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Community Structure of Benthic Macroinvertebrates as Bioindicators of Water Quality in the Upstream Setail River, Banyuwangi, East Java, Indonesia

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ABSTRACT

Setail River is the longest river in Banyuwangi Regency, East Java. The current condition of Setail River is experiencing an alarming decline in water quality due to the activities of the surrounding community. This decline in water quality can have a negative impact on aquatic biota. To assess water quality, one of the methods used is to use biological indicators, namely benthic macroinvertebrates. The purpose of this study was to assess water quality in the upstream to middle reaches of the Setail River using benthic macroinvertebrates as bioindicators. The assessment was carried out based on community structure, the Biological Monitoring Working Party-Average Score Per Taxon (BMWP-ASPT) method and water physicochemical parameters. This study was conducted at 5 sampling points. Upstream to midstream of the Setail River waters, benthic macroinvertebrate communities were found consisting of 3 classes, 25 families from 10 orders, namely Trichoptera, Ephemeroptera, Diptera, Coleoptera, Plecoptera, Odonata, Lepidoptera, Lumbriculida, Littorinimorpha and Basommatophora. The abundance of benthic macroinvertebrates ranges from 62-451 individuals/m². The diversity of benthic macroinvertebrates ranges from 0.85-2.55 (low-moderate). The evennes index value ranges from 0.43-0.88 (low-high), while the dominance index at station V (0.66) is classified as high ($C > 0.5$) since at this station there is dominance by one family, namely Hydrobiidae from the Gastropoda class. The ASPT value for each sampling point ranges from 4.4 - 6.9, indicating that the water conditions vary from clean water, doubtful quality to probable moderate pollution depending on the sampling point. These results indicate that the water quality ranges from very good to moderate pollution, especially at Sampling Points III and V. Based on the analysis of the effects of activities around the river, it causes changes in the composition and structure of benthic fauna. Management activities (campaigns for the community to avoid river pollution) are needed to restore and maintain the quality of the environment and our results can contribute information to these activities.

INTRODUCTION

River ecosystems are unique, spatially heterogeneous ecosystems, originating from the interaction between biological communities and the river environment **(Chowdhury *et al.*, 2024)**. Rivers are natural resources that flow from upstream to downstream **(Anderson *et al.*, 2019)**, which are widely used to meet human needs, as

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well as living things that live in them **(Ummuzzahra *et al*., 2022)**. Excessive exploitation of water resources and pollution of the aquatic ecological environment will have an impact on the incompatibility of river ecosystem functions, both ecologically and economically **(Zhang *et al*., 2021)**. In general, river ecosystem degradation is caused by land conversion, population growth, and low public awareness of the importance of conserving river ecosystem resources **(Cui *et al*., 2021)**.

Setail River is one of the longest rivers in Banyuwangi Regency. The Setail River is the result of the curve of eruption material from the eruption of Mount Raung. The river flows to the south then to the east of Banyuwangi Regency and empties into the Bali Strait or the Indian Ocean. Among other rivers, the Setail River is 73.35km long, passing through 6 sub-districts, namely Sempu, Genteng, Tegalsari, Gambiran, Purwoharjo and Muncar sub-districts. The Setail River is used directly by the community living around it. The Setail River is used for human activities such as tourism or recreation, fisheries, agriculture, plantations, households such as cooking, bathing, washing, and among others. The Setail River from upstream to midstream passes through various agricultural areas, plantations, urban and residential areas, which have the potential for pollutant input into the river body. The large amount of domestic waste produced, imperfect waste processing, increasing urban land, increasing urbanization in urban areas, and various industrial activities have caused a decline in river water quality **(Zhao *et al*., 2022)**. According to statistics, the river environment can be affected by various human activities, and more than 99.8% of river pollution worldwide is related to human activities **(Vorosmarty *et al*., 2010)**. Activities in the upstream part of the river will affect the water quality in the downstream part of the river. In line with this phenomenon, the accumulation of pollution loads in the upstream and tributaries will reduce the quality of downstream river water **(Novita *et al*., 2021)**.

The implementation of monitoring and management strategies for the Setail River, especially in the upstream to middle areas, is important to maintain the river ecosystem. Various methods can be used to monitor water quality, one of which is knowledge related to indicator species and community structure indices **(Hu *et al*., 2022)**, which can be used to describe and evaluate the health status of river ecosystems, through the biota that live in them, namely benthic macroinvertebrates **(Jihanlillah, 2024)**. Macrozoobenthos as biomonitoring agents can provide an accurate picture of global water conditions **(Pan *et al.*, 2021)**. This is because the large number of sessile taxa and their long life span allow macrozoobenthos to be used to assess the ecological conditions of waters **(Bertoli *et al*., 2022)**. They are a highly diverse group with varying lifestyles and tolerance levels to ecosystem disturbances, allowing for their classification into different ecological functional groups **(Jayachandran *et al*., 2022)**. In a study by **Akyildiz and Duran (2021)**, in the Buyuk Menderes watershed, several dominant macrozoobenthos groups were found, including Chironomidae (Diptera), Baetidae (Ephemeroptera), Hydropsychidae (Trichoptera), and other groups, each of which can explain the health conditions of the river. Several studies have used macroinvertebrate community structure for water quality bioassessment such as the Shannon–Wiener index and Average Score per Taxon (ASPT) **(Patang *et al*., 2018)**. Additionally, examination of parameters such as richness, diversity, abundance, evenness, and community composition is essential for determining river pollution levels **(Basu *et al*., 2018)**, community structure and diversity of benthic macroinvertebrates as bioindicators of water quality **(Retnaningdyah *et al*., 2023)**. Therefore, the use of macroinvertebrates as bioindicators has certain advantages over other communities.

This study aimed to monitor the health of the upstream to the middle area of the Setail River. As a result of the high utilization of the upstream river, such as for agricultural, plantation and industrial needs, it can have a negative impact on the river ecosystem, so it is necessary to monitor the ecological conditions of the river through benthic macroinvertebrates including assessment of composition, diversity index, evenness index, dominance index, and Biological Monitoring Work Party-Average Score Per Taxon (BMWP-ASPT) index. Water management in the upstream section will have an impact on the downstream section, where water pollution in the upstream section will cause externality effects, while conservation in the upstream section provides benefits in the downstream section **(Tarwotjo *et al*., 2018)**. This relationship highlights the importance of using such information to support effective river ecosystem management and to conduct a comprehensive evaluation of various water quality aspects for the sustainable management of the Setail River.

MATERIALS AND METHODS

1. Study area

This study was conducted in Setail River, Banyuwangi Regency, East Java, Indonesia. Sampling was conducted in September 2024. This study is a survey study conducted in the field. The selection of sample locations was based on purposive sampling. There are 5 Sampling Points (SP) which can be seen in Table (1) and Fig. (1).

Table 1. Sampling point in Setail River, Banyuwangi, East Java, Indonesia

Sampling Point	Coordinate	Positioning and Characteristics
1	8°11’38.1” S and 114°07’36.5” E	Upstream area, near the waterfall, Location at 712 meters above sea level
2	8°16’24.1” S and 114°08’09.6” E	Around the agricultural area and location at 355 meters above sea level
3	8°18’45.9” S and 114°08’56.4” E	Around the residential areas and location at 243 meters above sea level
4	8°20’48.3” S and 114°08’42.8” E	Around the city areas and around cafe areas and location at 195 meters above sea level
5	8°23’36.9” S and 114°08’39.8” E	Around the residents gardens (moorland) and location at 138 meters above sea level

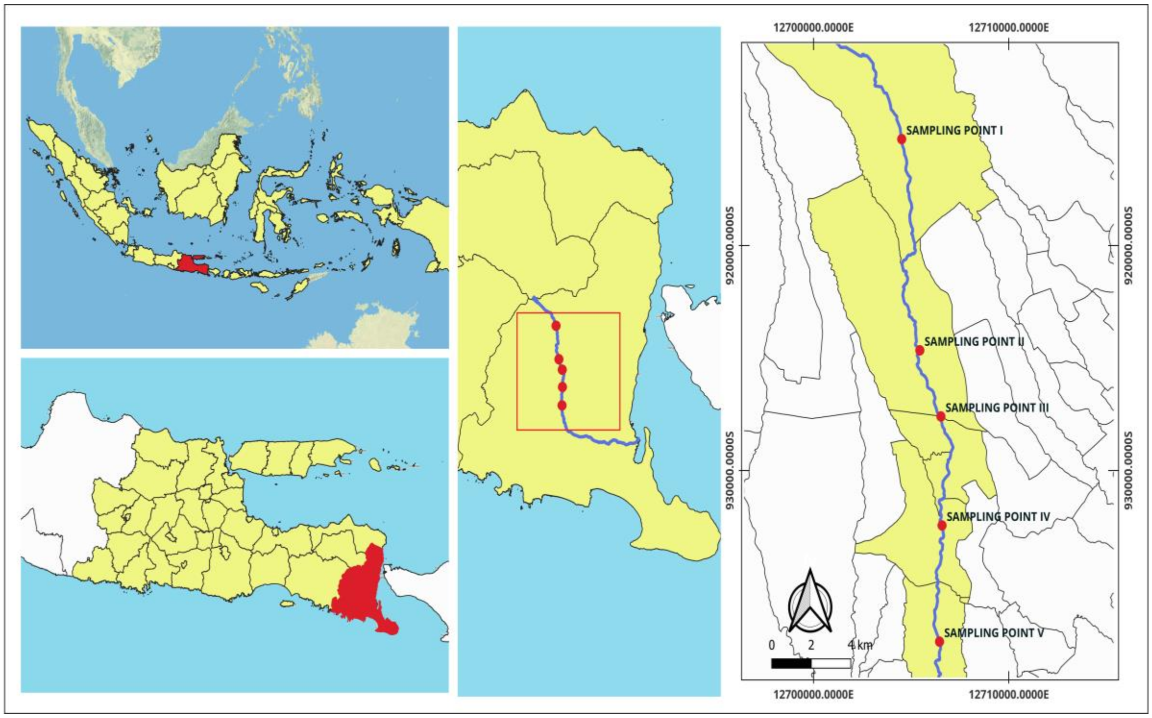

Fig. 1. Map location

2. Sampling and identification of benthic macroinvertebrates

The sampling technique uses a non-probability sampling technique, namely purposive sampling. Samples of benthic macroinvertebrates were taken using a Surber net with a size of 30cm × 30cm, a net pole height of 2-3m and a mesh size of 500µm. The sampling process was carried out with the net facing the current and placing the net frame at the bottom of the waters and the kicking technique was carried out with two feet stirring the substrate with their backs to the current and walking along 10m. This step was followed by washing twigs and stones in the net then inserting the samples by turning the net into the sample container and labeling it. Preserving samples using 96% alcohol.

The sample identification process was carried out by filtering samples using a graduated sieve with a size of 500µm to 4.74mm. The filtered samples were sorted by pouring the samples onto a white tray so that the benthic macroinvertebrates could be seen clearly. The sorted benthic macroinvertebrates were placed in a petri dish to be observed using a digital microscope. Benthic macroinvertebrates with the same family were put into 20ml vials and preserved using 96% alcohol and water in a 1:1 ratio. Samples were identified to the family level using the guidelines of **de Zwart and Trivedi (1995)**.

3. Water quality measurement

The water quality conditions of the Setail River were measured *in situ* and *ex situ.* Temperature, water clarity, pH, and dissolved oxygen were measured *in situ*.

Temperature and DO were measured using a DO meter (DO9100), water clarity (Secchi Disk), current velocity (Current meter) and pH using pH paper (Ref 921 10, pH-Fix 0-14, Macherey-Nagel, Düren, Germany). Ammonia and total organic matter were measured *ex situ*. A total of 600mL of water sample were taken. Ammonia was measured using a spectrophotometer (Genesys 10S UV-Vis Spectrophotometer, Thermo Scientific, USA), while total organic matter was measured using the KMnO4 titration method.

4. Statistic analysis

a. Relative abundance (KR)

Relative abundance is the percentage of the total number of species with the abundance of species found. The relative abundance of benthic macroinvertebrates was calculated using the formula **(Mustofa, 2018)**:

$$\mathbf{KR = Number\ of\ type\text{-}}\boldsymbol{i}\ \mathbf{/Total\ Number\ of\ Individuals \times 100\%}$$

a. Diversity index (H')

The Shannon-Weaver Diversity Index was used to determine the Makroinvertebrata benthic diversity index **(Shannon & Weaver, 1949)**. The calculation was as follows:

$$H' \sum (ni/N) \ln(ni/N)$$

Where, H': Diversity index, S: Number of species, pi: ni/N, ni: Number of individuals of species i, N: Total number of individuals.

The Diversity index criteria, $H<1$ (Low diversity), $1<H<3$ (Medium diversity), $H>3$ (High diversity).

b. Evennes index (E)

The evenness index indicates the evenness of the species **(Shannon & Weaver, 1949)**. The evennes index was calculated using the following formula:

$$E = H'/H\ max$$

Where, H': Diversity index, H max : Maximum value of diversity/ ln(S), S: Number of species.

The Evennes index criteria, 0 to 0.4 (Low diversity), 0.4 to 0.6 (Medium diversity), 0.6 to 1.0 (High diversity).

c. Dominance index (C)

The dominance index was calculated to determine the type of macroinvertebrates Benthic that dominates. The Simpson dominance index formula was used to calculate the dominance index **(Shannon & Weaver, 1949)** as follows:

$$C = \Sigma (ni/N)^2$$

Where, C: Dominance index, ni: Number of individuals-i, N: Total number of individuals in the sample

The dominance index value ranges from 0 to 1. If the C value is close to 0, there are no dominant species; conversely, a C value closer to 1 means that there is a dominant species. The greater the dominance index value indicates that the diversity is lo.

d. Similarity index (Bray-Curtis)

The index used to determine the level of community similarity from one point to another in this study is the Bray-Curtis index. The calculation of the Bray-Curtis similarity index in this study used PAST 4.03 software.

e. BMWP-ASPT

The BMWP-ASPT method was applied **(Bima *et al*., 2022)** as follows:

$$\mathbf{ASPT = \Sigma A/B}$$

Where, $\sum A$: Total BMWP index score, B: Number of families found

Average Score Per Taxon (ASPT) represents the average tolerance score of all taxa in a community, and the ASPT value can be calculated by dividing the Biological Monitoring Working Party (BMWP) score by the number of families represented in the sample. The BMWP system takes into account the sensitivity of invertebrates to pollution; families are assigned scores that reflect the sum of values for all families present in the sample. The ASPT index values are classified into four categories as follows:

- > 6: clean water
- 5–6: questionable quality
- 4–5: possible moderate pollution
- < 4: possible severe pollution **(Mandaville, 2002)**.

RESULTS AND DISCUSSION

1. Macroinverterbrate community

The results of the study conducted in the upper reaches of the Setail River showed the presence of 25 families of 10 benthic macroinvertebrates. The orders include Trichoptera, Ephemeroptera, Diptera, Coleoptera, Plecoptera, Odonata, Lepidoptera, Lumbriculida, Littorinimorpha and Basommatophora. 3 classes (Insecta, Citellata and Gastropoda) and 3 phyla (Arthropoda, Annelida and Mollusca).

The results showed a very wide diversity of benthic macroinvertebrate groups, with densities ranging from 62 to 451 individuals/m². Chironomidae is the phylum with the highest abundance, namely 371 individuals/m² obtained at 5 stations, and the highest was found at station 4. Table (4) provides complete information on the composition of macroinvertebrates found in the upstream of the Setail River.

2. Relative abudance

Based on the results, the relative abundance of each benthic macroinvertebrate at each sampling point was obtained, the highest percentage of benthic macroinvertebrates was obtained at Sampling point I, namely Baetidae 31%, sampling point II, namely Hydropsychidae 14.8%, sampling point III, namely Chironomidae 45%, sampling point IV Chironomidae 41%, sampling point V Hydrobiidae 91%. Fig. (2) provides complete information on the relative abudance of macroinvertebrates found in the upstream of the Setail River.

Table 2. Composition of benthic macroinvertebrates in the Setail River, Banyuwangi, East Java

No	Phylum	Class	Order	Family	Sampling Point					Total
					I	II	III	IV	V	
1	Arthropoda	Insecta	Trichoptera	Ecnomidae	6	0	0	0	0	**6**
2				Lepidostomatidae	6	0	0	0	0	**6**
3				Philopothamidae	3	32	0	0	0	**35**
4				Hydropsychidae	3	52	4	11	0	**70**
5			Ephemeroptera	Baetidae	48	49	6	24	0	**127**
6				Caenidae	42	30	11	46	3	**132**
7				Ephemerellidae	0	5	0	0	0	**5**
8			Diptera	Chironomidae	25	15	70	185	2	**297**
9				Chironomidae (P)	4	6	7	55	2	**74**
10				Simuliidae	0	2	0	0	0	**2**
11				Tipulidae	0	17	0	2	0	**19**
12			Coleoptera	Elmidae	10	21	7	91	0	**129**
13				Hydrophilidae	0	4	2	4	2	**12**
14				Scirtidae	0	28	0	0	0	**28**
15				Drypidae	0	11	0	0	0	**11**
16			Plecoptera	Perlidae	3	44	0	0	0	**47**
17				Perlodidae	2	0	0	0	0	**2**
18			Odonata	Heptageniidae	5	24	0	3	0	**32**
19				Cordulegastridae	0	0	0	0	2	**2**
20				Amphipterygidae	0	2	0	0	0	**2**
21			Lepidoptera	Pyralidae	0	3	0	0	0	**3**
22	Annelida	Clitellata	Lumbriculida	Lumbriculidae	0	4	0	0	1	**5**
23	Molusca	Gatropoda	Littorinimorpha	Hydrobiidae	0	0	26	24	50	**100**
24				Thiaridae	0	2	19	6	1	**28**
25			Basommatophora	Lymnaeidae	0	0	2	0	0	**2**
				Total	**157**	**351**	**154**	**451**	**62**	

The relative abundance at the 5 sampling points presented in Fig. (2A) shows that the Baetidae family was found the most at SP (sampling point) I, because the source of pollution was relatively less being located in the upstream and surrounding areas that were still natural. The Baetidae family from this study can be proposed as an indicator of water quality and ecosystem health, especially because of its presence in polluted and unpolluted river basins/streams. However, it seems sensitive to pollution because the richness and number of species decreased significantly in downstream locations **(Kubendran *et al.*, 2017)**.

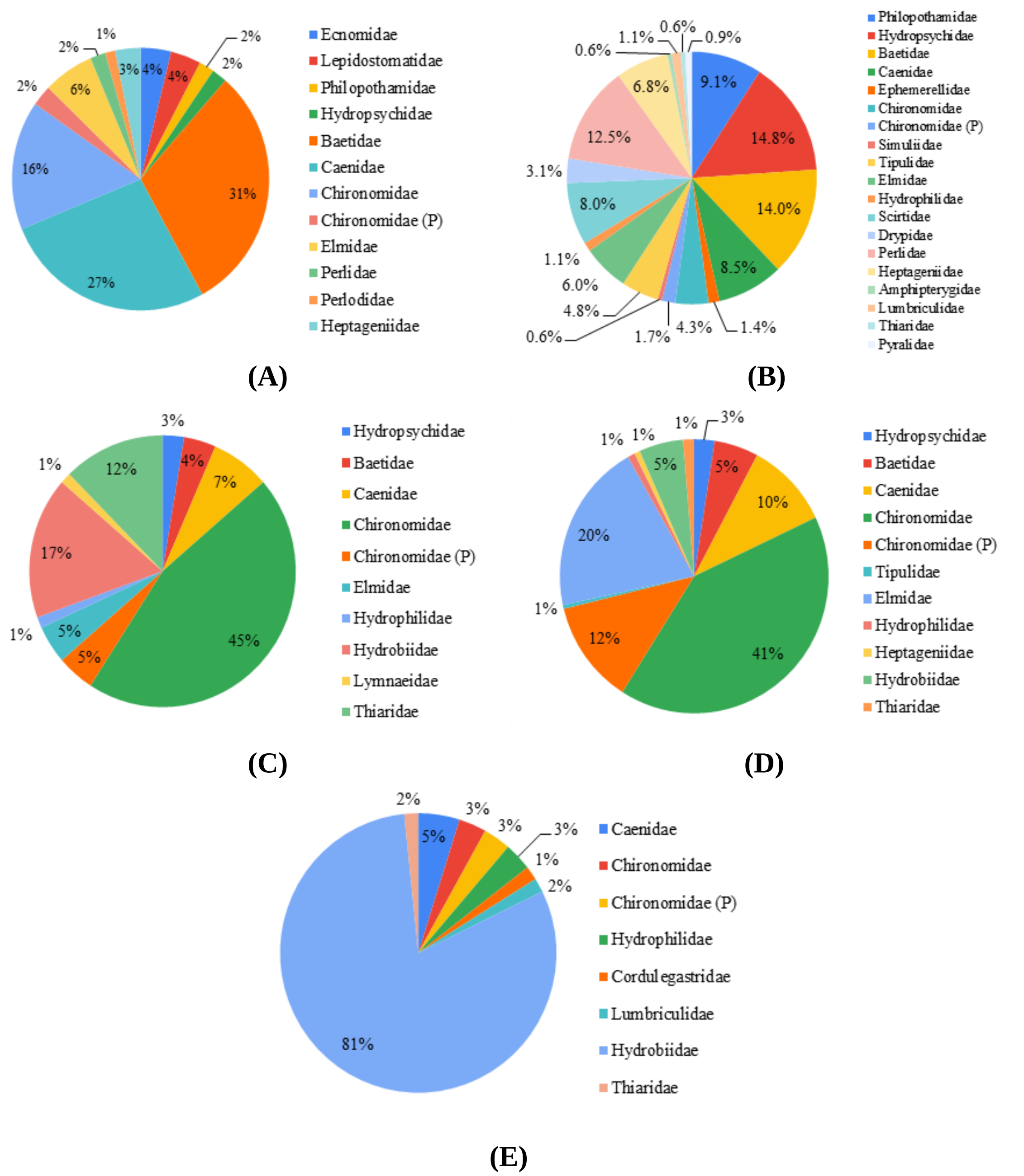

Fig. 2. Relative Abudance of Benthic Macroinvertebrates A. Sampling Point I; B. Sampling Point II; C. Sampling Point III; D. Sampling Point IV; E. Sampling Point V in the Setail River, Banyuwangi, East Java

Larvae of the Baetidae species are the most common families distributed in different water conditions and are usually associated with Caenidae larvae in flowing freshwater bodies. Species from the Baetidae family show moderate tolerance to pollution levels and are often found in very clean water to moderately polluted water. The Baetidae family is more tolerant to pollution than the Caenidae family **(Alhejoj *et al.*, 2023)**. The Hydropsychidae family is the family whose organisms are most commonly found at SP II (Fig. 2B). Hydropsychidae larvae, or commonly called the caddis fly larvae, are usually found in moderate to fast-flowing waters and submerged on rocky or woody substrates **(Morse *et al*., 2019)**. Although the Hydropsychidae family (Hydropsyche) can be found in lightly polluted waters; this group is also sensitive to heavily polluted waters **(Purdyaningrum *et al*., 2013)**. The Hydropsychidae family belongs to the Trichoptera order which has a relatively tolerant nature to pollution with a tolerance value of 4, which means this family can indicate lightly polluted waters. If this family is found in waters, it indicates that the location is lightly polluted with little organic material **(Janah *et al*., 2024)**.

The high abundance of the Chironomidae family at SP III and IV (Fig. 2C, D**)** can be caused by its ability to tolerate different environmental conditions. The high abundance of the Chironomidae family in SP III and IV may be due to its ability to tolerate different environmental conditions. According to **Nicacio and Juen (2015)**, Chironomidae is a highly species-diverse group and its members can be found in various habitats. This family has various sensitive species and several species groups with tolerance to environmental gradients, ranging from undisturbed ecosystems to ecosystems impacted by humans. Among macroinvertebrate taxa, Chironomidae is one of the richest groups with many species inhabiting lotic and lentic habitats **(Al-Shami *et al*., 2010)**. Chironomid larvae occupy very diverse biotopes due to their ability to tolerate various environmental water quality gradients and their extraordinary ecological range and environmental sensitivity **(Odume & Muller, 2011)**. The chironomid taxa that survive there (*Chironomus* spp.) are resistant to low oxygen levels because their hemolymph fluid contains high concentrations of hemoglobin, which has a high sensitivity to oxygen molecules that diffuse through the body wall. Fly larvae overcome the problem of low dissolved oxygen through a respirator tube that allows them to breathe oxygen from above the water surface of water bodies with high nitrogen, phosphorus and carbon content which are mostly dominated by large chironomid larvae **(Beneberu *et al*., 2014)**. Chironomidae was found most abundantly at this station, allegedly due to the influence of organic pollutant input from community activities.

The abundance of Hydrobiidae was high at SP V (Fig. 2E), which was influenced by the location which was a lowland. The high abundance of this family was due to the difference in substrate, namely rock and sand. This family was found attached to rock areas and vegetation on the banks of the river. Current speed also affected the high abundance of this family. The results of this data are supported by research conducted by **Mabrouki *et al*. (2020)**, the Hydrobiidae family is a family found in calm and slow streams. Its life is relatively attached to rocks and vegetation in shallow waters. According to **Tawati *et al*. (2020)**, Hydrobiidae can be an indicator of waters experiencing moderate pollution. Macroinvertebrates that are tolerant to pollution are most likely caused by runoff from domestic waste, livestock, and agricultural operations. In the study of **Elvira *et al*. (2024)**, the Order Gastropoda showed the highest abundance among macroinvertebrates. These organisms, which live in sediment, are known to be tolerant of organic pollution, low oxygen levels, and sediment disturbance.

3 Macroinvertebrate biology index

Benthic macroinvertebrates at sampling point I to IV (1.72 – 2.55) have moderate diversity (1<H'<3: moderate). Benthic macroinvertebrates at SP V (0.85) are classified as low (H'<1: low). The evennes index (E) at SP I to IV (0.75-0.88) shows a high category (E>0.6). The evennes index at station V (0.43) is included in the low category (E<0.4), because at this station there is dominance. The dominance index at SP V (0.66) is classified as high (C>0.5) because at this station there is dominance by one family, namely Hydrobiidae from the Gastropoda class. Dominance at SP I to IV (0.09 – 0.26) shows that there is one family that dominates (C<0.5). Table (3) provides complete information on the biologi indices (Diversity, evennes and domonace indexes) of macroinvertebrates found in the upstream of the Setail River.

Table 3. Biological indices of benthic macroinvertebrates (Diversity (H'), Evennes (E), Dominance (C)) in the Setail River, Banyuwangi, East Java

Sampling Point	Indexes		
	Diversity (H')	**Evennes (E)**	**Dominance (C)**
I	1.91	0.77	0.20
II	2.55	0.88	0.09
III	1.72	0.78	0.26
IV	1.73	0.75	0.24
V	0.85	0.43	0.66

The biological indices (diversity, evenness, and dominance) of benthic macroinvertebrates at five sampling points, as shown in Table (3), indicate that sampling points I to IV exhibit moderate diversity (1 < H' < 3). This moderate diversity is attributed to the relatively diverse abundance of families found at these sites. In contrast, sampling point V demonstrates low diversity (H' < 1) due to the limited number of families present. The substrate at SP V consists of fine sand and rocks, which restricts the adaptability of many benthic macroinvertebrates.

Previous studies have shown that substrate size, heterogeneity, compactness, cavities, and surface structures on the riverbed significantly influence the composition of benthic macroinvertebrates. Macroinvertebrate richness, abundance, density, and biomass are typically higher on rocky substrates than on coarse or fine sands or silts. Sandy, silty, and clay-based riverbeds are less suitable for macroinvertebrates, whereas rocky substrates provide gaps that facilitate water and nutrient flow **(Su *et al.*, 2019)**. According to **Roman and Bunyani (2024)**, the adaptability of benthic macroinvertebrates to environmental conditions directly affects riverine diversity index. Additionally, **Armadan *et al.* (2022)** noted that low diversity index values may reflect the dominance of a single family, often a result of anthropogenic disturbances, which lead to declines in richness, abundance, and overall biodiversity.

The calculated evenness index (E) at SP I to IV falls within a high category (E > 0.6), indicating an even distribution of individuals across families at these stations. In contrast, SP V shows a low evenness index (E < 0.4), reflecting the dominance of a single family. **Armadan *et al.* (2022)** suggested that a high evenness index indicates an even distribution of species, while a low value may imply uneven distribution. This unevenness often correlates with species dominance. According to **Isdianto *et al.*** (**2023**), the evenness index (E) reflects the balance of organisms in aquatic environments; a balanced community features similar individual counts across species, whereas a low evenness value signifies imbalance.

The dominance index at SP V is high due to the prevalence of a single family—Hydrobiidae from the class Gastropoda. The dominance of this family is linked to the adaptability of benthic macroinvertebrates to specific environmental **conditions (Yolanda *et al.,* 2021)**. The fine sand and rocky substrate at SP V is well-suited to Gastropods, particularly the Hydrobiidae family. Mollusks are typically associated with low-oxygen environments and are resilient in flexible ecosystems. SP V, characterized by stagnant water and a shallow, organic-rich substrate, supports a high density of mollusks, especially Gastropods. The reduced diversity of benthic macroinvertebrates downstream may result from factors such as water depth, flow velocity, anthropogenic impacts, and unstable substrates **(Basu *et al.,* 2018)**.

4. Similarity index (Bray Curtis)

The Bray-Curtis similarity index was calculated to group benthic macroinvertebrate organisms based on the similarity of their ecological conditions. This analysis was performed using the PAST 4.03 software, as illustrated in Fig. (3). The results reveal notable similarities among several sampling points. Sampling points I and II exhibit the highest similarity, with a value of 0.47, while points III and IV show a similarity of 0.44. In contrast, sampling point V displays the lowest similarity in the study, with a value of 0.14. The dendrogram representing the Bray-Curtis similarity index is shown in Fig. (15).

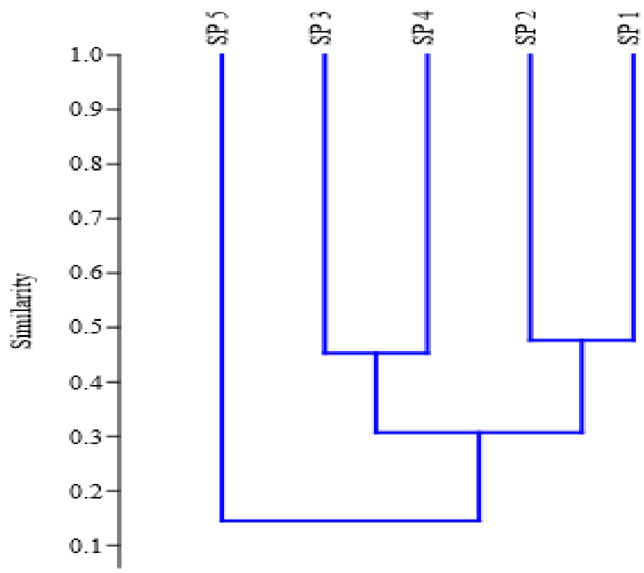

Fig. 3. Similarity index (Bray Curtis)

The similarity index (Bray Curtis) presented in Fig. (3) shows that SP I and II have a relatively high similarity index in this study due to the almost identical station conditions. The water quality conditions at both stations are not much different and the substrates at SP I and II have similarities, namely sandy rocks. One of the benthic macroinvertebrate families found at both stations is Heptageniidae. The Heptageniidae family can be found in optimal environmental conditions with sandy rock substrates **(Roman & Bunyani, 2024)**. SP III and IV have similarities in benthic macroinvertebrates due to the substrate conditions that tend to be the same. The Chironomidae family is the family found with the highest relative abundance at these two stations. Chironomidae can be found on river substrates composed of sandy rocks. Families from the Diptera order can live in environments that are suspected of being polluted due to their tolerant characteristics. Rivers with land use close to settlements are one of the locations where this family can be found **(Kawirian *et al*., 2020)**. SP V has a low similarity value due to the difference in substrates at this station with the four stations. The family with the highest abundance at this station comes from the Gastropoda class. The Gastropoda class has a wide tolerance due to its adaptability to various substrates **(Kurniawati *et al*., 2023)**.

5. ASPT – BMWP

Based on the calculation of the BMWP-ASPT score, it shows that the health condition of the Setail River, Banyuwangi is in the category of water that is still very clean to the possibility of moderate pollution. The highest ASPT value is at SP I, namely 6.9 (clean water). The ASPT values that are classified as doubtful quality are SP II, namely 5.9 and SP IV, namely 5.2. The ASPT values that are classified as Probable moderate pollution are SP III and V, namely 4.4 and 4.6.

Table 4. Biotic index (ASPT) of benthic macroinvertebrates in the Setail River, Banyuwangi, East Java

No	Description	ASPT-BMWP Value	Description
1	Sampling Point I	6.9	Clean Water
2	Sampling Point II	5.9	Doubtful quality
3	Sampling Point III	4.4	Probable moderate pollution
4	Sampling Point IV	5.2	Doubtful quality
5	Sampling Point V	4.6	Probable moderate pollution

Based on the BMWP-ASPT score calculations (Table 4), the health condition of the Setail River in Banyuwangi ranges from very clean to possibly moderately polluted.The highest ASPT value is at sampling point (SP I), namely 6.9 (clean water). The families found at this sampling point with high BMWP scores are Heptageniidae, Perlidae, Perlodidae and Lepidostomatidae. According to **Mariantika and Retnaningdyah (2014)**, the Lepidostomatidae family is a family of benthic macroinvertebrates that are intolerant of environmental pressure. The ASPT values that are classified as of questionable quality are SP II, namely 5.9 and SP IV, namely 5.2. The ASPT value at this station is slightly lower than SP I due to the presence of the Lumbricidae and chironomidae families. The ASPT values that are classified as possible spring pollution are SP III and V, namely 4.4 and 4.6. The families found in abundance at this station are from the Chironomidae, Thiaridae and Hydrobiidae families. The health condition of the river at SP III and V is likely moderate pollution due to the influence of the location close to the residential area which is a source of pollutant input. **Anh *et al*. (2023)** stated that the condition of polluted water is mostly caused land use patterns can have negative impacts on water quality parameters. Land clearing, livestock waste, and agricultural activities can release sediment, nutrients, organic matter, and pathogens through runoff or irrigation. Rapid population growth and urbanization have put greater pressure on ecosystems and aquatic environments.

6. Water auality

The temperature of the Setail River water from SP 1 to V ranges between 23 - 30.3°C, Current velocity ranges between 0.09 - 0.77m/ s, pH is neutral, namely 7, DO ranges between 6.00-7.05mg/ L, ammonia ranges between 0.063 - 0.142mg/ L, TOM ranges between 9.55 -20.96mg/ L, the type of substrate in SP 1 to IV is the same while SP V has a different substrate.

Table 5. Water quality parameters in the Setail River, Banyuwangi, East Java

Parameter	**SP I**	**SP II**	**SP III**	**SP IV**	**SP V**
Temperature (°C)	23	26.9	26.3	26.5	30.3
Current velocity (m/s)	0.71	0.77	0,77	0.71	0.09
pH	7	7	7	7	7
DO (mg/L)	7.05	6.63	6.73	6.50	6.00
Ammonia (mg/L)	0.063	0.071	0.099	0.067	0.142
TOM (mg/L)	17.20	20.96	19.90	13.87	9.55
Substrate	Sandy and rocky	Sandy and rocky	Sandy and rocky	Sandy and rocky	Cadas stone and sandy

As shown in Table (5), the water temperature of the Setail River ranges from 23 to 30.3°C across sampling points SP I to SP V. The lowest temperature was recorded at SP I, which is located in a highland area with relatively dense plant canopy cover, contributing to cooler water conditions. In contrast, the highest temperature was observed at SP V, situated in the lowlands where surrounding vegetation is relatively sparse, resulting in higher water temperatures. Higher than usual summer water temperatures and a larger than usual annual temperature range in locations with reduced flow contribute to lower invertebrate richness **(Dewson *et al*., 2007)**. The dominant organisms usually come from organisms that have a high tolerance to high temperatures (eurythermal). Current speed ranges from 0.09 - 0.77m/ s, the current speed at SP V tends to be very low compared to other sampling point. Invertebrate density changes in response to flow. Low flow causes invertebrate density to decrease and also decreases downstream due to reduced wetlands and can sometimes be attibute to the increase in individuals being concentrated in a smaller area **(Gore 1977; Wright & Berrie 1987; Dewson *et al*., 2007)**. Environmental changes in rivers, such as increased water temperature, increased sedimentation, and changes in periphyton assemblages, can cause changes in taxonomic richness as flow decreases.

The pH is neutral at 7, the optimal pH value for benthic macroinvertebrate life is 5<pH<9 **(Wang *et al*., 2012)**. This is clarified by **Patty and Akbar (2018)** that the pH value in waters can be influenced by various factors including rainfall and the influence of land and oxidation processes that cause the pH value to be low. This is in accordance with the data obtained, namely the low diversity of macrozoobenthos epifauna caused by the pH value of the waters being too low, which inhibits the development and growth of macrozoobenthos **(Rahman *et al*., 2023)**. The pH value at all sampling points is still considered good for the life of benthic macroinvertebrates. Dissolved oxygen (DO) ranges from 6.00-7.05mg/ L. According to **Ridwan *et al*. (2016)**, dissolved oxygen plays a role in determining the benthic macroinvertebrate community in waters. Benthic macroinvertebrates can live in waters with a minimum dissolved oxygen level of 5mg/ L. Several families can survive in lower or higher dissolved oxygen conditions depending on their ability to adapt. According to **Diantari *et al*. (2017)**, families from the EPT group (Ephemeroptera, Plecoptera and Trichiotera) are often found in upstream areas of rivers with high DO levels.

Ammonia ranged from 0.063 - 0.142mg/ L, where the highest ammonia was at station 5. This happened because the location was in the lowlands that received runoff from upstream areas, which had passed through residential areas, urban areas, plantations that received pollutant runoff from previous flows. Macroinvertebrate diversity also decreased significantly in waterways near places with intense human activity with the exception of several taxa that were sensitive to physicochemical conditions, and an increase in the density of tolerant taxa, resulting in decreased alpha diversity and community evenness. Several genera of Chironomidae were the only dominant and tolerant to high ammonia levels. Several taxa appear to be tolerant to moderate pollutant levels such as Simuliidae, Odonata, and molluscs **(Docile *et al*., 2016)**.

CONCLUSION

In the upstream to midstream sections of the Setail River, the benthic macroinvertebrate community is composed of 3 classes and 25 families from 10 orders, including Trichoptera, Ephemeroptera, Diptera, Coleoptera, Plecoptera, Odonata, Lepidoptera, Lumbriculida, Littorinimorpha, and Basommatophora. The abundance of benthic macroinvertebrates ranged from 62 to 451 individuals/m². Species diversity varied from 0.85 to 2.55, indicating a low to moderate diversity. The evenness index ranged from 0.43 to 0.88 (low to high), while the dominance index at Station V was 0.66, which is considered high ($C > 0.5$), due to the dominance of a single family, Hydrobiidae from the Gastropoda class.

The Average Score Per Taxon (ASPT) across sampling points ranged from 4.4 to 6.9, reflecting water quality conditions ranging from clean water to questionable quality, and even possible moderate pollution, depending on the location. These results indicate that the water quality of the Setail River ranges from very good to moderately polluted, with Sampling Points III and V being of particular concern.

Analysis of surrounding land use and activities suggests that these changes in benthic community structure and composition are linked to elevated ammonia levels at certain points, especially SP III and V. This highlights the need for management actions, such as community awareness campaigns to prevent river pollution, and strategies specifically aimed at reducing ammonia sources. The findings of this study provide valuable data to support such efforts and to help guide environmental restoration and conservation of the Setail River ecosystem.

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