batang, Tebo Batang, Sumai Batang, Merangin Batang, Bungo River, and Alai River (Nurdawati et al 2006). According to Desrizal et al (2019), apart from functioning as a source of water for agriculture, the Batanghari River has an essential role in supporting the activities of the public's daily life, including transportation, water resources for bathing and washing, inland fishing activities and industry, and it is even used for mining activities. Despite the many benefits produced, the freshwater ecosystem of the Batanghari River has faced increasing pressure from human activities. Various human activities carried out along the Batanghari River watershed, such as mining upstream and clearing land for oil palm plantations, have caused sedimentation and affected water quality in river bodies. The results of the study by Kalsum et al (2019) showed that the water quality status of the Batanghari River in the Tebo region's middle zone is moderately polluted, with a pollution index value of 6.72. In addition, Desrizal et al (2019) reported that mercury (Hg) contamination was relatively high in the upstream areas of the river in the South Solok District. Wiriani et al (2018) also emphasized that the construction of industries and factories whose waste is discharged into rivers, also contributes to decreasing the water quality of the Batanghari River. These anthropogenic activities have the potential to produce organic and inorganic waste that can enter rivers and affect the balance of river ecosystem functions. Awuah et al (2020) stated that pressures arising from human activities, such as chemical pollution, can affect species diversity and the functioning of freshwater ecosystem services. Maltby et al (2017) reported that the pressure from anthropogenic activities can disrupt the ecosystem structure (species abundance and composition) and function (e.g., dynamic food web). The presence of pollutants in freshwater ecosystems not only has a direct impact on aquatic species that act as service provider units (SPU), in the context of the ecosystem services (ES), it also reduces their capacity to provide ES, which ultimately harms human well-being and the function of sustainable ecosystem services.

Phytoplankton and macrozoobenthos are components of aquatic ecosystems that can be used as biological indicators of the ecological status of waters in evaluating aspects of ecosystem health (Kenney et al 2009; Tampo et al 2021). Both are essential biological components that facilitate nutrient cycling and accelerate energy flow through decomposition and food webs (Covich et al 1999). Phytoplankton is used as a bioindicator due to its fast-breeding rate in response to water eutrophication (Ray et al 2021). Several factors, such as pH, temperature, light, and nutrient content, affect phytoplankton composition in water bodies (George et al 2012; Gharib et al 2011). Among the various biological components of the river, macrozoobenthos is the most sensitive component to anthropogenic pressures (Ko et al 2020; Pratiwi et al 2020). Its community structure is strongly influenced by environmental factors, including sediment and water quality, and hydrological factors that affect the physical habitat (Matin et al 2018). It has a low mobility (sessile) and will remain in the waters even though it is contaminated with pollutants (Indarmawan & Manan 2011), which make it a biological indicator that reflects the condition of the waters. In this context, related to water quality, the updated information delivered by this study on the water quality and on the diversity of plankton and macrozoobenthos in the Batanghari River is needed for assessing its current condition.

Material and Method

Research sites. Water, plankton, and benthos were sampled in the Batanghari Watershed (DAS), Jambi Province, Indonesia, from October to November 2022. Water quality sampling locations can be seen in Figure 1. The map was generated with ArcGIS 10.8.

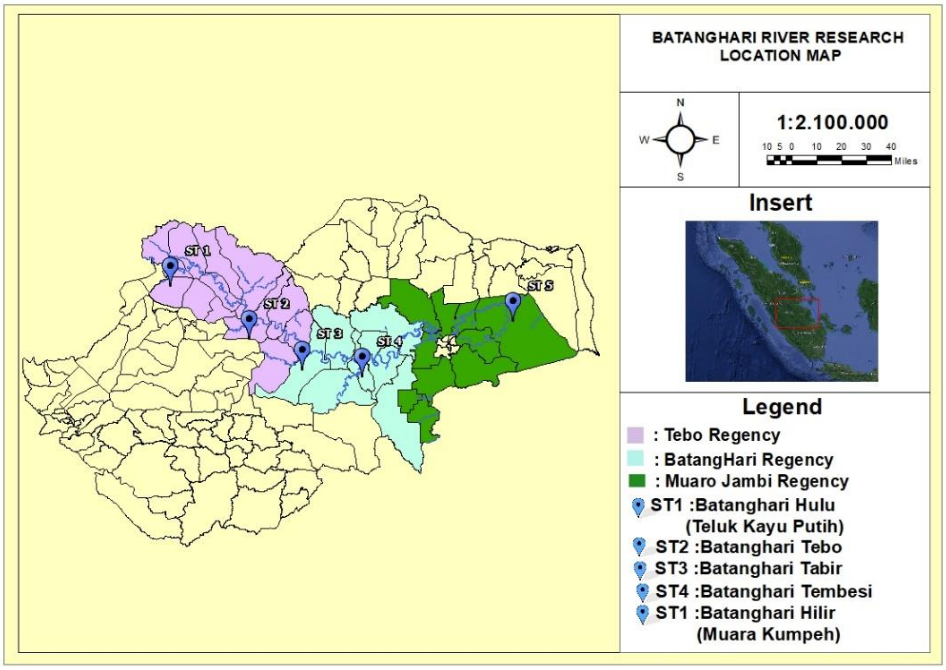

Figure 1. Map of the Batanghari River: location of the study sample. ST 1: Batanghari Hulu (Teluk Kayu Putih); ST 2: Batanghari Tebo; ST 3: Batanghari Tabir; ST 4: Batanghari Tembesi; ST 5: Batanghari Hilir (Muara Kumpeh).

The method used was a direct survey in the field. Samples were taken at five stations which were the Batanghari sub-watershed, namely: A. Batanghari Hulu (Kayu Putih Bay, at the confluence of the mainstream of the Batanghari river with the Junjuhan river), of coordinates 1°10'53.1"S, 101°59'22.8"E; B. Batanghari Tebo (Muara Tebo, at the confluence of the Batanghari main river with Batangtebo river), of coordinates point 1°29'22.9"S, 102°26'51.6"E; C. Batanghari Tabir (Muara Tabir, at the confluence of the headwaters of the Batanghari River with the Tabir River), of coordinates 1°40'05.1"S, 102°45'30.6"E; D. Batanghari Tembesi (Muara Tembesi, at the confluence of the headwaters of the Batanghari river with the Sorolangun river), of coordinates 1°42'34.8"S, 103°06'24.9"E; E. Batanghari Hilir (Muara Kumpeh, at the confluence of the headwaters of the Batanghari river with the Kumpeh river), of coordinates 1°23'08.7"S, 103°59'07.9"E.

Water quality measurement. Water quality data were sampled in situ and ex-situ. In-situ parameters consist of brightness, temperature, pH, and dissolved oxygen. Meanwhile, the ex-situ parameters, including nitrite (NO_3), nitrate (NO_2), ammonia (NH_3), phosphate (P_2O_5), and mercury (Hg), were analyzed. Water samples were taken at 10.00 AM - 12.00 PM, using 2 L sample bottles from the body of water at each sampling point. The samples were analyzed at the Freshwater Cultivation Fisheries Center Indonesia. Nitrate parameters were analyzed using the Indonesian National Standard SNI.06-6989.9-2004 (BSN 2004). The nitrite content was analyzed using the Cadmium Reduction standard method. Ammonia was analyzed using the Nassler standard method. Total phosphate was analyzed using the standard method SNI.06-6989.31-2005 (BSN 2005), and mercury was analyzed using the standard method SNI.06-6989.78-2011 (BSN 2011).

Plankton and macrozoobenthos measurement. Plankton sampling refers to the standard method (APHA 2012). Plankton sampling was carried out by taking 3 L of water at each sampling point using a plankton net with a 20 cm diameter and 20 μm of mesh size, resulting in 100 mL of a filtered water sample. Then, the sample was stored in a plastic bottle and four drops of Lugol's iodine were added. Then, samples were stored in the refrigerator. Plankton was identified at the Research Institute for Fish Resource Enhancement, Indonesia. The macrozoobenthos sampling was carried out using a sediment core with a diameter of 2 inches and a depth of 15 cm. The sediment samples were then stored in plastic sample containers and preserved using formalin at a concentration of 4%. Macrozoobenthos samples were identified and observed at the Aquatic Productivity and Environment Laboratory, IPB University, Indonesia. The abundance of phytoplankton, zooplankton, and macrozoobenthos was observed by using a Sedgwick rafter and a binocular microscope with 40x magnification. Phytoplankton and zooplankton were identified based on identification books, i.e., Mizuno (1970), Davis (1955), Needham & Needham (1963), and Sachlan (1982) using the APHA standard method (2012). The abundance of types of phytoplankton and zooplankton were calculated based on the following equation (APHA 1989):

$$N = \frac{Oi}{Op} \, x \, \frac{Vr}{Vo} \, x \, \frac{1}{Vs} \, x \, \frac{n}{p}$$

Where:
N - Number of individuals per liter;
Oi - Area of the cover glass (mm^2);
Op - Area of one field of view (mm^2);
Vr - Volume of filtered water (mL);
Vo - Observed volume of water (mL);
Vs - Filtered water volume (L);
N - Number of individuals in the entire field of view;
p - Number of visual fields observed.

Macrozoobenthos identifications were carried out by using the standard method of SNI 03.3401-1994 (BSN 1994). The abundance of macrobenthos was also calculated using the following formula with reference to Brower & Zar (1984):

$$D = \frac{ni}{A}$$

Where:
D - Density of macrozoobhentos (ind m^{-2});
ni - Number of individuals for each species;
A - Area (m^2).

The Shannon-Wiener index was used to calculate the species diversity index, evenness index, and dominance index calculated according to Odum (1998) with the following formulas:

$$H = -\sum_{i=1}^{s}\left(\frac{ni}{N}\right) ln\left(\frac{ni}{N}\right)$$

$$E = \frac{H'}{Hmax}$$

$$D = \sum_{i=1}^{s}[\frac{ni}{N}]$$

Where:
H' - Shannon-Wiener diversity index;
E - Uniformity index;
D - Simpson dominance index;
ni - Number of individuals of genus i;
N - Total number of individuals of all genera;
Hmax - Maximum diversity index (Hmax = ln *s*, where *s* = Number of species).

The Shannon-Wiener index indicates a category, according to the value ranges: $H' < 1$ low diversity, $1 \le H' \le 3$ moderate diversity, and $H' > 3$ high diversity.

Results

Physicochemical parameters. The physicochemical parameters of the Batanghari River are shown in Table 1.

Table 1

Physicochemical parameters of Batanghari River

Parameters	*Units*	*Sampling sites*					*Reference value*
		ST 1	ST 2	ST 3	ST 4	ST 5	
pH		7.2-7.6	6.9-7.3	7.2-8.0	7.2-7.7	7.1-8.2	6-9**
DO	mg L^{-1}	6.3-7.5	4.7-6.3	5.0-6.2	5.0-5.8	4.2-5.4	6**
Temp.	(°C)	26.5-27.8	27.7-28.3	28.2-29.0	27.8-28.1	27.8-28.0	-
NO_2	mg L^{-1}	18.45	13.75	12.1	8.4	11.25	0.06**
NO_3	mg L^{-1}	0.1	0.12	0.14	0.1	0.11	Long-term exposure: 13 Short-term exposure: 550***
NH_3	mg L^{-1}	0.69	0.91	0.84	0.85	0.84	0.019***
P_2O_5	mg L^{-1}	0.265	0.335	0.35	0.265	0.285	-
TP	mg L^{-1}	0.058	0.073	0.076	0.058	0.062	0.01**
Hg	mg L^{-1}	<LOD*	-	0.6241	-	-	0.001**
Clarity	m	0.1	0.15	0.15	0.15	0.1	1**

DO-Dissolved oxygen; NO_2-Nitrite; NO_3-Nitrate; NH_3-Ammonia; P_2O_5-Phosphate; TP-Total Phosphorus; Hg-Mercury; ST1-Batanghari Hulu (Teluk Kayu Putih); ST2-Batanghari Tebo; ST3-Batanghari Tabir; ST4-Batanghari Tembesi; ST5-Batanghari Hilir (Muara Kumpeh); *Limit of detection (LOD) value=0.002; **National Water Quality Standard of Republic Indonesia (Government Regulation Number 22 of 2021) for drinking water (Setkab RI, 2021); ***Canadian water quality guidelines for the protection of aquatic life (CCME 2010a; CCME 2010b)

Based on the results, the pH value of the river ranged from 6.9-8.0. DO varied between 4.2 and 7.5 mg L^{-1}, with temperatures ranging from 26.5 to 29°C. The NO_2 concentration ranged from 8.4 to 18.45 mg L^{-1}, while the NO_3 content was 0.1 to 0.14 mg L^{-1}. NH_3 concentration ranged from 0.69 to 0.91 mg L^{-1}. The P_2O_5 concentration varied between 0.265 and 0.35 mg L^{-1}. Meanwhile, TP was ranging from 0.058 to 0.076 mg L^{-1}. Hg concentrations were measured at 2 sampling points, i.e., Batanghari Hulu and Batanghari Tabir. The Hg concentration in Batanghari Hulu was below the limit of detection (<0.002 mg L^{-1}), while in Batanghari Tabir, Hg was detected at 0.624 mg L^{-1}. The brightness level of the water was in the range of 0.1-0.15 cm.

Macrozoobenthos diversity. The types of macrozoobenthos obtained from the 4 sampling points of the Batanghari River consist of three main groups, i.e., Trichoptera, Coleoptera, and Oligochaeta (Table 2). Trichoptera consisted of the family Limnephilidae, with *Limnephilus* sp.; Coleoptera also consisted of the family Chrysomelidae, with *Donacia* sp. Meanwhile, Oligochaeta consisted of one family with two species, namely *Lumbriculidae* (sp1) and *Lumbriculus* sp. The Oligochaeta group dominated the four sampling locations: Batanghari Hulu, Batanghari Tebo, Batanghari Tabir, and Batanghari Hilir. Meanwhile, the orders Trichoptera and Coleoptera were only found at the sampling points of Batanghari Tebo and Batanghari Tembesi, respectively.

Table 2

Macrozoobenthos profile of Batanghari River

No.	*Groups*	*Families*	*Species*	*Abundance (ind m⁻²) per sampling site*				
				ST 1	*ST 2*	*ST 3*	*ST 4*	*ST 5*
1.	Trichoptera	*Limnephilidae*	*Limnephilus* sp.	0	494	0	0	0
2.	Coleoptera	*Chrysomelidae*	*Donacia* sp.	0	0	0	494	0
3.	Oligochaeta	*Lumbriculidae*	*Lumbriculidae* (sp 1)	494	987	494	0	0
			Lumbriculus sp.	0	0	0	0	494
		Number of taxa		1	2	1	1	1
		Total abundance (ind m^{-2})		494	1481	494	494	494
		Diversity index		0	0,637	0	0	0
		Evenness index		0	0,918	0	0	0
		Dominance index		1	0,556	1	1	1

ST1-Batanghari Hulu (Teluk Kayu Putih); ST2-Batanghari Tebo; ST3-Batanghari Tabir; ST4-Batanghari Tembesi; ST5-Batanghari Hilir (Muara Kumpeh).

The abundance of macrozoobenthos in Batanghari Hulu, Batanghari Tabir, Batanghari Tembesi, and Batanghari Hilir was 494 ind m^{-2}. Batanghari Tebo had the highest abundance of macrozoobenthos, 1481 ind m^{-2}, which came from Trichoptera and Oligochaeta species. The diversity index of benthos organisms was 0.637 at Batanghari Tebo, and no diversity was detected in Batanghari Hulu, Batanghari Tabir, Batanghari Tembesi and Batanghari Hilir. The evenness and dominance index of Batanghari Tebo were 0.918 and 0.556, respectively.

Plankton diversity. There were 19 species of phytoplankton found in Batanghari River, consisting of 8 orders and 12 families. The types of phytoplankton found consisted of 2 species from the Centrales, one species from the Euglenales, one species from the Lithodesmiales, one species from the Mastogloiales, 11 species from the Pennales, one species from the Peridiniales, one species from the Sphaeropleales, and one species of the Order Surirellales. Out of 19 species found during the study, eight were found in Upper Batanghari, ten were found in Batanghari Tebo, ten were found in Batanghari Tabir, and ten were found in Batanghari Tembesi, and 8 species were found in Batanghari Lower. Six zooplankton species were found in the Batanghari River (Table 3), Jambi, consisting of five orders and 5 families.

Table 3

Phytoplankton profile of Batanghari River

No	Groups	Families	Species	Abundance (ind L^{-1}) per sampling site				
				ST 1	*ST 2*	*ST 3*	*ST 4*	*ST 5*
1	Centrales	Thalassiosiraceae	*Aulacoseira* sp.	-	-	-	-	667
2	Centrales	Thalassiosiraceae	*Cyclotella* sp.	-	-	-	1,333	-
3	Euglenales	Euglenaceae	*Trachelomonas* sp.	-	-	-	667	-
4	Lithodesmiales	Lithodesmiaceae	*Ditylum* sp.	-	667	-	-	-
5	Mastogloiales	Mastogloiaceae	*Mastogloia* sp.	-	667	-	-	667
6	Pennales	Bacillariaceae	*Nitzschia* sp.	12,000	5,333	6,000	5,333	2,000
7	Pennales	Cymbellaceae	*Cymbella* sp.	2,667	667	1,333	1,333	1,333
8	Pennales	Cymbellaceae	*Gomphonema* sp.	2,000	1,333	1,333	-	-
9	Pennales	Eunotiaceae	*Eunotia* sp	-	-	667	-	-
10	Pennales	Fragilariaceae	*Asterionella* sp.	-	-	-	2,667	-
11	Pennales	Fragilariaceae	*Fragillaria* sp	2,667	-	1,333	-	1,333
12	Pennales	Fragilariaceae	*Synedra* sp.	667	4,667	3,333	6,000	2,667
13	Pennales	Naviculaceae	*Navicula* sp.	1,333	2,667	5,333	2,667	-
14	Pennales	Naviculaceae	*Pinnularia* sp.	1,333	667	3,333	667	667
15	Pennales	Naviculaceae	*Pleurosigma* sp.	-	-	2,000	-	-
16	Pennales	Naviculaceae	*Stauroneis* sp.	2,000	667	-	-	-
17	Peridiniales	Peridiniaceae	*Peridinium* sp.	-	667	-	667	667
18	Sphaeropleales	Scenedesmaceae	*Scenedesmus* sp.	-	-	667	-	-
19	Surirellales	Surirellaceae	*Cymatopleura* sp.	-	-	-	667	-
		Number of taxa		8	10	10	10	8
		Total abundance (ind L^{-1})		24,667	18,000	25,333	22,000	10,000
		Diversity index		1.652	1.918	2.060	1.973	1.934
		Evenness index		0.794	0.833	0.895	0.857	0.930
		Dominance index		0.280	0.191	0.151	0.174	0.164

ST1-Batanghari Hulu (Teluk Kayu Putih); ST2-Batanghari Tebo; ST3-Batanghari Tabir; ST4-Batanghari Tembesi; ST5-Batanghari Hilir (Muara Kumpeh).

The types of zooplankton consisted of one species from the Anomopoda order, two from the Ploima order, one from the Arcellinida order, one from the Euglyphida order, and one species of the Halteriida order. Out of a total of six species found in this study, one was found in Upper Batanghari, one in Batanghari Tebo, two species were found in Batanghari Tabir and Batanghari Tembesi and two species were found in Batanghari Hilir. The composition of the types of zooplankton found during the study is presented in Table 4.

Table 4

Zooplankton profile of Batanghari River

No	*Groups*	*Families*	*Species*	*Abundance (ind L^{-1}) per sampling site*				
				ST 1	*ST 2*	*ST 3*	*ST 4*	*ST 5*
1	Anomopoda	Bosminidae	*Bosmina* sp.	667	-	-	-	-
2	Ploima	Brachionidae	*Keratella* sp.	-	-	-	667	-
3	Ploima	Brachionidae	*Notholca* sp.	-	-	667	-	-
4	Arcellinida	Difflugiidae	*Difflugia* sp	-	-	667	667	1,333
5	Euglyphida	Euglyphidae	*Euglypha* sp.	-	667	-	-	-
6	Halteriida	Halteriidae	*Halteria* sp.	-	-	-	-	667
Number of taxa				1	1	2	2	2
Total abundance (ind L^{-1})				667	667	1,333	1,333	2,000
Diversity index				-	-	0.693	0.693	0.637
Evenness index				-	-	1.000	1.000	0.918
Dominance index				1.000	1.000	0.500	0.500	0.556

ST1-Batanghari Hulu (Teluk Kayu Putih); ST2-Batanghari Tebo; ST3-Batanghari Tabir; ST4-Batanghari Tembesi; ST5-Batanghari Hilir (Muara Kumpeh).

Discussion. This study showed that pH slightly increased from upstream (Batanghari Hulu) to downstream (Muara Kumpeh), ranging from 6.9 to 8.2. According to the United States Environmental Protection Agency, living things can tolerate a pH value of 6.5-9.0 (US EPA 2023). In their report, Chen et al (2021) stated that water's pH increases consistently after flowing through areas that have experienced much revitalization. Dissolved oxygen concentration was 4.2-7.5 mg L^{-1}, where the value generally decreased slightly from upstream to downstream. Those findings were supported by Sulawesty et al (2020) who explained that downstream human activities produce higher levels of organic and inorganic compounds than upstream, which require higher dissolved oxygen for the decomposition process. In their study, Chittoor-Viswanathan et al (2015) stated that the pH of a river is influenced by several factors, namely dissolved CO_2 levels, respiration processes, and photosynthesis. The respiration process increases the CO_2 content in the water and causes a decline in pH, while photosynthesis causes an increase in pH and affects dissolved oxygen. However, the result of this study showed the opposite trend, where the pH tended to increase, but the DO concentration decreased (Table 1). The nitrite concentration in the Batanghari River ranged from 8.4 to 18.45 mg L^{-1}, with a tendency to decrease from upstream to downstream. The content of nitrate and ammonia did not show high fluctuations at none of the sampling locations. Nitrate was still in good range for aquatic life (Table 1). Meanwhile, ammonia and nitrite were higher, compared to the allowable values from the water quality standard for aquatic life.

The water phosphate concentration ranged from 0.265 to 0.35 mg L^{-1}, with a 10-15 cm clarity level. Phosphorus is an essential component of nucleic acids and many intermediary metabolites, such as sugar phosphates and adenosine phosphates, which are an integral part of the metabolism of all life forms. Phosphorus has been known to be a limiting factor in fresh water. Excessive concentrations of P are the most common cause of eutrophication in freshwater lakes, reservoirs, streams, and in the headwaters of estuarine systems (Correll 1998). Besides, nitrite, nitrate, ammonia, and phosphorus levels were relatively higher than the thresholds set by the Canadian Water Quality Guidelines for Aquatic Life.

Mercury contamination was detected at one sampling location with a value of 0.624 mg L^{-1}. Compared to the national water quality standard of Republic of Indonesia (Government Regulation Number 22 of 2021) for drinking water, the value was relatively high for human consumption. The rise of illegal gold mining along the Batanghari River was suspected of contributing to mercury pollution in the river. Mulyadi et al (2020) in his study reported that mercury could continue to accumulate in water as the concentration increases. It will harm the environment and could affect human health. Changes in the river water quality could affect the community structure of organisms in the ecosystems. Planktonic algae are excellent bioindicators and have long been used to assess water quality. The number of species found in this study was 25, consisting of 19 species of phytoplankton and 6 species of zooplankton. Sampling was conducted at the beginning of the rainy season (October). At that season, the volume and water velocity were increased, resulting in a decrease of the abundance and diversity of plankton. Compared to Setiawan et al (2018), there were 65 species of phytoplankton and 5 species of zooplankton during the dry season (August) at the Simpang Heran and Sugihan rivers in Sumatera. Some studies also show that the consequences of human activity on the landscape, including increased temperature, flooding, deforestation, and many others, have a negative influence on the ecological status. Many of these changes will interact with the effects of organic nutrients on phytoplankton community structure (Reinl et al 2022). Phytoplankton nutrient uptake rates are expected to increase with the temperature (Aksnes & Egge 1991).

The Bacillaryophyceae was found more commonly, with as many as 16 species, compared to other species from the Chlorophyceae, Dynophyceae, and Euglenophyceae, which were only represented by one species. In previous reports, Bacillaryophyceae have been dominant in fast-flowing river waters (Dembowska et al 2021; Aprilliani et al 2018; Setiawan et al 2018). The Bacillaryophyceae class lives in various water conditions and has become the most capable group to attach the substrate compared to others. According to Sachlan (1974), Bacillaryophyceae have mucus to help the attachment. Meanwhile, the low diversity of the phytoplankton from the classes Chlorophyceae, Dynophyceae, and Euglenophyceae might be caused by the low organic matter level in Batanghari River. Other studies show that the three classes of phytoplankton could only live and reproduce in water with high organic matter (Prescott 1978; Setiawan et al 2018). Nitrogen forms in the water could affect the phytoplankton growth. According to Muro-Pastor et al (2005), ammonium (NH_4^+) is typically the preferred source of inorganic N for most species of phytoplankton because ammonium uptake is energetically more advantageous but is often present in low concentrations relative to NO_3^- assimilation. A research study shows that while NH_4^- may be the N form most readily taken up by phytoplankton, the dissolved organic N may be utilized before the NO_3^- pool is utilized (Chaffin & Bridgeman 2014). In addition, Reinl et al (2022) explained that the variability of the dissolved organic N affinity among species leads the phytoplankton community's characteristics.

Zooplankton abundance was categorized as low, with only one to two species found at each station. As with phytoplankton, the sampling time might affect the abundance of zooplankton. This can be explained by the fact that during the rainy season, water volume and flow rate increase, leading to the decreasing abundance of phytoplankton as a food source for zooplankton (Nwonumara 2018). A decrease in the abundance of plankton in flowing rivers during the rainy season has also been reported in the Kapuas River (Aprilliani 2018), Cross River (Okogwu & Ugwumba 2013; Ekwu & Sikoki 2006) and Paranapanema River (Perbiche-Neves et al 2011).

Based on the results of the study (Table 2), four types of species from three orders were observed, namely *Limnephilus* sp. (Order Trichoptera), *Donacia* sp. (Order Coleoptera), *Lumbriculidae* (sp 1) and *Lumbriculus* sp. (Order Oligochaeta). Oligochaeta is one of the groups found in 4 observation sites. Its members are deposit feeders, primarily found in the lowland parts of the river, where the water velocity is low with high levels of turbidity and Chl-a (Kang et al 2017). Oligochaeta can tolerate low levels of dissolved oxygen (Håkanson 2006), so they can survive in locations with high anthropogenic contamination (e.g., high turbidity, high organic matter, and toxic substances) and they can even replace other benthic macroinvertebrates, which are less tolerant of these conditions (Schenková & Helešic 2006). The Coleoptera group was only found in the Batanghari Tembesi area in this study. Its members play a vital role in both terrestrial and aquatic ecosystems. The role of the order of Coleoptera insects in the ecosystem is as an eater of decaying organic matter, decomposer of organic matter, and natural predator. The

Trichoptera group was also found at one sampling location (Batanghari Tebo). The low diversity of Trichoptera might be related to habitat loss by urbanization and deforestation, leading to increased sedimentation of rocky substrates and reduced litter input to rivers (Bisposar et al 2004).

The highest abundance and diversity of benthos was found at ST 2 (Muara Tebo). *Limnephilus* sp. and member species of the Lumbriculidae family were reported at this location (Table 4). Sarker et al (2016) stated that diversity is generally positively correlated with pH. Meanwhile, Hossain & Marshall (2014) stated that the characteristics of sediment particles have a more decisive influence on species distribution and community arrangement than water's chemical properties (pH and salinity). After all, the diversity index of the benthic community was relatively low. The diversity index of 4 sites (Batanghari Hulu, Batanghari Tabir, Batanghari Tembesi, and Batanghari Hilir) was reported as 0. That index value indicates no diversity because only one species was found on the site. The study's results show that the four sampling locations were dominated by one type of macrozoobenthos, as indicated by the dominance index value of 1, while the evenness index value was 0. Furthermore, Batanghari Tebo had a high level of evenness with the value of 0.918.

Conclusions. In general, some water quality parameters were higher than the reference values for aquatic life and human consumption, including nitrite, ammonia, total phosphorus, and mercury level. Furthermore, phytoplankton was categorized as of a moderate diversity. While zooplankton and macrozoobenthos were relatively low in diversity.

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