Pol. J. Environ. Stud. Vol. 32, No. 5 (2023), 4281-4290
DOI: *10.15244/pjoes/168222* ONLINE PUBLICATION DATE: 2023-07-13

Original Research

Assessing Benthic Community and Water Quality as the Bioindicator of Environment in Semayang Lake East Kalimantan, Indonesia

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Received: 9 April 2023
Accepted: 12 June 2023

Abstract

Lake Semayang is a floodplain lake with an area of ±13,000 ha. Over time, this lake has experienced a lot of ecological pressure due to anthropogenic changes that have an impact on the condition of the waters in it. Water quality is highly dependent on the presence of aquatic biota. One of the aquatic biotas that are very important in determining the condition of the waters is the benthos, namely animals that live on the bottom of the waters and are bioindicators from a biological point of view. The methodology is by taking benthic samples in the field using the Ekman Grab, identifying, and analyzing the calculation of abundance, diversity, and looking at the condition of the surrounding waters. This paper describes the presence of benthic macroinvertebrate communities as bioindicators of aquatic health. The research was conducted from March to October 2018 at five observation stations with purposive sampling. The results showed that the highest macrozoobenthos communities were in the families Tubificidae and Thiaridae, namely *Branchiura sowerbyi* and *Melanoides* sp. The presence of *B. sowerbyi* and *Melanoides* sp indicates that the condition of the waters is still in the good category with moderate diversity values, rich in organic matter with low *dissolved oxyge*n (DO) conditions, and high suspended particles.

Keywords: Semayang Lake, water quality, East Kalimantan, macrozoobenthos, bioindicator

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Introduction

Indonesia is an archipelagic country [1] and has a very large wealth of natural resources [2, 3]. The total area of natural lakes in Indonesia is more than 5,000 km^2 [4] with an area of lakes in Indonesia of less than 1,000 ha [3]. Lake ecosystems provide productive natural resources [5] as a source of protein, minerals, and energy as a means of transportation, and as a tourist area [2]. The typology of lakes in Indonesia varies greatly [6]. Lakes are habitats for fish and biota resources to grow and develop, as well as fishing grounds [7-10], fish cultivators [11], fishery product processors, transportation, education, and recreation facilities.

Lake Semayang is a lake that is connected to the Mahakam River [12, 13]. Lake Semayang has a depth of ±13 m, a volume of 390,000,000 m^3, and a lake area of ±13,000 ha [8, 14, 15] and is located at coordinates 0°13'24.48" LS and 116°27'17" BT. The lake is a floodplain where the water recedes during the dry season, so it becomes dry land and only small grooves and a bottom remains, and its function has been changed to be used by residents for farming, such as planting rice. Seasonal changes cause fishermen in the lake to switch from fishermen to farmers during the dry season [14, 16]. Over time, Semayang Lake has suffered a lot of damage due to erosion, sedimentation, overfishing, habitat degradation, and increased catches [11, 17-20].

Many studies have been conducted in Lake Semayang, including regarding dolphins [21, 22], *Anabas testudineus* Bloch [23], *Trichopodus pectoralis* Regan [24], and community strategies for dealing with floods [25], while research on aquatic bioindicators using biological parameters and water quality approaches has not been carried out. Biological parameters with the community structure approach of aquatic organisms that function as bioindicators and one of the aquatic organisms are benthic macroinvertebrates [26]. Macrozoobenthos are organisms that live at the bottom of the waters, have relatively slow movements, and have a long-life cycle to continuously respond to water quality conditions [27]. The research objective was to determine the diversity of macrozoobenthos in Lake Semayang. [28] stated that benthos is closely related to mineralization and changes in aquatic organic matter, this is because organic matter is a source of nutrition for aquatic organisms [29, 30, 31, 32]. Communities in shallow waters in the form of benthos are useful as biological parameters for evaluating water pollution [27, 33]. This paper describes the existence of the benthic macroinvertebrate community as a bioindicator of aquatic health. The results of this study can be used for biomonitoring aquatic so that inland waters can be used and managed in a sustainable manner.

Materials and Methods

Study Site and Data Collection

The research was conducted from March to October 2018 at Semayang Lake, Kutai Kartanegara Regency, East Kalimantan Province (Fig. 1). Parameters observed were water quality and diversity of macrozoobenthos. Benthos sampling was carried out at five stations around Lake Semayang, East Kalimantan. Determination of location points based on purposive sampling method. There are 5 stations (St) namely: St 1 N 00°14'44.7' and E 116°32'04.8'' which represent the inlet area of Semayang Lake which still has a lot of vegetation; St 2 N 00°15'32.1'

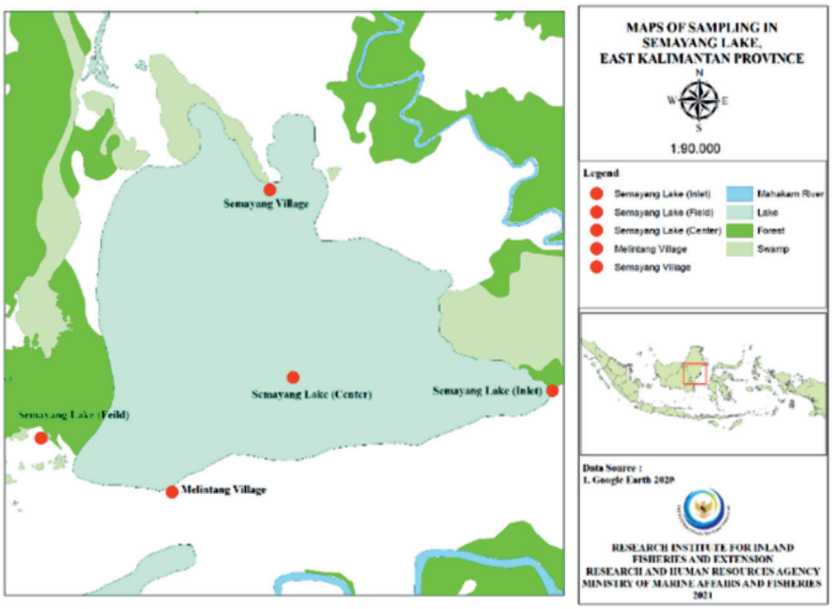

Fig. 1. Research location of Semayang Lake, Indonesia.

and E 116°23'30.5'' are paddy field or swamp area; St 3 N 00°14'31,9' and E 116°27'44,1'' is the middle station of a flooded swamp lake which contains a lot of silt; St 4 N 00°16'25.8' and E 116°25'42.5'' the transverse area village; and St 5 N 00°11'25.2' and E 116°27'20.6'' are Semayang settlements (outlet). Location points represent representative locations representing settlements/villages, locations where there are plants or vegetation as well as lake inlet and outlet locations. Water sampling was carried out from 08.00-15.00 WIB. There are water quality parameters that are measured in situ and there are also laboratory tests by bringing water samples. Water sampling was carried out by taking surface water using a Kemmerer Water Sampler with a depth of one meter from the surface of the water. One liter of water is taken, put in a one-liter bottle, and tightly closed. This treatment was repeated at each station.

Identification and Data Analysis

Benthic sampling was carried out using the Ekman grab tool, sampling at each station was carried out in a composite manner with three repetitions then put in benthic plastic, the next station was carried out in the same way so that 5 benthic sample plastics were obtained, then benthic samples were filtered using a filter stratified benthic, the screening results are sorted to separate the organisms from the soil/litter obtained, the organisms that have been sorted are put in vials and given 70% formalin preservative and taken to the laboratory for identification. Samples were analyzed in the Research Institute for Inland Fisheries and Extension laboratory and then identified using a microscope with a magnification of 10x10 with reference to the identification book in the laboratory [34-38]. After obtaining the benthos identification results, an analysis was performed to calculate the composition, abundance, and diversity index values using the Shannon-Wiener index formula in Microsoft Excel. Then the water quality was linked to benthos analysis data using the SPSS 16 program. Abundance and individual diversity used the Shann-Wiener index [39]. In this research, only composition values were calculated which were sufficient to find macrozoobenthos with the most composition found as well as abundance and diversity values which were sufficient to represent the presence of macrozoobenthos in waters.

$$Y = \frac{10000\ x\ a}{b}$$

Where: Y is the Number of Macrozoobenthos Organisms (eng/m²); a is the number of individuals of Macrozoobenthos species (eng); and b = Area Square (m²).

Relative Abundance using the formula Cox (1967) in [40].

$$R = \frac{ni}{N} x\ 100\%$$

Where: R = Relative Abundance; ni = Number of Individuals of Each Type; N = Total Individuals.

Diversity Index (H') which is calculated according to [41], as follows:

$$R = (ni/T)\ x\ 100\%$$

Where: H' = Diversity Index; ni = the number of individuals in each species; and N = Total Number of Individuals.

Results and Discussion

Parameters Water Quality

Research in Semayang Lake measures water quality parameters namely, physical and chemical parameters. The results of observations of several water quality parameters of Semayang Lake can be seen in Table 1.

The value of ammonia in Lake Semayang ranges from 0.02-0.2 mg/l. The results of the research on ammonia st 1, st 2, st 3, and st 4 were below the maximum quality standard referring to [42]. Some research conducted by [43-46] and showed different ammonia concentration, Ammonia in waters comes from organic matter, the rest of the metabolism of aquatic organisms, and decay or organic waste such as household waste that is carried away by currents. Semayang Lake's electrical conductivity ranges from 21.3 to 87.9 s/cm. The DHL value is used as an indicator of the level of water fertility [47]. The maximum quality standard for river water that is still suitable for drinking water quality, namely DHL, is 20-1500 s/cm [48]. Thus, the DHL of Semayang Lake is still within the threshold. Nitrate is the main nitrogen in water and the main nutrient for plant and algae growth [49-51]. Lake Semayang highest nitrate is 0.32 which shows that it is still within the threshold according to [42]. In [40, 52] explain that the main source of nitrogen enrichment is runoff from agricultural land. If nitrate is more than 5 mg/L, then pollution has occurred [53]. High phosphate concentrations are harmful to aquatic biota. The total phosphate value in Lake Semayang ranges from 0.15-0.21 mg/l. As a result, the potential for eutrophication or algal blooms is very high when phosphate is high. [54, 55] said that the maximum recommended phosphate level for rivers and waters that have been reported is 0.1 mg/L as eutrophic waters. [56, 57] clarified that phosphate in waters is obtained from natural sources such as soil erosion, animal waste, and weathering of plants/organic and mineral destroyers, this is consistent with the nature of Lake Semayang which is a swamp lake which is stagnant with water. The Total Solid Suspension (TSS) value of Lake

Table 1. Parameter of water quality observed.

Parameter	1	2	3	4	5
NH_3	0.2	0.16	0.11	0.02	0.18
DHL	21.3	69.3	87.9	25.33	38.03
NO_2	0.02	0.01	0.02	0.01	0.02
NO_3	0.31	0.24	0.32	0.2	0.15
TP	0.21	0.15	0.2	0.12	0.17
Turbidity	192.85	61.2	99.3	58.1	127.4
TSS	26.36	18.17	25.71	6.5	21.4
Temp	30.1	30.9	31.1	32.3	32
pH	6.6	6.5	5.28	6.13	6.53
DO	6.4	6.4	5.5	5.6	6.4
CO_2	0.2	0.2	0.3	0.5	0.25

Semayang ranged from 6.50-26.36 mg/l. Suspended solids will reduce the absorption of sunlight into the water which will affect oxygen regeneration and photosynthesis [58]. Turbidity ranged from 58.10 to 192.85 NTU. This is because Lake Semayang is a stagnant area that has a lot of clay particles and swampy properties where during the rainy season the water will inundate the lake a lot otherwise during the rainy season. Based on Government Regulation Number 82 of 2001 still meets the optimum range [59]. Dissolved oxygen ranges from 5.50-6.40 mg/l. The DO value is still in the very good category and is still feasible for the survival of organisms. Balanced dissolved oxygen for freshwater fish farming is more than 4 mg/l. The pH value indicates disturbed waters [60] and the temperature has a vital role in aquatic biota, where the process of growing with fish requires an optimal temperature of 28º-32ºC [61]. The pH of the lake ranges from 5.28-6.6. This value is still within the limits supported by [62] that the ideal pH for the life of freshwater biota is 6.0-9.0.

Composition Macrozoobenthos

Based on observations, it was found that the macrozoobenthos composition of Lake Semayang at five stations namely, there were 11 families (Tubificidae, Chironomidae, Tipulidae, Ephemeropteridae, Palingeniidae, Polycentropodidae, Thiaridae, Ampullaridae, Viviparidae, Corbiculidae, and Unionidae) of macrozoobenthos has found. The highest st 1,2, and st 4 (84%, 100%, and 70%) were of the Tubificidae family, while at st 3 (61%) and 5 (71%), there were Thiaridae (Fig. 2). Based on observations, Tubificidae and Thiaridae are the highest compositions. Tubificidae belongs to the sediment-eating macrobenthos [63, 64, 65]. The density and diversity of Thiaridae will differ depending on the pollutant power.

Research by [66, 67], Thiaridae has the most significant family composition and [68] Thiaridae is a macrozoobenthos family in parks and rivers in Karang Suko Village, Malang. [69] stated that of the ten families most found in the Cokro River, Malang is Thiaridae. This is presumably because the waters that fall into that category are still intact and healthy. The existence of Thiaridae shows the quality of the waters is still in the appropriate category [70]. Thiaridae belongs to the class Mollusca. [71] stated that the physical characteristic of the Thiaridae family is that the threads are regularly tapered from anterior to posterior. According to [72] Thiaridae are parthenogenetic, so they have an abundance of freshwater.

Abundance and Diversity of Macrozoobenthos

Abundance at five stations, st 1 and st 2 with the highest in *Branchiura sowerbyi* (14558.3 Idv/cm^2

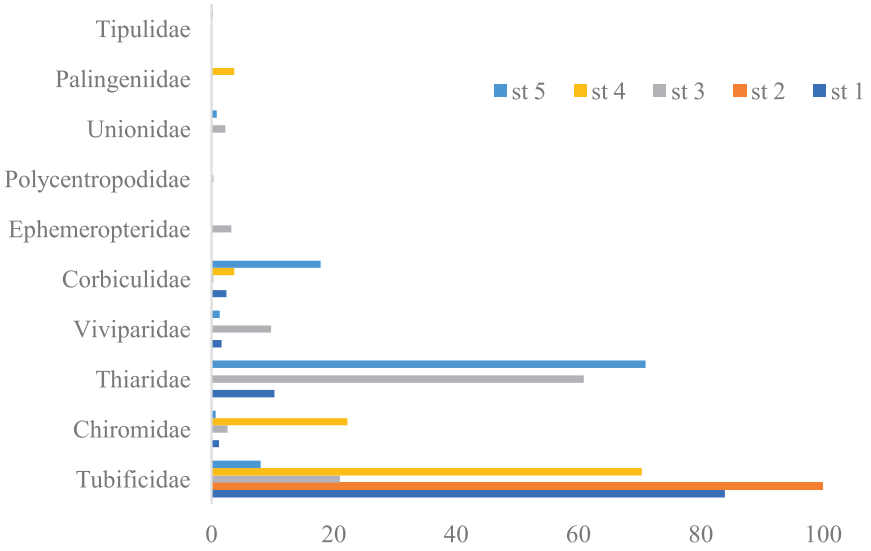

Fig. 2. Macrozoobenthos composition in Lake Semayang, Indonesia.

and 50 Idv/cm^2), st 3 contains *Melanoides* sp (1058.33 Idv/cm^2), st 4 Immature *tuffificid* without hair setae (66.67 Idv/ cm^2) and St 5 *Melanoides tuberculate* (2358 Idv/cm^2) (Fig. 4). The diversity index value (H') ranged from 0.41-1.95, while the dominance index value ranged from 0.2-0.7 (Fig. 3). When viewed from its index value, Lake Semayang is in the medium category of diversity and dominance [29, 39, 69, 73].

The highest abundance was in *B. sowerbyi* (14558.3 Idv/cm^2 and 50 Idv/cm^2), st 3 contains *Melonoides* sp (1058.33 Idv/cm^2), st IV *Tuffificid* immature without hair setae (66.67 Idv/cm^2) and St 5 *Melanoides tuberculate* (2358 Idv/cm^2) (Fig. 4). According to [74], *B. sowerbyi* is a class of Oligochaeta that live in freshwater in Europe and North America. According to [75], the spread of *B. sowerby*i is caused by human activities such as transporting plants or importing fish for fish farming and it should be noted that the presence of this species can disrupt relationships in benthic communities and, as a result, have an influence on aquatic ecosystems in the water chain. Food [76, 77]. A distinctive feature of *B. sowerbyi* is that it lives with its head buried in the sediment, its tail actively waving, and a layer of water above the bottom. These animals adapt and can live in waters with currents of 0.5-1 ms. This biota lives in aquatic sediments that contain almost no oxygen, shallow water, stagnant water, and slow flow [76]. Gastropods are animals that live in aquatic environments, namely fresh water, and they are present at the bottom of the waters for a long time [78] as bioindicators in aquatic ecosystems [79].

The observation results found *B. sowerbyi* and *Melanoides sp. Melanoides* is one of the genera of the gastropod class. Lake Semayang is a lake that is flooded with a muddy bottom. According to [80, 81], one of the characteristics of the existence of this species is influenced by physical and chemical factors in the waters, namely one of the substrates that this organism likes is a fast, shallow, and slightly muddy bottom so that these snails can breed in almost all habitats.

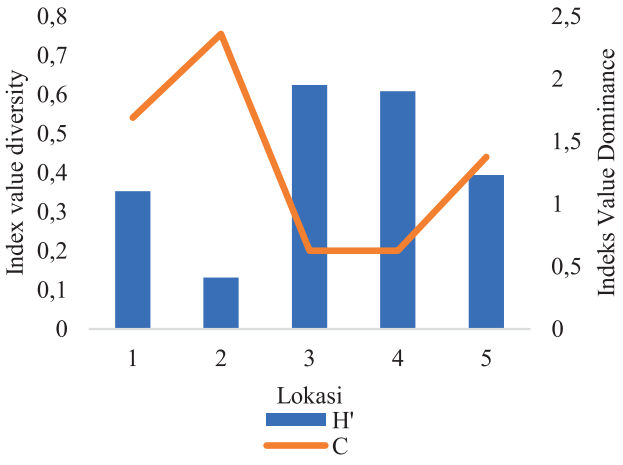

Fig. 3. Diversity and dominance index values Semayang lake, Indonesia.

Substrate changes and the presence of pollutants will affect the density, composition, and level of diversity of zoobenthos [82].

The Relationship between Water Quality and Macrozoobenthos

The macrozoobenthos community as a bioindicator of water quality can be seen from the dominance of the presence of *B. sowerbyi* and *Melanoides* sp. According to [83], *B. sowerbyi* is a Tubificidae worm that is commonly found in freshwater environments that are rich in organic matter and are generally found in the tropics and areas with temperate climates. *B. sowerbyi* is also a worm that is widely distributed and found almost all over the world, these worms usually live in calm waters with a type of mud substrate and have good osmoregulation abilities, and are able to survive extreme pH and DO conditions [84, 85], and has great potential for use as a species test in toxicological bioassays [86].

Furthermore [87], stated that the species *Melanoides* sp. Is a bioindicator of organic matter contamination. This is due to the level of survival tolerance of the species *Melanoides* sp. To pollutant is higher than other species. This species is generally found in waters containing a lot of organic matter and can live in low *dissolved oxygen* (DO) conditions with highly suspended particles [88].

However, the relationship between macrozoobenthos and several water quality parameters can be seen in that in general the water quality parameters have a directly proportional relationship to the presence of macrozoobenthos, and only the DHL parameter has an inverse relationship (Fig. 5). According to [89], water's physical and chemical properties will directly or indirectly affect benthos life. [39] stated that temperature changes have a significant effect on the life of aquatic biota. This is supported by [90] that temperature is a limiting factor for the growth of benthos. According to [91], the higher the water temperature, the lower the oxygen solubility, and vice versa. The life of aquatic organisms is greatly affected by fluctuations in the pH value. The pH value of the waters in Lake Semayang ranges from 5.84 to 6.06. This value is still tolerant to macrozoobenthos life. The analysis results of Nitrite content analysis in Semayang Lake water are still within reasonable limits. [92] said the total phosphorus content in natural waters rarely exceeds one mg/l. The results showed that the TSS value of Semayang Lake was 6.5-26.36 mg/l, and the TSS parameters in the waters were still in good condition. A higher TSS value will also result in turbid water [93].

In general, the condition of the waters of Semayang Lake is still very good for aquatic biota, however, it is necessary to pay attention to suspended particles which tend to increase due to the long-term sedimentation process which will reduce the availability of fish resources. The existence of fish resources is very important as a source of protein, and in the food

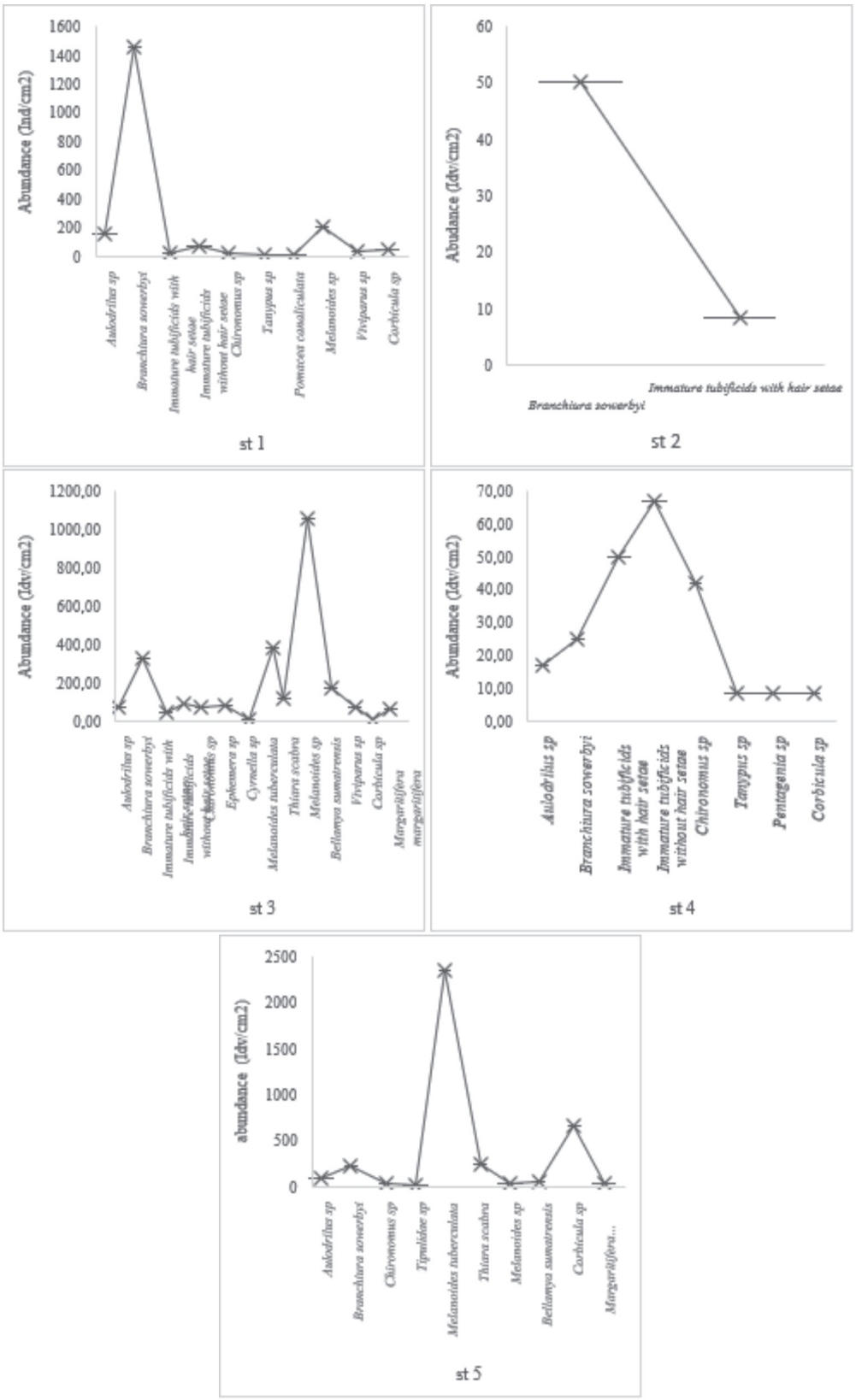

Fig. 4. Abundance values macrozoobenthos Semayang lake, Indonesia.

chain as a food source for the *Irrawaddy Dolphin* in maintaining its survival [94]. Furthermore, [94] stated that the proportion of *Irrawaddy Dolphin* migrating into the lakes is 5% both during high, medium, and low water times so the existence of lake habitat is important in maintaining the survival of *Irrawaddy Dolphin* and other fish resources.

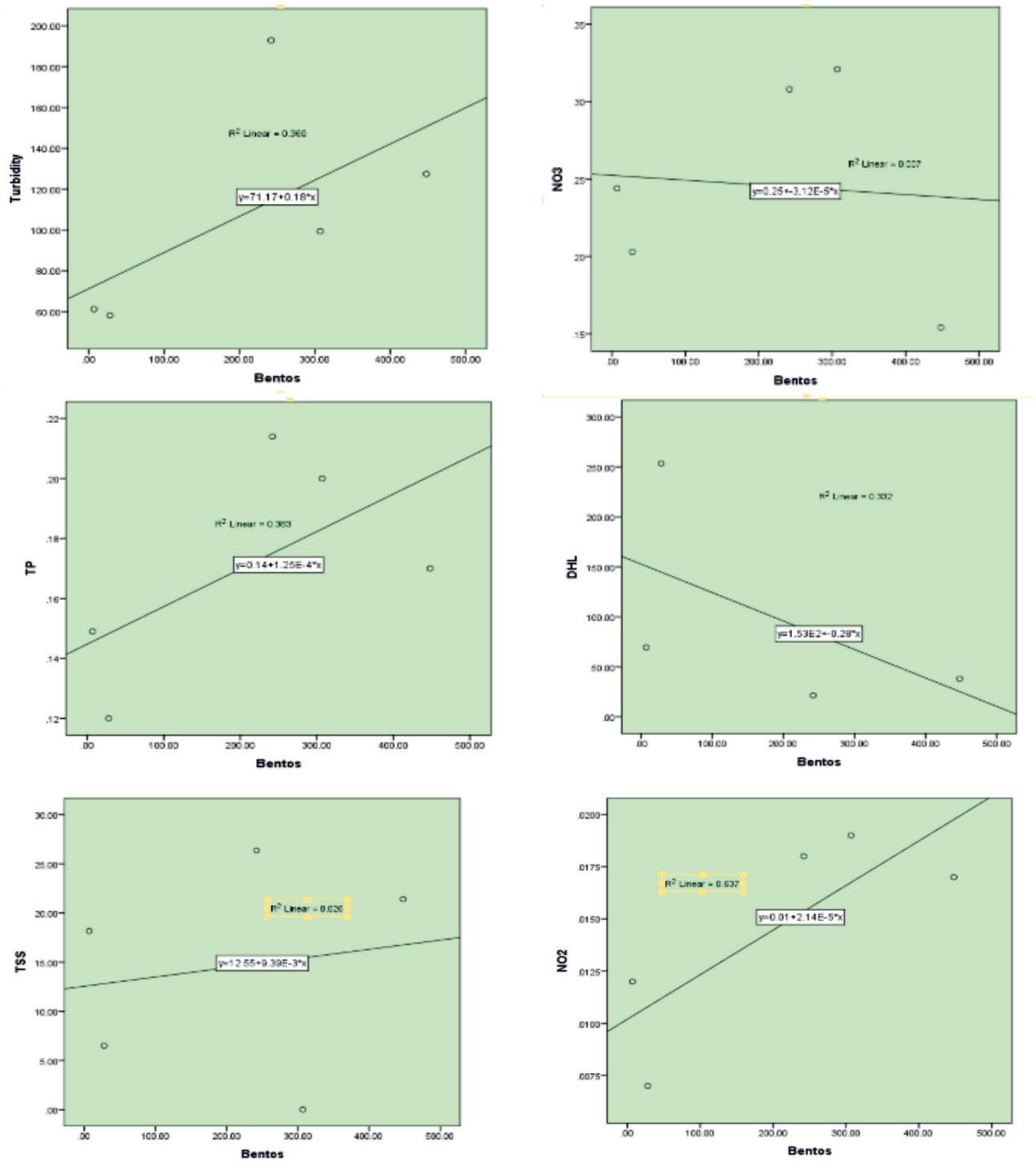

Fig. 5. Relationship of water quality with macrozoobenthos, Semayang Lake, Indonesia.

Conclusions

Lake Semayang has a high diversity of macrozoobenthos in the Tubificidae and Thiaridae families, namely *B. sowerbyi* and *Melanoides* sp, and with moderate category dominance, so it can be concluded that the condition of the waters of Semayang Lake is still stable and not polluted, rich in organic matter with low *dissolved oxygen* (DO) conditions and highly suspended particles.

Acknowledgments

The author would like thanks to Research Institute for Inland Fisheries and Extension for facilitating this research through the budget as well as all the teams involved in research activities at Lake Semayang, East Kalimantan.

Conflict of Interest

The authors declare no conflict of interest.

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