

# Study of The Relationship of Water Quality with The Ecological Index of Aquatic Biota in The Permata Pilang Beach Estuary Area, Probolinggo

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## ABSTRACT

The sustainable use of estuary areas is needed to maintain the sustainability. The purpose of this research is to know the relationship of water quality with ecological index of aquatic biota in The Permata Pilang Beach Estuary Area, Probolinggo. The method used is survey with data analysis Principal Component Analysis. The results of showed that the temperature was 31.5-33.6°C, pH of 8.1-8.2, salinity of 1.6-32.1 ppt, DO of 11.1 – 11.8 mg/L, and water transparency of 0.5-1 meters. The grain size of the sediment is dominated by the fine sand. Found 20 species of macrozoobenthos which consisted of 10 species of gastropods and 10 species of bivalve. Fish community structure found 3 fish species (*Chanos chanos*, *Mugil cephalus*, *Acentrogobius audax*). The results of PCA analysis, it was found that the diversity of macrozoobenthos has a positive relationship with temperature and pH. The evenness of macrozoobenthos has a positive relationship with temperature, the dominance of macrozoobenthos has a positive relationship with salinity, pH, DO and water transparency. Fish diversity and evenness had a positive relationship with temperature and DO. Fish domination index has a positive relationship with salinity, pH and water transparency.

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## Introduction

Coastal areas that have a fairly high fertility rate are estuaries. Several areas in Indonesia that have a fairly large estuary area are the coastal areas of Sumatra, Kalimantan, the northern coast of Java and Irian Jaya (Asyiwati & Akliyah, 2014). Estuary is a mixing zone of fresh water from rivers and sea water which produces a unique, complex and dynamic environmental and biota condition. The estuary water environment is an environment that is rich in nutrient sources, so it is known as a nursery ground where there are many types of economically important fish, invertebrates (crustaceans, bivalve, echinoderms, annelids) and infauna groups. The estuary area includes river mouths and large deltas, mangrove forests near estuaries and vast expanses of mud

and sand (Asyiwati & Akliyah, 2014). One of the beaches in the north of Probolinggo City is Permata Pilang Beach. Permata Pilang Beach has the characteristics of tidal areas with muddy habitats and mangrove ecosystems. One of the important ecosystems in the Permata Pilang Beach area is the estuary.

Aquatic biota is biota that part or all of its life is in the waters. Aquatic biota based on their way of life are grouped into neuston, pleuston, nekton, plankton, periphyton, benthic and demersal. The structure of the aquatic biota community is largely determined by the physical and chemical conditions of the waters. This allows aquatic biota to be used as bioindicators of changes in water quality (Sulistiyaningsih & Arbi, 2020). There are several aquatic biota that

exist in the estuary area including benthos and fish. Estuary areas have an important role for aquatic ecology, including as a habitat for various stages in the life stadia of fish. The distribution of fish in rivers to estuaries in the tropics is an interesting study for aquatic ecologists (Mote, 2017). In addition, organisms that have a long survival are macrozoobenthos. Macrozoobenthos acts as an indicator of ecological conditions in certain areas (Ramadhan et al, 2021; Olli & Paramata, 2019).

The sustainable use of estuary areas is needed to maintain its sustainability through an understanding of the characteristics of estuaries. Understanding of estuary characteristics includes water quality and aquatic organisms in the estuary area. Based on this background, research is needed that aims to determine the relationship between water quality and the ecological index of aquatic biota in the estuary of Permata Pilang Beach, Probolinggo.

## Materials and Methods

The location of this research was conducted in the estuary of Permata Pilang Beach, Pilang District, Probolinggo City with consideration of differences in salinity values. There are 4 different stations, namely in areas near ponds, near mangroves (*Avicennia sp*), river estuaries, and the sea. This research was conducted in December 2020-June 2021.

Fish samples were taken using nets and fishing rods. The fish samples obtained were then washed with aquadest, then put into a 4% formalin solution which was then identified (Adiguna et al, 2018). Sampling of macrozoobenthos and sediments was carried out using the Ekman Grab. Sediment containing macrozoobenthos was filtered using a sieve. The macrozoobenthos were then separated from the substrate and put into plastic, given 4% formalin. The collected samples are labeled which will then be identified (Jhonatan et al, 2016). Measurement of water quality using DO meter, pH meter, refractometer, secchi disk, and thermometer.

Data Processing is carried out at the Integration Laboratory of UIN Sunan Ampel Surabaya. Laboratory studies were carried out to determine abundance and biomass, species identification using the FAO 1998 guide "The Living Marine Resources of the Western Central

Pacific" and various related reference sources. Laboratory study biomass was used to determine the Shannon-Wiener diversity index, evenness index and Simpson dominance index.

The sediment was analyzed using the dry sieve method on a sieve net. Several parameters of the water quality produced are compared with the environmental quality standards that apply in Indonesia, namely Kepmen LH number 51 of 2004 concerning the criteria for sea water quality standards for marine biota. The relationship between water quality and the ecological index of aquatic biota uses the XLSTAT 2021 statistical tool with the Principal Component Analysis method. The interval values are presented in table 1.

**Table 1 The value of the relationship interval between variables**

Coefficient interval	Relationship level
0.00- 0.199	Very low
0.20 – 0.399	Low
0.40 – 0.599	Medium
0.60 – 0.799	Strong
0.80 -1.00	Very strong

Source: (Khoiriyah, 2019)

## Results and Discussion

### Water Quality

The results of observations of the physical and chemical quality can be seen in table 2.

**Table 2 Water quality**

Parameter	Unit	Station			
		I	II	III	IV
Temperatur	°C	31,5	31.7	33.6	31.6
Salinity	ppt	1.6	11.5	31.0	32.1
pH	-	8.1	8.1	8.1	8.2
DO	mg/L	11.6	11.1	11.8	11.7
Water transparency	m	0.5	0.5	0.6	1.0

Source: Data Processing, 2021

The surface temperature shows that the highest temperature value is at station II which is in the near mangroves, the high temperature value is thought to be due to sunlight that enters the mangrove area which is rather open. According to Sidabutar et al (2019), stated that the mass movement of fresh water and river flows that enter the waters can cause heat due to friction between water molecules so that the seawater temperature becomes warmer. According to Irmawan et al (2010), stated that a good water temperature for benthic life is 20-30°C with

fluctuations of no more than 5°C. The high value of sea surface temperature in the estuary area of Permata Pilang Beach is due to the shallow depth of the water so that heating is more intensive and data collection is carried out during the day where the intensity of solar radiation is high. According to rahmadi, high temperature affect the life of biota which includes physical, chemical and biological process. According to Arbi (2013), states that the high and low water temperatures are influenced by meteorological factors such as rainfall, evaporation, humidity, air temperature, wind speed and intensity of solar radiation.

Salinity in the estuary of Permata Pilang Beach, resulted in low salinity values at stations I and II due to the supply of fresh water through rivers that emptied into sea waters. The distribution of salinity values from estuaries, estuaries to the high seas shows an increasing salinity value. Salinity in a waters that affects the growth and distribution of aquatic biota, making it one of the determining factors for the distribution of marine biota such as macrozoobenthos which is included in the marine biota euryhaline organisms (Hariawansyah et al, 2019). According to Hamuna et al (2018), it is stated that salinity levels in estuaries are low due to the influence of incoming fresh water and ebb and flow in the area.

The pH value at stations I, II and III is 8.1 while station IV is worth 8.2. The pH in the estuary of Permata Pilang Beach is in accordance with the quality standard of Kepmen LH number 51 of 2004 which states that the pH for aquatic biota is 7-8.5. According to Hamuna et al (2018), states that an alkaline or acidic pH value will be harmful to the survival of an organism because it interferes with metabolic and respiratory processes.

DO value at station I DO value is 11.6 mg/L, station II of 11.1 mg/L, station III of 11.8 mg/L and station IV of 11.7 mg/L. The DO obtained meets the sea water quality standards for marine biota in the KEPMEN LH number 51 of 2004 with a DO value of > 5 mg/L. According to Megawati et al (2014), states that the DO is one of the main supports for marine life and an indicator of water fertility. DO levels decrease along with the increasing organic waste in the waters. This is due to the presence of oxygen, which is needed by bacteria to decompose organic substances into inorganic substances.

The water transparency of the waters at each observation station can be seen in table 2. According to Arizuna et al (2014), stated that a good water transparency value for living organisms is greater than 0.45 meters, this is because the water penetration and absorption process can run optimally. According to Hamuna et al (2018), stated that the level of water transparency is influenced by turbidity, where the level of water transparency will affect the level of photosynthesis of biota in the waters.

Sediment, grain size classification of estuary sediments at estuary area of Permata Pilang Beach, Probolinggo shows the category of very fine sand to coarse sand. The grain size distribution is influenced by several oceanographic factors such as currents, waves, winds and tides. According to Nugroho et al (2012), that fine sand have a relatively higher oxygen content than smooth substrates, because there are air pores that function as a place for more intensive nutrient mixing with the water above. Gastropods live by immersing themselves in mud or sand which contains remnants of organic substances and phytoplankton that live on the bottom of the soil.

### **Macrozoobenthos Community Structure**

In the Pemata Pilang Beach estuary, Probolinggo, 10 species of gastropods and 10 species of bivalve were found from 4 research stations can be seen in 3.

The research of Palealu et al (2018), states that the relative abundance value serves to determine the number of a species contained in the research station. Table 3 the highest relative abundance at station I is *Telescopium telescopium* because it is close to the aquaculture area. The anatomical structure of the *Telescopium telescopium* allows it to adapt to pond habitats. The aquaculture area has high nutrients due to the abundance of microalgae which are food for *Telescopium telescopium* (Arbi, 2013). The highest abundance of bivalve class at station I was *Acteocina striata*. *Acteocina striata* is a cosmopolitan shellfish and is the most abundant in the tropics. Station I has a type of fine sand sediment fraction so that it is suitable for *Acteocina striata* habitat. Based on the research of Heryanto & Radjab (2014), *Acteocina striata* was found on fine sand substrates. The fine sand makes it easy for *Acteocina striata* to immerse

itself when moving from place to place and will come to the surface when its habitat is hit by waves.

**Table 3 Distribution of macrozoobenthos species at each station**

No	Species name	Station			
		I	II	III	IV
<b>Gastropoda</b>					
1	<i>Cerithidea cingulata</i>	2	3	3	1
2	<i>Cerithidea quadrata</i>	3	2	2	1
3	<i>Lophiotoma indica</i>	1	1	1	0
4	<i>Strombus labiatus</i>	1	1	2	1
5	<i>Tectarius coronatus</i>	2	1	1	1
6	<i>Littoraria scabra</i>	0	1	0	0
7	<i>Nassarius coronatus</i>	1	1	4	1
8	<i>Turritella terebra</i>	1	1	1	2
9	<i>Telescopium telescopium</i>	4	1	2	0
10	<i>Polinices mammilla</i>	1	1	0	0
<b>Bivalvia</b>					
11	<i>Glaucanome virens</i>	1	1	3	0
12	<i>Scapharca cornea</i>	1	3	2	1
13	<i>Atactodea striata</i>	2	0	0	1
14	<i>Codakia punctata</i>	1	1	1	1
15	<i>Cyclina sinensis</i>	0	1	1	1
16	<i>Siliqua winteriana</i>	1	1	1	0
17	<i>Meropesta capillacea</i>	0	1	1	0
18	<i>Tapes literatus</i>	0	1	0	0
19	<i>Anadara antiquata</i>	1	1	1	1
20	<i>Fimbria soverbii</i>	0	0	0	2
<b>Total</b>		<b>23</b>	<b>23</b>	<b>26</b>	<b>14</b>

Source: Data Processing, 2021

The relative abundance at station II of the gastropod class, *Cerithidea cingulata*, belongs to the Potamididae family where this family has a high dependence on mangroves. The Potamididae family lives near estuaries, tidal areas. Most members of the Potamididae group are microalgae eaters or detritus from mangroves (Arbi, 2013). The highest abundance of bivalve class at station II, namely *Scapharca cornea*, belongs to the *Anadara* genus. *Anadara* is cosmopolitan and can be found in tropical and subtropical waters. In general, species from the *Anadara* clan live in brackish water near river mouths, mangroves, offshore with a depth of 10-30 meters and in seagrass or coral sand areas (Sulistiyaningsih & Arbi, 2020).

The highest relative abundance at station III of the gastropod class, *Nassarius coronatus*, belongs to the Nassariidae family. Nassariidae can live on various types of substrates such as sand,

mud, rock. The Nassariidae family are scavengers that live on soft or mud substrate types to brackish waters in intertidal and sublittoral areas (Cappenberg, 2016). The highest abundance of bivalve at station III was *Glaucanome virens*. *Glaucanome virens* have a habit of burrowing and nesting in the substrate. In general, mussels with a habit of digging prefer to be on a softer substrate (Herman et al, 2016).

The highest relative abundance was at station IV of the gastropod class, namely *Turritella terebra*. The relative abundance of the highest class of bivalve is *Fimbria soverbii*. According to Subagio & Agus (2014), Stated that the high and low abundance of an organism in a waters is influenced by abiotic factors such as temperature, salinity, DO, pH and substrate. In addition to these factors, the abundance value can also be influenced by habitat trends and food availability.

#### Macrozoobenthos Ecological Index

The value of the macrozoobenthos ecological index at each station is shown in table 4.

**Table 4 Makrozoobenthos ecological index**

Ecological index	Station			
	I	II	III	IV
Diversity index	2.43	2.79	2.58	2.16
Evenness index	0.90	0.96	0.95	0.90
Dominance index	0.09	0.07	0.09	0.09

Source: Data Processing, 2021

Diversity is closely related to the stability of an ecosystem, namely if the diversity of an ecosystem is high, the condition of the ecosystem tends to be stable. On the other hand, species diversity tends to be low in polluted ecosystems (Nento et al, 2013). Factors that affect species diversity are contaminated substrates, abundance of food sources, competition between and intra-species, disturbances and environmental conditions in which species with high tolerance will increase while those with low tolerance will decrease (Labbaik et al, 2018). All stations at the research site are included in the diversity of the stability of the moderate biota community.

The results of the calculation of the evenness index at table 4 each station ranged from 0.90 to 0.96. The highest evenness index was at station II (0.96) and the lowest was at stations I and IV (0.90). This shows that the number of individuals of each type at each station has a high

distribution of the number of individuals. The distribution of species is related to dominance, where if the evenness value is small, there is a dominance of certain species (Hasanah et al, 2014).

Dominance indicates favorable environmental conditions in the growth of certain species. The dominance index value at each observation station ranged from 0.07 to 0.09 The lowest dominance value was at station II (0.07) and the highest dominance value was at stations I, III and IV (0.09). This shows that at all observation locations have low dominance.

**Fish Community Structure**

In this study, from a total of four research stations, 3 fish species were found, namely *Chanos chanos*, *Mugil cephalus* and *Acentrogobius audax* (table 5).

**Table 5 Distribution of fish at each station**

Species name	Station			
	I	II	III	IV
<i>Chanos chanos</i>	0	7	23	18
<i>Mugil cephalus</i>	10	9	19	2
<i>Acentrogobius audax</i>	19	3	13	0
Total	29	19	55	20

Source: Data Processing, 2021

Table 5 shows the highest relative abundance at station I, *Acentrogobius audax*, belongs to the family Gobiidae. In general, the Gobiidae family lives in fresh water to the sea because it has the ability to adapt to differences in salinity. Gobiidae are commonly found in estuaries (Khoncara et al., 2018).

At station II, the highest relative abundance was the species *Mugil cephalus*. *Mugil cephalus* is a type of marine fish that uses estuarine waters as its habitat. *Mugil cephalus* has a wide tolerance to salinity and temperature, and is able to adapt to various foods in its habitat (Nuringtyas et al., 2019).

Stations III and IV the highest relative abundance was *Chanos chanos*. Station III is a station located at the mouth of a river that is directly affected by tides with a salinity of 31 ppt. Meanwhile, station IV is a station located at sea with a salinity value of 32.1 ppt. Hendrajati (2018), states that *Chanos chanos* is euryhalin which is resistant to large change in salinity.

Water quality suitable for *Chanos chanos* life is salinity (0-60 ppt), temperature ranging from 24-31°C with optimal temperature ranging from 23-32°C, pH 6.5 – 9.0, DO of 3-8 mg/L.

**Fish Ecology Index**

**Table 6 Fish ecology index**

Ecological index	Station			
	I	II	III	IV
Diversity index	0.64	1.01	1.04	0.09
Evenness index	0.93	0.92	0.98	0.14
Dominance index	0.55	0.39	0.38	0.82

Source: Data Processing, 2021

The fish diversity index value is influenced by several factors including location, season, habitat, fishing gear used and skills in catching fish (Maturbongs et al, 2018). The table 6 shows diversity index obtained in the Permata Pilang Beach estuary at stations I and IV is included in the low level of diversity. While at stations II and III included in the moderate diversity. Moderate diversity shows the distribution of the number of individuals of each species is moderate and the stability of the community is moderate (Maturbongs et al, 2018). The evenness index value of the four stations ranged from 0.14 to 0.98 with the highest evenness index at station III of 0.98 and the lowest evenness index at station IV of 0.14. The evenness index at stations I, II and III is classified as high evenness. While the evenness index at station IV is low. The dominance index in the Pantai Permata Pilang estuary ranged from 0.38 to 0.82 with the highest value at station IV of 0.82 and the lowest at station III of 0.38. At stations I, II and III are in the category of moderate dominance. While at station IV is in high dominance.

**Relationship of Water Quality with The Ecological Index of Aquatic Biota**

Components F1 and F2 are eigenvalues that indicate the characteristic value of a matrix that determines the number of components used. The eigenvalues are used to determine the number of components in the matrix and graph so that it can explain the diversity of the main components. he minimum requirement that must be met in determining the number of components to be taken is the cumulative variable at least reaching 60% or 75% (Kinasih et al., 2018).

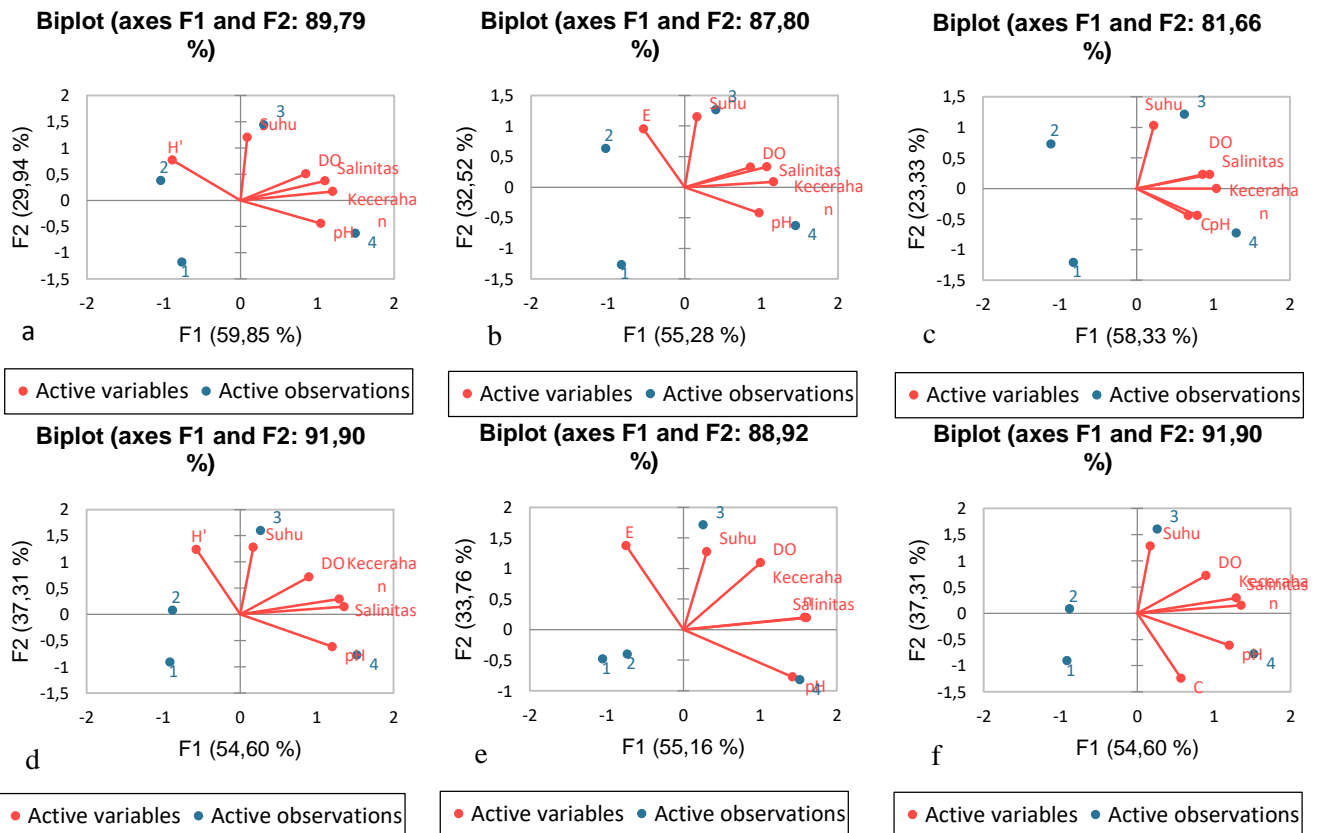
**Table 7 Matrix of the relationship between water quality and the ecological index of aquatic biota**

Variable	Macrozoobenthos diversity (H')	Macrozoobenthos evenness (E)	Macrozoobenthos dominance (C)	Fish diversity (H')	Fish evenness (E)	Fish dominance (C)
Temperature	0.600	0.738	-0.258	0.800	0.400	-0.800
Salinity	-0.400	-0.105	0.258	-0.200	-0.400	0.200
pH	-0.775	-0.544	0.333	-0.775	-0.775	0.775
DO	-0.400	-0.316	0.775	0.200	0.400	-0.200
Water transparency	-0.632	-0.389	0.544	-0.316	-0.316	0.316

Source: Data Processing, 2021

Macrozoobenthos diversity is positively related to temperature. The relationship between temperature and diversity of macrozoobenthos is in a strong category. According to Maula (2018), states that temperature affects the metabolism, growth and migration of macrozoobenthos. Other variables that have a negative relationship to the diversity of macrozoobenthos are salinity, pH, DO and water transparency. A negative relationship indicates that the relationship between variables has an inversely proportional

value. The highest relationship is pH of -0.775 including strong category. According to Maula (2018), pH has the effect of reducing resistance to stress in macrozoobenthos. Based on figure 1 shows that the relationship between temperature and diversity which has the highest value is at station 3. This is because station 3 is at the mouth of the river. Station 3 has the second largest value after the diversity value at station 2 of 2.58 and the temperature value of 33.6°C.



**Figure 1 Relationship of water wuality with the ecological index of aquatic biota (a. macrozoobenthos diversity index, b. macrozoobenthos evenness index, c. macrozoobenthos dominance index, d. fish diversity index, e. fish evenness index, f. fish dominance index) Source : Data Processing, 2021**

The relationship of water quality that has a positive relationship with the evenness of

macrozoobenthos is temperature. Water temperature has a relationship with the evenness

of macrozoobenthos including the strong category. While the negative relationship to the evenness of macrozoobenthos is salinity, pH, DO and water transparency. The highest relationship is salinity of -0.105 including very strong category. The relationship between salinity and evenness includes an inverse relationship. According to Maula (2018), salinity has an influence on the distribution of macrozoobenthos species. Based on figure 1 shows that the relationship between evenness and temperature is the highest at station 3. This is because station 3 has an evenness value of 0.95 and a temperature of 33.6°C.

The relationship between several variables is shown in the matrix in table 7. The relationship between water quality and macrozoobenthos dominance has positive values for salinity, pH, DO and water transparency. According to Maula (2018), dissolved oxygen (DO) has an influence on the amount, type and mortality. While the water transparency affects the number of species, number of individuals and biomass. Based on figure 1 shows that the relationship between the dominance index and dissolved oxygen (DO) has the highest value at station 3. This station is located at the mouth of the river with a dominance index value of 0.09 and DO of 11.8 mg/L.

Table 7 shows that the relationship between water quality and fish diversity has a positive value for temperature and dissolved oxygen (DO). Temperature has a value of 0.800 in the very strong category and DO has a value of 0.200 in the low category. According to Ernawati & Dewi (2016), temperature affects the metabolic processes of marine organisms such as respiration rate and dissolved oxygen consumption. While DO is needed for breathing, metabolism that produces energy for growth and reproduction. The relationship between water quality and fish diversity has a negative value, which means that there is an inverse relationship between salinity, pH and water transparency. Based on figure 1 shows that the relationship between diversity and temperature has the highest value at station 3. This station is located at the mouth of the river with a diversity index value of 1.04 and a temperature of 33.6°C.

Fish evenness index is positively related to temperature and DO. The relationship between temperature and DO with fish evenness is in the medium category. Other variables that have a

negative relationship to the diversity of macrozoobenthos are salinity, pH and water transparency. According to Koniyo & Lamadi (2017), pH has an influence on the metabolism and physiological processes of an organism including fish. Based on figure 1 shows that the relationship between evenness and temperature is the highest value at station 3. This station is at the mouth of the river with an evenness index value of 0.98 and a temperature of 33.6°C.

The relationship of water quality that has a positive relationship with fish dominance is salinity, pH and water transparency. The salinity of the waters has a relationship with the dominance of fish in the low category, pH has a relationship with the dominance of fish in the strong category, water transparency has a relationship with the dominance of fish in the low category. While the negative relationship to fish dominance is temperature and DO. According to Koniyo & Lamadi (2017), salinity has an influence on metabolism, growth, migration, osmotic behavior and reproduction, distribution, and length of life of fish. Meanwhile, water transparency affects photosynthesis for fish food. Based on figure 1 shows that the dominance relationship with the highest pH is at station 4. This is because station 4 has the dominance value and the highest pH among all research stations is 0.82 and pH is 8.2°C.

## Conclusion

Based on the results of PCA analysis, the diversity index of macrozoobenthos has a positive relationship with temperature and pH. Evenness index of macrozoobenthos has a positive relationship with temperature. Macrozoobenthos dominance index has a positive relationship with salinity, pH, DO and water transparency. The relationship between water quality and fish ecological index, the results obtained that the diversity index and fish evenness index have a positive relationship with temperature and DO. Fish dominance index has a positive relationship with salinity, pH and water transparency.

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