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Exploration of Aquatic Macroinvertebrates as a Bioindicator of Water Quality in Nogosari River, Pacitan Regency

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ABSTRACT

This study aims to explore the diversity of aquatic macroinvertebrates in the Nogosari River and study the physico-chemical parameters. The research sample was taken using a plot with a purposive random sampling method. Each station is installed 3 plots and each Plot measuring 1m x 1m. Data analysis was carried out by describing and calculating the macroinvertebrate diversity index found. This study found 12 families of macroinvertebrates in the Nogosari River. The macroinvertebrate diversity index was calculated using the Shannon-Wiener Diversity Index (H') calculation (Krebs, 1978). The average diversity of macroinvertebrate species in the Nogosari river is 2.51. This value is in the range of $1.0 < H' < 3.322$ or the category of diversity index at the Medium level. This means that the diversity of macroinvertebrates in the Nogosari River has sufficient productivity, and the condition of the ecosystem is quite good. The water quality in the Nogosari River is categorized as moderately polluted. It was calculated based on the Biotic Index Value with an average BMWP-ASPT score of 5.83.

Keywords: *Explorations, Macroinvertebrates, Bioindicators.*

1. INTRODUCTION

Rivers are aquatic ecosystems that have important functions and roles for life. The role of the river is also very important for the hydrological cycle and as a catchment for the surrounding area. The Nogosari River is a river that flows in the Pacitan Regency area, precisely in Nogosari Village, Ngadirojo District with a village area of 358,355 ha, mostly mountainous areas that extend and stretch to the north. This river crosses hilly areas, settlements, and also rice fields. The Nogosari River also crosses Tanjung Lor Village in the south. The Nogosari River area that crosses Tanjung Lor Village is dominated by rice fields.

The Nogosari watershed (DAS) is widely used by the community as a source of water and also to irrigate the surrounding rice fields. The development of population activities such as agricultural activities and the increase in residential areas and daily activities such as washing will affect the quality and condition of river water. Seeing the importance of the benefits and the role of the Nogosari river to meet the daily needs of the population, the quality of clean water needs to be maintained so as not to cause problems for human health.

Monitoring of river water quality can be carried out and known biologically by using the bioindicator method (Jain et al. 2010). This bioindicator method is carried out by utilizing the presence of aquatic organisms in the form of macroinvertebrate animals that live in the Nogosari river itself. The animals that can be used as bioindicators are usually from the group of aquatic macroinvertebrates (Parmar et al. 2016).

Currently, the determination of water quality by using macroinvertebrates as bioindicators is said to be more able to show the actual environmental conditions because of the characteristics of each macroinvertebrate related to the preferences of the environmental conditions in which they live (Parmar et al. 2016).

The diversity of aquatic macroinvertebrates is determined by several factors such as temperature, pH, DO (dissolved oxygen) and current strength. Each type of macroinvertebrate has different characteristics. The responses of these aquatic organisms also vary to the condition of river water quality. If there is a change in the

quality of the environment in their habitat, some species that cannot tolerate these changes will die. In general, some insects are more tolerant or more sensitive to environmental disturbances.

2. RESEARCH METHODS

This research is a descriptive qualitative research with an exploratory approach whose data processing is based on the sample data obtained. The study was conducted for 4 months in March – July 2020 in the Nogosari River watershed area, Ngadirojo Pacitan District at three different stations, namely in the calm flow section near the upstream, the heavy flow section around the Dam/DAM, and in the medium flow area around the rice fields.

The data source is the primary data source obtained from the exploration of aquatic macroinvertebrates, namely physico-chemical parameter data, including water temperature, air temperature, water pH, DO and current velocity. The tools used to collect physico-chemical data in the form of a pH meter, thermometer, ping pong ball and ropope are used to measure the current velocity and DO meter.

Sampling of macroinvertebrates using the Purposive Random Sampling method with the following steps:

1. Determine 3 stations as sampling locations, namely (a). Upstream is a watershed area with calm currents. (b). watershed areas with strong currents. (c). watersheds in rice fields.

2. Make a plot measuring 1 m x 1 m quadrant.

3. Collect and record all macroinvertebrate species found.

4. Repeat sampling 3 times at each station randomly.

The data analysis technique of this research is data processing. Macroinvertebrate diversity is calculated using the Shannon-Wiener Diversity Index (H') calculation (Krebs, 1978):

$$H' = - \Sigma \, Pi \, In \, . \, Pi$$

Description:
H' = Proportional abundance of the I species
Pi = ni/N
ni = Number of individuals of the ith species
N = Number of individuals of all species in the community

The indicator index of the status of the waters can be determined using the BMWP index. The steps:

1. The data that has been classified is matched with the BMWP table and gives a score for each family per station.

2. From the data obtained for each family of macroinvertebrates, then look for the Avarage Score Per Taxon (ASPT) value. This ASPT value determines the status of the water quality.

$$ASPT\ Value = A/B$$

Description:
A : total BMWP index score
B : Number of families found and scored

This research procedure consists of several stages, including: (a). Exploration Stage. The sampling location is determined based on the water flow conditions. The cruising area includes 3 different stations, approximately 1 kilometer between stations, the temperature and current speed are measured. In this area, the sampling process is carried out. (b). Inventory Stage. Sampling was carried out using a net measuring 30 cm x 30 cm. Samples to be observed, separated between specimens with litter and rock. Samples were taken using tweezers and put into a plastic bag filled with 70% alcohol for the preservation process. (c). Identification Stage. Samples were identified to the family level by observing the morphology of macroinvertebrates and then validated based on literature studies (Nuha, et al. 2015).

3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. Identification of Macroinvertebrates

Researchers found 8 orders from 12 macroinvertebrate families. The results of the identification of macroinvertebrate observations are presented in the form of a brief classification in Table 1.

Table 1. Identification of Aquatic Macroinvertebrates in the Nogosari Pacitan River.

No.	Ordo	Family	Class
1.	Hemiptera	1. Veliidae 2. Gerridae	Insecta
2.	Plecoptera	1. Perlidae	Insecta
3.	Ephemeroptera	1. Heptageniidae 2. Ephemerilidae	Insecta
4.	Trichoptera	1. Hydropsychidae	Insecta
5.	Diptera	1. Tipulidae	Insecta
6.	Sorbeoconcha	1. Thiaridae 2. Pachylidae 3. Pleurociridae	Gastropoda
7.	Hygrophila	1. Lymnaeidae	Gastropoda
8.	Architaenioglossa	1. Ampullaridae	Gastropoda

The results of the identification of aquatic macroinvertebrates at three stations in the Nogosari River can be seen in Table 2.

Table 2. Table of Findings of Aquatic acroinvertebrates in the Nogosari Pacitan River.

No.	Species	Station			
		I	II	III	Total
1.	Nimfa (Hemiptera/Veliidae)	15	0	22	37
2.	Nimfa (Hemiptera/Gerridae)	57	9	54	120
3.	Nimfa (Plecoptera/Perlidae)	23	7	11	41
4.	Nimfa (Ephemeroptera/Heptageniidae)	52	0	9	61
5.	Nimfa (Ephemeroptera/Ephemerilidae)	81			81
6.	Larva (Trichoptera/ Hydropsychidae)	54	0	22	76
7.	Larva (Diptera/ Tipulidae)	3	0	5	8
8.	Sorbeoconcha (Thiaridae)	201	86	55	342
9.	Sorbeoconcha (Pachylidae)	51	43	43	137
10.	Sorbeoconcha (Pleurociridae)	41	32	2	94
11.	Hygrophila (Lymnaeidae)	16	23	27	66
12.	Architaenioglossa (Ampullaridae)	0	0	3	3
Total		**594**	**200**	**272**	**1.112**

2. Macroinvertebrate Diversity Index (H')

The diversity index shows the diversity of a species, productivity, stress on ecosystems, and ecosystem stability. The diversity index can be determined by calculating using the Shannon-Wiener formula. The index of macroinvertebrate diversity in the Nogosari Pacitan river can be seen in table 3.

Table 3. River Macroinvertebrate Diversity Index Table Nogosari Pacitan (Shannon-Wiener H')

No.	Spesies	Jumlah Individu per-stasiun			*pi* IN *pi*			Individual	*Pi* IN *pi*
		Station I	Station II	Station III	Station I	station II	station III		
1.	*Rhagovelia obesa*	15	-	22	-0,09	0	-0,22	37	-0.11
2.	*Gerris marginatus*	37	4	23	-0,17	-0,08	-0,23	64	-0.16
3.	*Gerris argentatus*	20	5	31	-0,11	-0,1	-0,27	102	-0.21
4.	*Togoperla sp.*	23	7	11	-0,13	-0,11	-0,15	41	-0.12
5.	*Heptagenia solitaria*	52	0	9	-0,21	0	-0,13	61	-0.15
6.	*Drunella cornuta*	45	0	0	-0,20	0	0	45	-0.12
7.	*Drunella tuberculata*	36	0	0	-0,17	0	0	36	-0.11
8.	*Hydropsyche venularis*	54	0	22	-0,22	0	-0,22	76	0,18
9.	*Tipula maxima*	3	0	5	-0,03	0	-0,08	8	-0.03
10.	*Melanoides granifera*	57	34	21	-0,22	-0,30	-0,29	112	-0.23
11.	*Melanoides tuberculata*	18	0	0	-0,11	0	0,00	18	-0.06
12.	*Thiara rufis*	53	23	19	-0,22	-0,25	-0,26	95	-0.21
13.	*Thiara scabra*	19	7	0	-0,11	-0,12	0,00	26	-0,08
14.	*Terebia granifera*	54	22	15	-0,22	-0,24	-0,23	91	-0,20
15.	*Brotia testudinaria*	33	12	19	-0,16	-0,17	0,00	64	-0,16
16.	*Sulcospira testudinaria*	18	31	24	-0,11	-0,29	-0,29	73	-0,17
17.	*Elimia acuta*	41	32	21	-0,18	-0,30	-0,28	94	-0,20
18.	*Lymnaeae rubiginosa*	16	23	27	-0,10	-0,25	-0,31	66	-0,16
19.	*Pila ampulacea*	0	0	3	0	0	-0,10	3	-0,01
total number		**594**	**200**	**272**					
Diversity Index (H')					**2,75**	**2,19**	**2,59**	**1.112**	**2,77**

3. Water Quality Analysis (BMWP-ASPT)

Aquatic macroinvertebrates that have been found were then identified by the BMWP-ASPT score table. Furthermore, it is identified using a table of biotic index scoring scores to assess water quality. Water quality

indicators are in the form of biological indicators by utilizing aquatic organisms in the form of aquatic macroinvertebrates to monitor water quality in addition to physical and chemical indicators. Physico-chemical indicators to determine and describe water quality at a certain time, while biological indicators such as macroinvertebrates can monitor continuously. Macroinvertbrata have limited movement and are relatively sedentary, so they tend to respond directly to the impact of changes in water quality. The results of the aquatic macroinvertebrate scores found in the Nogosari Pacitan river can be seen in table 4.

Table 4. Table of Results Scores for Aquatic Macroinertebrata Found in the Nogosari Pacitan River.

No.	Species	Score
1	Nimfa (Hemiptera/Veliidae)	5
2	Nimfa (Hemiptera/Gerridae)	5
3	Nimfa (Plecoptera/Perlidae)	10
4	Nimfa (Ephemeroptera/Heptageniidae)	10
5	Nimfa (Ephemeroptera/Ephemerilidae)	10
6	Larva (Trichoptera/Hydropsycidae)	5
7	Larva (Diptera/Tipulidae)	5
8	Sorbeoconcha (Thiaridae)	4
9	Sorbeoconcha (Pachylidae)	4
10	Sorbeoconcha (Pleurociridae)	4
11	Hygrophila (Lymnaeidae)	4
12	Architaenioglossa (Ampullaridae)	4
Average		5. 83
Biotic Index Value = Medium Polluted		

3.1.4. Physico-Chemical Parameters

Table 5 Physico-Chemical Parameters of the Nogosari Pacitan River Flow.

Station	pH Air	Water Temperature (°C)	DO (Mg/L)	Current Speed (m/s)	Air temperature (°C)	Total Individual
Station I	6, 8	25	7, 9	0,55	27	594
Station II	6, 8	25	7, 8	0, 80	27	200
station III	6, 9	25	7,4	1,2	28	230

Environmental conditions greatly affect the presence of aquatic macroinvvertebrates in river ecosystems. Sampling uses physico-chemical parameters, where the physical indicators of polluted water are signs or changes that can be observed, such as temperature, pH, color, odor and taste as well as the presence of sediment and solvents (Wardhana, 1995). Chemical parameter indicators commonly used are DO, BOD, COD, Nitrogen and Phosphorus, heavy metals and inorganic solids (Eckenfelder, 1978 in Indarsih 2011). Environmental parameters at the time of sampling from Physico-Chemical data can be seen in Table 5.

3.2. Discussion

The results of the identification and calculation of macroinvertebrate animals at 3 stations showed that the total number of species found was 1,112 species. The highest number of species is found at station I, which is 594 species when compared to station II which is only 200 species and station III is 272 species. This is because at station I is a part near the upstream of the river where at this location the water conditions are still natural and not so polluted by pollutants. The cleaner the water quality, the more macroinvertebrate animals that live in that environment. On the other hand, if the quality of the water is dirty or polluted, it will affect the survival of the macroinvertebrates. This is in accordance with the theoretical basis of the opinion of Khairuddin, (2016), which states "polluted waters will affect the survival of macroinvertebrate organisms". The lowest number at station II is due to by the rapid and deep flow of river water because it is near a DAM or dam, causing the movement of macroinvertebrates to be swayed by the current and difficult to survive on the substrate present in the fast flow. The water quality at station II is also not as clean as at station I, due to heavy currents making the water agitated and a little cloudy, so that macroinvertebrate animals tend to be intolerant of dirty water conditions. This is supported by the opinion of Djumanto (2013), namely "each aquatic macroinvertebrate animal has a tolerance range for the quality of the aquatic ecosystem to normalize its body metabolism". The diagram of the difference in the total number of species at each station can be seen in Figure 1.

Each station contained some of the same species, but were also found at other stations. These species are divided into 12 families, including Vellidae, Gerridae, Perilidae, Hepageniidae, Ephemerilidae, Hydropschydae, Tipulidae, Thiaridae, Pachylidae, Pleurocharacteridae, Lymnaeidae, and Ampullaridae. Of the 12 families identified 19 species, each of which has different characteristics and tolerance levels to the quality of water conditions. This is in accordance with the theoretical basis which states "aquatic macroinvertebrates have quite a lot of variety and each type has characteristics that are able to show different responses due to changes in water environmental conditions" (Maruru, 2012).

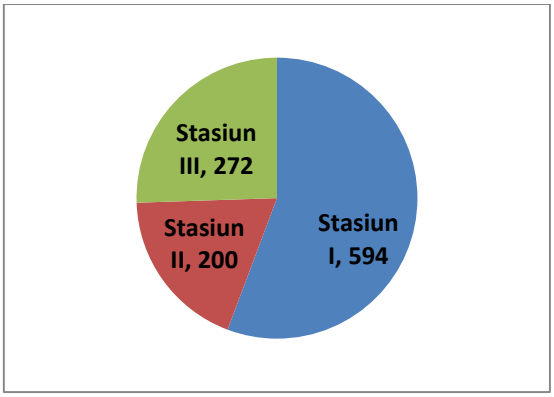

Figure 1. Comparison diagram of the number of macroinvertebrate species at each station.

The most common species found were from the Sorbeoconcha order which belongs to the gastropod (snail) class, with a total number of 573 species, including Melanoides granifera, Melanoides tuberculata, Thiara rufis, Thiara scabra, Terebia granifera, Brotia testudinaria, Sulcospira testudinaria, and Elimia acuta. ,. The highest number was also found at station I, where indeed snails and snails are a group of macroinvertebrates that occupy habitats with water quality that is still lightly polluted, because these types of animals have a moderate level of sensitivity. As revealed by Rahayu, et al (2009). that "Types of macroinvertebrates such as beetle larvae (Coleoptera), dragonfly nymphs (Odonata), snails, snails, and shrimps have a moderate level of sensitivity. In addition to snails, other macroinvertebrate species from the order Ephemeroptera from the class Insecta also dominate the Nogosari River environment, with a total of 142 species, including Heptagonia solitaria, Drunella cornuta, and Drunella tuberculata, where the macroinverterata group from the order Ephemeroptera is a biological indicator for lightly polluted water, because Ephemeroptera was mostly found at station I where the water conditions were still natural. This is supported by the opinion of Marmita, (2013) which states that macroinvertebrates that can be used as biological indicators for light pollution are Ephemenoptera (Stenonema sp, Baetis sp), Plecoptera (Acroneuria sp, Pteronarcys sp) and for moderate pollution, namely Gastropods. Other species found were Rhagovelia obesa, Gerris marginatus, and Gerris argentatus of the order Hemiptera ; Togoperla sp. of the order Plecoptera; Hydropsyche venularis of the order Tricoptera; Tipula maxima of the order Diptera, Lymnaea rubiginosa of the order Hygrophyla, and Pila ampulacea of the order Achitaenioglossa.

Based on the findings of macroinvertebrate animals obtained from this exploration activity, it indicates that the water quality condition in the Nogosari River is in the moderately polluted category. This is evidenced by the results of the analysis of water quality with the BMWP-ASPT scoring by calculating the total score of each macroinvertebrate family and the average score is 5.83 where the value according to the Biotic Index value is included in the moderately polluted category (Hawkes, 1998). A diagram of the findings of species at 3 stations of the Nogosari Pacitan River can be seen in Figure 2.

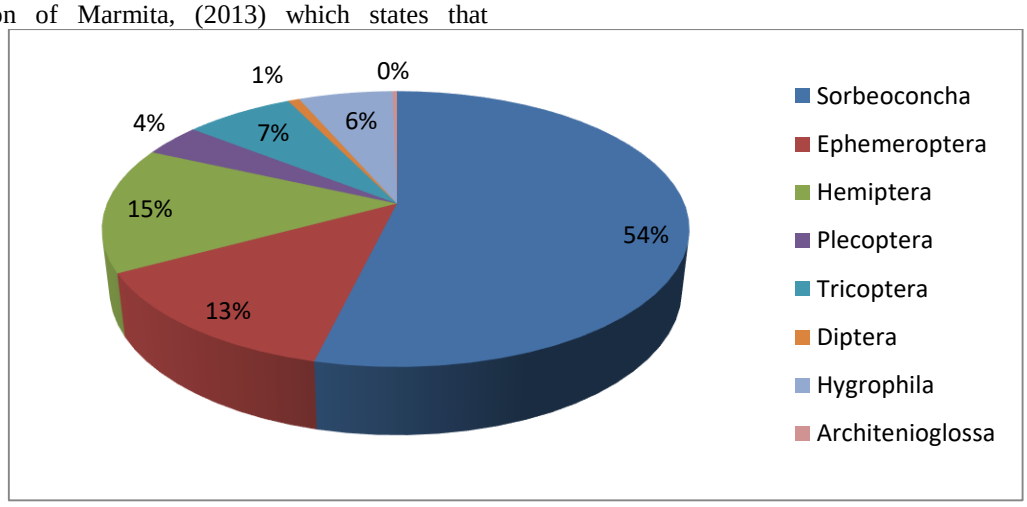

Figure 2. Diagram of the total number of macroinvertebrate species in the Nogosari River, Pacitan.

This research was conducted by measuring the environmental conditions in the Nogosari watershed in the form of physico-chemical parameters which included measurements of water pH, water and air temperature,

current strength and also DO or dissolved oxygen levels in water. Physico-chemical factors greatly affect the presence of macroinvertebrate animals, so it is necessary to measure them. In accordance with the basic theory put forward by Lubis (2009) that "Physico-chemical parameters are very influential on the existence of macroinvertebrates". The results of the measurement of physico-chemical parameters showed that at station I the pH of the water was recorded at 6.8, as well as at station II at 6.8 while at station III it was 6.9. This range value supports the growth of macroinvertebrate animals. This statement is supported by Welch's (1980) statement that the optimum pH for benthic life is between 5.5 – 8.5.

Another parameter, namely the water temperature at the time of the study was 25°C at all stations. In addition to water temperature, air temperature was also measured and showed a value of 27°C at stations I and II, while at station III the air temperature was 28°C. The current velocity at each station is very different, where at station I the current is measured at 0.55 m/s, at station II it is measured at 0.80 m/s, and at station III it is 1.2 m/s. at station I the current velocity is the lowest because at station I is an upstream area where the water flow is still calm and not so heavy. Meanwhile, the highest current velocity is at station III because this area is near the rice fields, and the river flow is influenced by the flow from the irrigation of the rice fields which continues to flow into the river. The last physico-chemical factor is DO. Dissolved oxygen or DO content at each station shows a range value that meets the requirements for the survival of macroinvertebrate animals, which is 7.9 Mg/L at station I; 7, 8 Mg/L at station II, and 7.4 Mg/L at station III. Waters with oxygen content as above, according to Sinambela (1994), are sufficient to meet the life of organisms because the DO size in water of 2 mg/L is sufficient to support normal life as long as it does not contain toxic compounds.

The diversity of macroinvertebrate animals found in the Nogosari Pacitan River basin after being identified was then calculated using the Shannon-Wiener Diversity Index (H') formula. The calculation results show that at station I, which has a good level of diversity with a numerical value of 2.75. While at stations II and III the results of the calculation of H' are 2.19 at station II, and 2.59 at station III. This figure shows that the level of macroinvertebrate diversity is moderate, productivity is sufficient, and the ecosystem condition is quite balanced (Krebs, 1978).

4. CONCLUSION

Exploration research conducted in the Nogosari River in Pacitan found 19 species of macroinvertebrate animals from 12 families and 8 orders, indicating that the level of macroinvertebrate diversity is moderate, productivity is sufficient, and the ecosystem condition is quite balanced. The condition of water quality in the Nogosari River is classified in the moderately polluted category with a BMWP-ASPT score and the average score is 5.83.

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