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The structure and composition of macrozoobenthos community in varying water qualities in Kalibaru Waters, Bengkulu, Indonesia

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Abstract. *Lilisti, Zamdial, Hartono D, Brata B, Simarmata M. 2021. The structure and composition of macrozoobenthos community in varying water qualities in Kalibaru Waters, Bengkulu, Indonesia. Biodiversitas 22: 106-112.* Various human activities affect the quality of the aquatic ecosystem that can be assessed by measuring the physical, chemical, and biological parameters of the waters and sediments. This is the case of Kalibaru Waters, Bengkulu, Indonesia which shows changes in the estuary and marine ecosystems due to the cut-off of the main river around the area for the development of roads and bridges. The objective of this study was to analyze the quality of the waters and substrate, and the structure of the macrozoobenthos community as a bioindicator at the Kalibaru Waters. A survey was carried out in four stations, which was purposively selected based on human activities around the waters. Data collected included the physical and chemical parameters, and the diversity and density of macrozoobenthos species. The density of macrozoobenthos species was analyzed for summed dominance ratio (SDR), diversity (H'), homogeneity (E), and dominance (D) indices. The results showed that the physical and chemical parameters of Kalibaru Waters were acceptable for aquatic life, however, the oil contents at two stations exceeded the ecological threshold. Analysis of the macrozoobenthos community as a bioindicator for water quality found that the diversity and homogeneity indices were at a medium level indicating an unstable community, while the dominant index remained low indicating that none of the species was dominant in the Kalibaru Waters. This information is needed as a reference for the government of Bengkulu Province to make appropriate policies and management decisions to maintain the quality of the aquatic ecosystem in Kalibaru Waters.

Keywords: Bioindicator, macrozoobenthos, physical and chemical parameters, transitional waters

INTRODUCTION

The accumulation of waste for a long period reduced the quality of water and sediments in the aquatic ecosystem (Tabatabaie and Amitri 2011). Water quality measurements include a variety of physical and chemical parameters, which are crucial factors in determining the degradation level in aquatic ecosystems (Grag et al. 2009; Sahin 2012; Xu et al. 2013). Physical parameters include temperature, flow, depth, salinity, transparency, while the chemical include DO (dissolved oxygen), degree of acidity (pH), and BOD_5 (biochemical oxygen demand) (Sarda and Sadgir 2015; Kale 2016). The composition of macrozoobenthos fauna as a biological parameter for water quality is related to the combination of physical and chemical factors (Doric and Cucukovic 2018).

Kalibaru Waters are located on the west coast of Bengkulu City, Bengkulu Province, Indonesia. The waters are estuaries that have been separated from the main river since 1990. This was due to the construction of new roads and bridges to access the plantation and community settlements, which shut the inlet water from the Jenggalu River. The Kalibaru Waters face the Indian Ocean and are adjacent to the Port of Pulau Baai, Bengkulu, therefore, dominantly influenced by the ocean (Zamdial et al. 2018). The rapid population growth and development of industrial activities in the coastal area of Bengkulu, increased the ecological pressure on ecosystems including Kalibaru Waters (Zamdial et al. 2018). The human activities carried out in these waters affected their quality, such as boat fishing, oil refueling, fishery product processing, construction of warehouses, and fishermen's bases. However, they are being used as a source of water for shrimp farming and transportation for mangrove tourism visitors. The quality of the waters' surface and the sediment are crucial issues in managing aquatic ecosystems (Kale 2016; Sahidin et al. 2018).

Macrozoobenthos are passive organisms living at the bottom of the waters (Astrini et al. 2013; Hakiki et al. 2017). The substrate where macrozoobenthos inhabit is made of inanimate materials, namely physical and chemical components consisting of soil, water, air, sunlight, and other materials (Collier et al. 1998; Krepski et al. 2014). Some substrate parameters include temperature, pH, C- and N-organic, texture, and oil content (Collier et al. 1998). The C- and N-organic content in the substrate shows the level of organic matter contained in the sediment. Oil content is an important parameter for assessing water quality and it usually comes from the waste of port activities (Nurrachmi and Amin 2007; Tabatabaie and Amitri 2011). The acidity degree of the substrate is strongly influenced by the conditions of the waters above it. When the pH of the waters is high, the pH of the substrate will increase, and vice versa (Kale 2016).

Decreasing water quality will disturb the life of aquatic organisms including macrozoobenthos (Cieminski and Zdanowski 2009). Change in their community is often used as a bioindicator to determine water quality (Effendi et al. 2015). Li et al. (2019) showed that aquatic bioindicators are a sensitive group of organisms providing clues of environmental pressures and biotic systems' destruction. The quality of surface waters and the sediment is crucial issue for the management of aquatic ecosystems (Kale 2016; Sahidin et al. 2018). That is the case of Kalibaru Waters which show conflicting interests between economic activities and environmental conservation. As such, there is a need to assess the state regulation of Kalibaru Waters as a tool to monitor the quality of the waters. This study aims to analyze the composition of the macrozoobenthos community in Kalibaru Waters and its relationship with the physical and chemical parameters as indicators of the ecosystem quality. We expect that the results of this study can serve as baseline information to monitor the condition of Kalibaru Waters to be used as a reference for management decisions.

MATERIALS AND METHODS

Study period and area

The data collection was conducted in June 2019 and located in Kalibaru Waters, Subdistrict of Kampung Melayu, Bengkulu City, Bengkulu Province, Indonesia at the geographical position of 3^0 45' to 3^0 59' south latitude and 102^0 14' to 102^0 22' east longitude (Figure 1).

Sampling procedures

The observations were started by selecting sampling locations. There were four sampling locations, named Station 1, 2, 3, and 4, which were selected purposively based on existing activities around the observation site (Figure 1). Station 1 was located at the north part of Kalibaru Waters, close to residential areas, and mostly used for fishing vessels docked. Station 2 was also located close to residential areas and placed for processing fishery products. Station 3 was located in the area used for waste disposal. And Station 4 was located at the south part of Kalibaru Waters, away from settlements and around the mangrove forests. The instruments used for data collection are listed in Table 1.

Sampling locations in each station were reached by a small boat. The sample and data collected in each station were carried out in one day during June 2019, started in the morning and ended in the afternoon. The water samples were taken using a Horizontal Water Sampler tool. The instrument was drowned in the water to pick up the water samples and put them into bottles for further analysis. The process of collecting the water samples was repeated four times with the same procedure at each observation station. Physical parameters, including temperature, water depth, transparency, and current flow velocity, were observed at the study site; while chemical parameters, including dissolved oxygen (DO), salinity, nitrite, nitrate, phosphate, and biochemical oxygen demand (BOD_5), were measured in the Laboratory of Aquaculture, the University of Professor Hazairin Bengkulu, Indonesia.

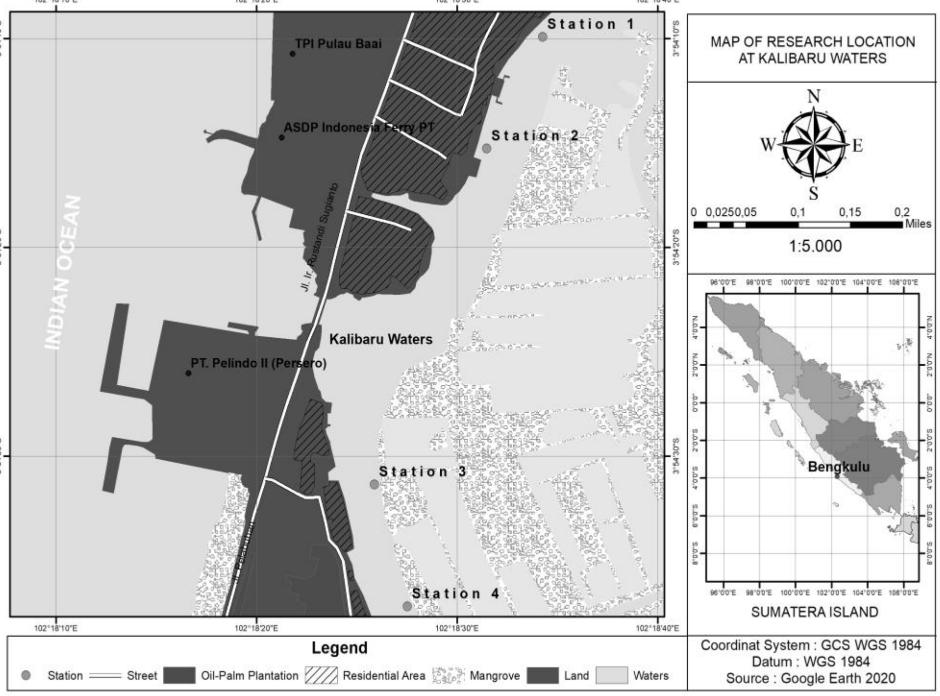

Figure 1. Map of the research location in the Kalibaru Waters, Bengkulu City, Bengkulu Province, Indonesia

Table 1. Instruments used for observation of the waters and substrate in Kalibaru Waters, Bengkulu, Indonesia

Instruments	Variable measured (unit)	Function
Thermometer	Temperature (°C)	-
Scale Rope	Water depth (cm)	-
Secchi disc	Waters transparency (cm)	-
Hand Refractometer	Waters salinity (ppm)	-
DO-Meter	DOB/BOD_5 (mg $L^{-1)}$	-
Horizontal Water Sampler	-	Water container
Ekman grab	-	Collecting substrate and macrozoobenthos samples
1-mm Strainer	-	Strain the macrozoobenthos of substrate
Stopwatch	-	Timer

The substrate samplings were collected using Ekman grab from the bottom of waters at the four research stations, and were analyzed for physical, chemical, and biological parameters. The tool was drowned at the bottom and lifted. The substrate samples were obtained, filtered with a 1-mm sieve, and inserted into a sample container or bottle. Similar procedures were repeated four times at each station. Macrozoobenthos were filtered and preserved with formalin 5%, and identified at the Marine Laboratory of BPTP Bengkulu, Indonesia. The substrate samples were further analyzed to identify the texture, C-organic, N-organic, oil, and pH at the Laboratory of Natural Sciences, Bengkulu University, Indonesia.

Data analysis

The data on physical and biological parameters were compared, whether they exceeded the standard qualifications based on the Environmental Regulation of Indonesia No. 51 (2004). The data of macrozoobenthos community were analyzed to obtain the density of species in meter square (N), summed dominance ratio (SDR), diversity index (H'), uniformity index (E), and dominance index (D) as described in equations 1, 2, 3, 4 and 5 (Brower et al. 1989).

$$N = \frac{10.000 \ x \ Xi}{A} \quad \text{(Equation 1)}$$

Where: N is macrozoobenthos density per m^2; a 10.000 is the conversion factor from cm^2 to m^2; Xi is the number of macrozoobenthos caught on by Ekman grab; A is the surface area of Ekman grab (cm^2).

$$SDR = \frac{RF + RD}{2} \ x \ 100\,\% \quad \text{(Equation 2)}$$

Where: SDR is summed dominance ratio; RF is relative frequency, the ratio of a species frequency to the total frequency of all species; and RD is relative density, the ratio of a species density to the total density of all species.

$$H' = -\sum_{n-i}^{s} \mathrm{Pi}\, ln(\mathrm{Pi}) \quad \text{(Equation 3)}$$

Where: H' is diversity index; s is the number of genera; Pi is the proportion of individual species (i) to some individuals; ni is the number of individual species; H' < 1: low diversity; 1< H'< 3: medium diversity; and H' > 3: high diversity.

$$E = \frac{H'}{Hmax} \quad \text{(Equation 4)}$$

Where: E is homogeneity index; H'is diversity index; H_{max} is ln S; 0 < E < 0.50: depressed community; 0.05 < E < 0.75: unstable community; and 0.75 < E < 1.0: stabil community.

$$D = \sum (ni/N)^{2} \quad \text{(Equation 5)}$$

Where: D is dominance index; *ni* is the individual number in a species; N is the total number of individual of all species; 0 < D < 0.5: low dominance; 05 < D < 0.75: medium dominance; and 0.75 < D < 1.0: high dominance.

RESULTS AND DISCUSSION

Physical and chemical parameters

The data on physical and chemical parameters in Kalibaru Waters are presented in Table 2. The temperatures at Stations 1 and 2 were 28-30°C, Stations 3 and 4 were 30-31°C and 28-31°C, respectively. The depth of the waters at Stations 1, 3, and 4 were 150-160 cm, while Station 2 was the deepest, ranging from 250-301 cm. The lowest transparency was at Station 3 of 70-74 cm, while the transparency at Stations 1, 2, and 4 were 96-121, 119-120, and 110-120 cm, respectively. The velocity of current flow at Station 1 was 11.6-12.5 cm sec^{-1}, while Stations 2, 3, and 4 were 13.7-16, 14-19, and 17.9-20 cm sec^{-1}, respectively.

The combination of the physical conditions of the water ecosystem can influence the quality related to aquatic life (Grag et al. 2009). The range of water temperature, depth, transparency, and current flow velocity in Kalibaru Waters was still at the acceptable level for macrozoobenthos life as described by Buffle and Vitre (1994) and in line with the Environmental Regulation of Republic of Indonesia No. 51 (2004). However, the transparency of the water at Station 3 was very low compared to other stations. The low level of transparency indicated turbid water (Kale 2016). This condition is because of the position of Station 3 which is close to the waste disposal of the community settlement. According to Li et al. (2019), macrozoobenthos animals are not much influenced by turbidity. However, they are more dominant in shallow waters with calm currents because their inherent nature is relatively slow movement. Humphries (1996) and Hakiki et al. (2017) stated that increasing water velocity and depth decrease the macrozoobenthic density.

Table 2. The range of physical and chemical parameters of water in Kalibaru Waters, Bengkulu, Indonesia observed in four stations

Parameter	Unit	Station 1	Station 2	Station 3	Station 4
Temperature	^{0}C	29 - 30	29 - 30	30 - 31	28 - 31
Depth	cm	150 - 160	250 - 301	150 - 160	156 - 160
Clearness	cm	96 - 121	119 - 120	70 - 74	110 - 120
Flow rate	cm sec^{-1}	11.6 -12.5	13.7 - 16	14 - 19	17.9 - 20
DO	mg L^{-1}	3.0 - 6.29	4.0 - 6.3	4.7	3.6 - 4.0
pH	-	7.0 - 8.3	7.0 - 8.7	8.3	8.4
Salinity	ppm	29 - 31	29 - 31	29	29
Nitrite	mg L^{-1}	0.05	0.04	0.04	0.04
Nitrate	mg L^{-1}	0.0003	0.0002	0.0001	0.0002
Phosphate	mg L^{-1}	0.01	0.01	0.02	0.02
BOD_5	mg L^{-1}	1.4 - 2.9	1.3 - 3.42	1.12 - 3.2	2.12 - 2.4

Notes: The quality standards for marine life in marine tourism: temperature (28 - 32 C), flow rate (<50 cm sec^{-1}), DO (>3 mg L^{-1}), pH (5 - 9), nitrite (< 0.06 mg L^{-1}), nitrate (<0.008 mg L^{-1}), BOD_5 (< 1: no pollution, 1-3: light pollution, 3-6: moderate pollution (Environmental Regulation of Republic Indonesia No. 51. 2004)

The data on the water chemical parameters included DO (dissolved oxygen), BOD_5 (biochemical oxygen demand), pH, salinity, nitrite (NO_2), nitrate (NO_3), and phosphate (PO_4) were presented in Table 2. The DO measurements at Stations 1, 2, 3, and 4 were 3.6-6.29, 4.0-6.3, 4.7, and 3.6-4.0 mg L^{-1}, respectively. The aquatic fauna needs dissolved oxygen level of > 3 ppm, and only certain organisms can survive in conditions with < 3 ppm (Xu et al. 2013; Basyuni et al. 2018). The BOD_5 values at Stations 1, 2, 3 and 4 were 1.4-2.9, 1.3-3.4, 1.12-3.2 and 2.12-2.4 mg L^{-1}, respectively. The results of the BOD_5 observations indicated that the quality of Kalibaru Waters was lightly to moderately polluted as described by Buffle and Vitre (1994). BOD_5 is the amount of oxygen needed by microorganisms in the decomposition process of organic matter (Sarda and Sadgir 2015; Kale 2016). The increase in BOD_5 indicated the rise in organic matter oxidation (Astrini et al. 2013). The degree of acidity (pH) at Stations 1 to 4 were in the range of 7.0-8.7, and this acidity level was acceptable for macrozoobenthos (Sahidin et al. 2018). Salinity levels were relatively the same at all stations, ranging from 29-31 mg L^{-1}. According to Zamdial et al. (2018), the location of Kalibaru Waters is directly connected to the ocean for tidal effects are to be very dominant in determining the salinity levels.

The content of nitrite, nitrate, and phosphate are also provided in Table 2. The nitrite concentration in water was 0.04-0.05 mg L^{-1}, while the tolerable limit for benthic life is < 0.06 mg L^{-1} (Buffle and Vitre 1994; Krepski et al. 2014). Nitrate content at Stations 1, 2, 3 and 4 were 0.0003, 0.0002, 0.0001 and 0.0002 mg L^{-1}, respectively. Nitrates are formed in the nitrification process by *Nitrosomonas* and *Nitrobacter*, which requires carbon and oxygen as energy sources (Odum and Barret 2005). The tolerated concentration of nitrate in water is < 0.008 mg L^{-1} as stated in the Environmental Regulation of Republic of Indonesia No. 51 (2004). The measurements of phosphate in all stations were between 0.01-0.02 mg L^{-1}, indicating that Kalibaru Waters were in moderate fertility. The process of dissolving organic compounds in the waters undergoes hydrolysis to form phosphate (PO_4). Phosphate molecules are not toxic; however, the excess availability of nitrate (NO_3) and phosphate (PO_4) can cause the blooming of algae, inhibiting the penetration of oxygen and sunlight into the water (Tabatabaie and Amitri 2011).

The data on physical and chemical parameters in the sediment of Kalibaru Waters were presented in Table 3. The texture of the substrate contains sand, clay, and dust of 98.44-98.45, 0.62-0.63, and 0.93 percent, respectively. The texture was dominated by sand because clay and dust particles were carried away by the water currents. The sand texture allows the macrozoobenthos species to live and develop in the water (Collier et al. 1998; Ruswahyuni et al. 2013). The acidity (pH) at the bottom of the waters was at a normal level of 6.2-6.7. The degree of acidity (pH) of the substrate is influenced by the conditions of the waters above it, when the pH of the water is high, that of the substrate is also high, and vice versa (Humphries 1996; Krepski et al. 2014). The content of C- and N-organic were in the range of 1.5-1.65 and 0.44-0.47 mg L^{-1}, respectively, indicating moderate fertility (Odum and Barrett 2005). The C- and N-organic content are associated with the level of organic matter in the substrate (Collier et al. 1998). Organic materials can be renewed, recycled, and broken down by bacteria into becoming nutrients, and used by living organisms at the bottom of the waters (Sahidin et al. 2018). The N-organic at the bottom of the waters comes from soil organic matter, N-fixing organism, and rainwater. Organic materials also release N and other compounds after undergoing a decomposition process by the activity of microorganisms on the substrate (Ruswahyuni et al. 2013).

The oil content measured at Stations 1, 2, 3, and 4 were provided in Table 3. The oil content at Stations 1 and 2 exceeded the threshold (> 1000 mg L^{-1}) set by the Environment Regulation of Republic of Indonesia No. 51 (2004). However, at Stations 3 and 4, the oil content was smaller than the recommended threshold. Stations 1 and 2 were located close to community settlements with dense industrial activities, such as fishery product processing, aquaculture ponds, and fishing bases. The oil content at Stations 1 and 2 that exceeded the threshold by environmental regulation, were possibly loaded from the pollution or waste from fishing bases, spills of oil, and ship cleaning (Tabatabaie and Amitri 2011; Zamdial et al. 2018). Meanwhile, Stations 3 and 4 were located far away from communities and close to mangrove forests, allowing the oil content to remain below the threshold of less than 1,000 mg L^{-1}.

Analysis of macrozoobenthos community

The difference of macrozoobenthos communities is one of the bioindicators in assessing the quality of an aquatic environment (Basyuni et al. 2018). The structure of macrozoobenthos observed in Kalibaru Waters were 9 species, 7 families, and 4 classes (Table 4). The total density of macrozoobenthos at Stations 1 and 2 was lower than that at Station 3 and 4. The benthos classes found at Station 1 were Gastropoda and Polychaeta, at Stations 2 and 3 were Pelecypoda, Gastropoda, Polychaeta and Arthropoda, and at Station 4 were Pelecypoda, Gastropoda, and Arthropoda. The families of benthos in the class of Pelecypoda are Tellinidae and Veneridae; in the class of Gastropoda are Cerithidae and Potamidae; in the class of Polychaeta are Lumbrinedae and Arabellidae, and in the class of Arthropoda is Crustacea. The analysis of the summed dominance ratio (SDR) of macrozoobenthos species counted the values of SDR per species which were 18, 16, 13, 13, 11, 9, 7, 7, and 6 % namely *Cerithium* sp., *Terebalia* sp., *Sunetta* sp., *Tellina* sp., *Temoclea* sp., *Euphausia* sp., *Drilonereis* sp., *Lumbrinerreis* sp., and *Liocarcinus* sp., respectively.

The structure of the macrozoobenthos community is influenced by the quality of the waters (Xu et al. 2013; Pratiwi et al. 2020). As described by Sihombing et al. (2007) and Sahin (2012), physical and chemical parameters are related to the differences of benthic communities. As shown in Table 2, the deepest water of 250-301 cm was found at Station 2, the highest nitrite content of 0.004 mg L^{-1} was found at Station 1, and the highest oil content, as shown in Table 3, were 15,097 and 10,143 mg L^{-1} found at Stations 1 and 2, respectively. According to Zamdial et al. (2018), the Kalibaru Waters are the estuary that had been cut off and do not flow as regularly river. However, they continuously receive wastes and other pollutants from settlements and oil spills from motorboats. Oil is toxic to aquatic life and suppresses the development of certain macrozoobenthos species (Nurrachmi and Amin 2007).

Table 5. Diversity, homogeneity, and dominance indices of macrozoobenthos in Kalibaru Waters, Bengkulu, Indonesia

Station	Diversity Index (H')	Homogeneity Index (E)	Dominance Index (D)
1	1.041	0.684	0.371
2	1.821	0.662	0.172
3	1.895	0.705	0.201
4	1.828	0.651	0.171

Table 3. The range of physical and chemical parameters of the substrate in Kalibaru Waters, Bengkulu, Indonesia observed in four stations

Parameter	Unit	Station 1	Station 2	Station 3	Station 4
pH	-	6.2 - 6.5	6.3 - 6.5	6.5 - 6.7	6.6 - 6.7
Sand	%	98.45	98.45	98.44	98.44
Clay	%	0.62	0.62	0.63	0.63
Dust	%	0.93	0.93	0.93	0.93
C-Organic	%	1.5	1.56 - 1.65	1.65	1.65
N-Organic	%	0.44	0.44 - 0.47	0.44	0.47
Oil	mg L^{-1}	15,097	10,143	1,711	1,451

Notes: The quality standards for marine life in marine tourism: Oil (<1000 mg L^{-1}) (Environmental Regulation of Republic Indonesia No. 51. the Year of 2004)

Table 4. Diversity, composition, and structure of macrozoobenthos community in Kalibaru Waters, Bengkulu, Indonesia

Class	Family	Species	Density (individuals m^{-2})				TD	TF	RD	RF	SDR (%)
			St. 1	St. 2	St. 3	St. 4					
Pelecypoda	Tellinidae	*Tellina* sp.	0	79	403	429	911	3	0.15	0.11	13
	Veneridae	*Timoclea* sp.	0	0	442	533	975	2	0.16	0.07	11
		Sunetta sp.	0	130	442	429	1,001	3	0.16	0.11	13
Gastropoda	Cerithidae	*Cerithium* sp.	39	171	546	494	1,250	4	0.20	0.15	18
	Potamidae	*Terebalia* sp.	39	157	429	442	1,067	4	0.17	0.15	16
Polychaeta	Lumbrinedae	*Lumbrinereis* sp.	52	52	39	0	143	3	0.02	0.11	7
	Arabellidae	*Drilonereis* sp.	65	91	39	0	195	3	0.03	0.11	7
Arthropoda	Crustacea	*Euphausia* sp.	0	65	156	143	364	3	0.06	0.11	9
		Liocarcinus sp.	0	0	130	104	234	2	0.04	0.07	6
	Total		195	745	2,626	2,574	6,140	27	1.00	1.00	100

Note: TD: Total density; TF: Total frequency; RD: Relative density; RF: Relative frequency; SDR: Summed dominance ratio

Table 4 showed that macrozoobenthos species of *Temoclea* sp. (Pelecypoda) and *Liocarcinus* sp. (Arthropoda) are very sensitive and have very low adaptability to the oil content of 10,143 and 15,097 mg L^{-1} in Stations 2 and 1, respectively. Macrozoobenthos of *Tellina* sp. and *Sunetta* sp. (Pelecypoda), *Euphausia* sp. (Arthropoda) were indicated to have low adaptability to the highest oil content of 15,097 mg L^{-1} in Station 1. This was in line with Nurrachmi and Amin (2007) and Sihombing et al. (2007), stating that some species of macrozoobenthos were very sensitive to degraded environmental quality, such as high oil content in the waters, they are therefore used as biological parameters of water pollution (Collier et a. 1998). However, *Cerithium* sp. and *Terebalia* sp. (Gastropoda), as well as *Lumbrinerreis* sp. and *Drolonereis* sp. (Polychaeta) were found at Stations 1 and 2, indicating that both of these species adapt well to the high oil content of 15,097 mg L^{-1}. The class of Gastropoda including *Cerithium* sp. and *Terebalia* sp. made extensive adaptations to all circumstances at the bottom of the water, including the high oil content, therefore, developing widespread with varying densities. However, the class of Polychaeta was also able to survive in oil-polluted conditions as seen at Stations 1 and 2, while the density of *Lumbrinereis* sp. and *Drilonereis* sp. decreased in Station 3 and none of them was found in Station 4. Probably the higher flow rate of the water of 17.9 - 20 cm sec^{-1} compared with the other stations may be used as an indicator of this circumstance. The difference in the population number of macrozoobenthos species indicates the level of tolerance to pollution. High organic matter, low oxygen content, and sandy texture of the sediments are some parameters influencing the growth and development of macrozoobenthos on bottom substrate (Ruswahyuni et al. 2013). Doric and Cucukoviz (2018) stated that organisms from the Polychaeta class inhabited the surface of sand and mud by digging and forming tubes.

The indices of diversity (H'), homogeneity (E), and dominance (D) were presented in Table 5. The values of the diversity index were 1.041, 1.821, 1.895, and 1.828, respectively at Stations 1, 2, 3, and 4. These data showed that the diversity was at a moderate level, except at Station 1 which was the lowest and close to 1. The low diversity index in Station 1 indicates that the individual distribution of each species tends to be uneven and the stability of the benthos community tends to be low. The smaller number of species with low-density results in an imbalance of the ecosystem. This may due to ecological pressure or disturbance from the surrounding environment as observed in Stations 1 and 2 (Tabatabaie and Amitri 2011).

The homogeneity index (E) at Stations 1, 2, 3 and 4 were 0.684, 0.662, 0.705 and 0.651, respectively (Table 4). These indicated that the community was unstable because of the low heterogeneity of the macrozoobenthos living on the sediment inside the water. According to Doric and Cucukovic (2018), this condition needs energy input to maintain the stability of the ecosystem. The dominance index (D) of the Stations 1, 2, 3 and 4 were 0.371, 0.172, 0.201 and 0.171, respectively. These indicated a low dominance, i.e., there was no extreme density of the macrozoobenthos species in Kalibaru Waters. This showed that none of the observed species dominated the macrozoobenthos community (Ruswahyuni et al. 2013; Pratiwi et al. 2020).

In conclusion, the ecological quality in Kalibaru Waters based on the physical and chemical parameters was still at an acceptable level for the aquatic life, except for the high oil content found in Station 1 and Station 2. Macrozoobenthos species of *Temoclea* sp. (Pelecypoda) and *Liocarcinus* sp. (Arthropoda) were indicated to have very low adaptability to the high oil content, while that of *Tellina* sp. and *Sunetta* sp. (Pelecypoda), and *Euphausia* sp. (Arthropoda) were low. These benthos species were used as biological indicators for oil-polluted water environment. The diversity and homogeneity in Kalibaru Waters were at a medium level, categorizing it in the unstable community. Meanwhile, the dominance index remained low indicating that none of the benthic species was dominant in Kalibaru Waters. Based on the SDR values, the most adaptive species in the Kalibaru Waters were *Cerithium* sp. and *Terabalia* sp. (Gastropoda) while the least, which were used as bioindicators for degradable water quality are *Liocarcinus* sp. (Arthropoda).

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