

Classification of the Penguluran River and Mbambang River using Macroinvertebrate with TWINSpan Analysis

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Abstract:- The Penguluran River and Mbambang River are strategic rivers from an ecological, economic, and social perspective. In the last 5 years there have been flood disasters which can affect the communities within them, for example macroinvertebrates. The aim of the research is the classification of macroinvertebrate habitat groups in Penguluran River and Mbambang River. Research methods uses survey methods and secondary macroinvertebrate data in 2023. Sampling at 25 sites based on different land uses by kicking technique with a hand net (mesh size of 500 μ m) in a 10 meter long riffle area. Data analysis using TWINSpan (Two-way Indicator Species Analysis). TWINSpan analysis obtained 9 site of group from 25 observation sites (site of groups A–I). Furthermore, the 9 site groups were divided into 3 large groups based on the level of macroinvertebrate sensitivity. Site of group E and F in Argotirto Village and Sumberagung Village have light sensitivity (30%) higher than medium sensitivity (20%) with current velocity ranges medium to fast, rock and gravel substrates that experience light smothering, plantation land use (coffee, mangosteen, and cloves) showed light degradation. Site of group A, B, C, H, and I in Argotirto Village, Sumberagung Village, and Sidodadi Village have moderate sensitivity (30%) higher than light sensitivity (20%), current velocity ranges slow to fast, rock substrate and gravel that experienced moderate smothering, secondary forest land use, plantations (sugar cane, coffee, banana), settlements, and livestock showed moderate degradation. Site of group D and E in Argotirto Village and Sumberagung Village have tolerant sensitivity (36%) than sensitive macroinvertebrates (28%), current velocity ranges medium to fast, rock and mud substrates that experience heavy smothering, plantation land use (coconut, banana, clove and mangosteen) showed heavy degradation. TWINSpan analysis of 9 site of group shows light degradation, moderate degradation, and heavy degradation.

Keywords:- Indonesia; Macroinvertebrate; River; TWINSpan

I. INTRODUCTION

A river basin is a topographical area where water flows from land areas to a river system that flows towards an estuary [1]. The current condition of watersheds has been damaged [2], one of which is the upstream Brantas watershed [3]. Rivers are the aquatic part of a watershed. River ecosystems have the characteristic of a flow that flows in one direction from upstream to downstream. Based on its trophic characteristics, the dominant biota that live in river ecosystems are heterotrophic organisms, meaning they cannot make their own food, namely benthic macroinvertebrates. The biological approach is generally complementary to the physical and chemical approach to water. Various aquatic biota can be used to monitor river water conditions, for example fish, benthic algae and macroinvertebrates [4], [5].

Macroinvertebrate are invertebrates that are retained in mesh sizes >200 to 500 μ m [6], [7]. Abundant invertebrates in upstream river ecosystems are dominated by insect larvae and nymphs till 95% [8]. Most macroinvertebrate habitats are fast-flowing rivers and substrate conditions that can support diverse macroinvertebrate communities [9], [10]. Macroinvertebrate taxa that are often found in Brantas River are insecta including the families Limnephilidae, Glossosomatidae, Heptageniidae, Perlidae, Philopotamidae, and Polycentropodidae [3].

The problem of environmental damage that occurs in Indonesia has become the concern of many parties. The frequent occurrence of natural disasters such as landslides, floods, and droughts is an indication that environmental damage has occurred. The reduction in the carrying capacity of river basins is thought to be the main cause of environmental damage which is getting worse from year to year.

The Penguluran River and Mbambang River are located in the Sumbermanjing Wetan District with a winding flow. The upper reaches of the Penguluran River and the Mbambang River are rivers with high and sharp gradients. Based on data from the Malang Regency Regional Disaster Management Agency Strategic Plan in 2021, several natural disasters occurred in 2016–2020, namely landslides, floods, drought and tornadoes. Sumbermanjing Wetan District is one of the sub-districts in South Malang. On July 8 2023, a flash

flood disaster struck in the Sitiadjo Village area which occurred because of the high intensity of rain resulting in high water overflow from the Penguluran River, submerging several hamlets [11]. Flood disasters are caused by damage to river watersheds, for example changes in land use. Apart from that, the pyrolytic mining located in Argotirto Village, Sumbermanjing Wetan District can have an impact on the river ecosystem.

Based on the description above, it is necessary to carry out research regarding the classification of the Penguluran River and Mbambang River using macroinvertebrates with TWINSpan (Two-way INDicator SPecies Analysis) analysis for the benefit of sustainable river watershed management.

The aim of the research is to analyze the status of the environmental conditions in Penguluran River and Mbambang River based on the classification of macroinvertebrate habitat groups.

II. RESEARCH METHOD AND SAMPLE

This macroinvertebrate research uses secondary data in 2023 from 5 studies in the Penguluran River and Mbambang River, Sumbermanjing Wetan District, Malang Regency (see Figure 1). Observation stations consist of site 1–5 [12], site 6–10 [13], site 11–15 [14], site 16–20 [15], and site 21–25 [16]. Determination of sites is based on different land use along the river.

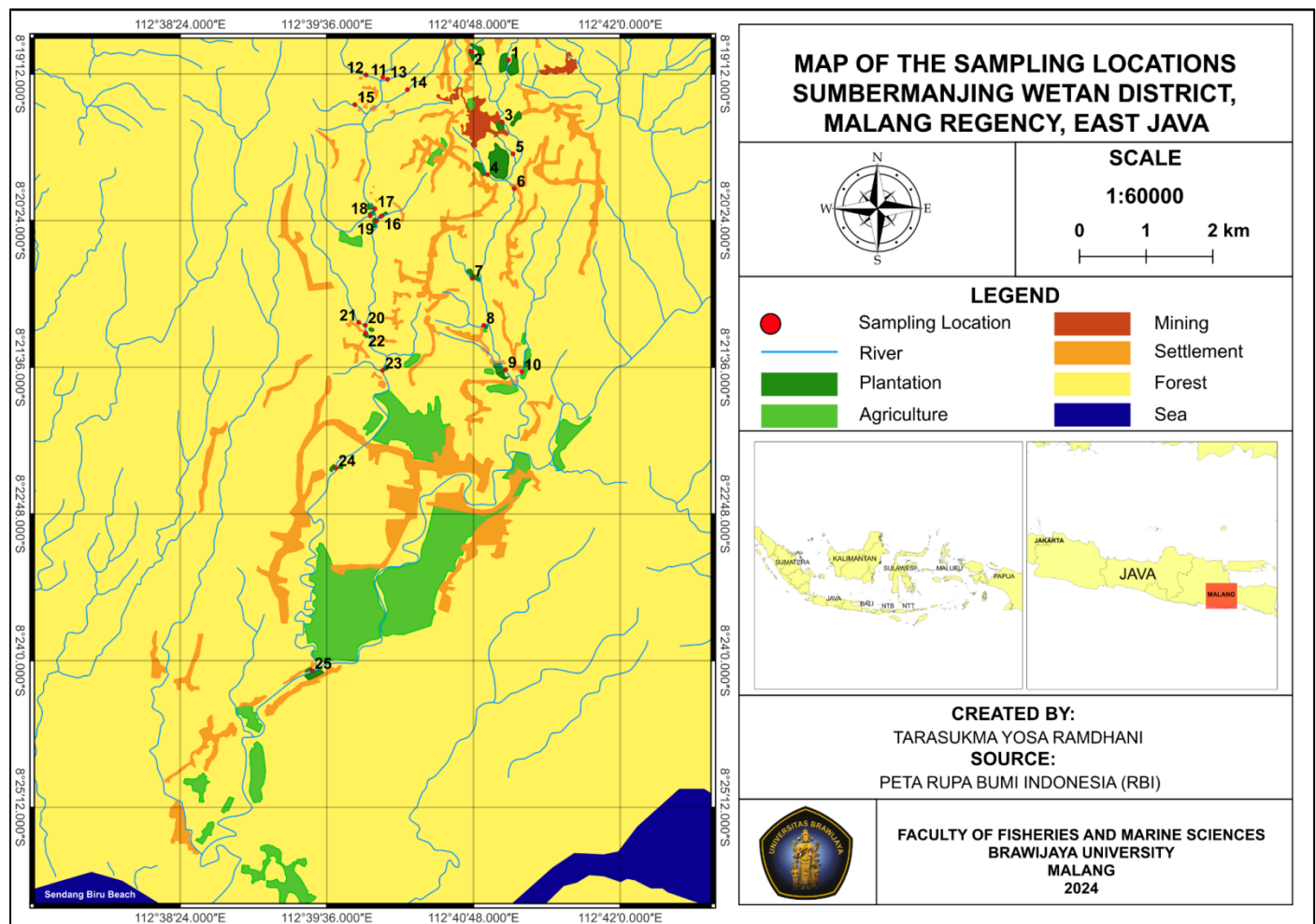


Fig 1: Sampling Site Location

Sampling is used to obtain a variety of different species. The tool used is a hand net with a kicking technique. The use of hand nets for sampling macroinvertebrates is generally used in shallow water with a total length of 10 m in the riffle area [17].

TWINSpan (Two-way Indicator Species Analysis) is a computer program designed primarily for ecologists and vegetation scientists who have collected data on the presence of a set of species in a set of samples. Samples can be stands, fauna, or whatever is suitable for research. The program first builds sample classifications, and then uses these

classifications to obtain species classifications that match their ecological preferences [18], [19].

TWINSpan is a multilevel classification technique that is often used to create site of groups classifications based on benthic macroinvertebrate communities [3], [20].

Since 1980 there has been increasing development regarding the use of the modern TWINSpan classification system using macroinvertebrates. The analysis method using TWINSpan software was first carried out by Sri Sudaryanti in 1995 in research on the Brantas River, East Java [21].

III. RESULT AND DISCUSSION

The macroinvertebrate found in the Penguluran River and Mbambang River in Sumbermanjing Wetan District at 25 sites were 50 taxa, consisting of 11 orders (Trichoptera, Ephemeroptera, Diptera, Odonata, Plecoptera, Hemiptera, Lepidoptera, Coleoptera, Mecoptera, Decapoda, and Malacostraca) and 4 classes (Gastropoda, Hirudinea, Tricladida, and Oligochaeta).

The result of data analysis using TWINSpan on the Penguluran River and Mbambang River showed that there

were 9 site of groups (A to I) from the 25 observation sites studied. The 9 groups of sites are grouped based on the types of macroinvertebrates found.

Futhermore after obtaining 9 site of groups from the result of analysis using TWINSpan, the 9 site of groups were divided into large groups based on macroinvertebrate composition and environmental factors. The result of dividing large groups based on macroinvertebrate composition and environmental factors can be seen on Table 1.

Table 1: Difference in Macroinvertebrates based on Environmental Factors

Site Group	Macroinvertebrate	Current Velocity and Substrate	Land Use and Shade Vegetation Types	Region	Category
E and F (2 sites)	Hydropsychidae, Baetidae, Tipulidae, Simuliidae, Elmidae, Amphipterygidae, Nepidae, Lygaeidae, Planaridae, Lepidostomatidae, Heptageniidae, Perlidae, Leptophlebiidae, Cordulegastridae, Leptoceridae, Gerridae, Veliidae, Athericidae, Muscidae, Caenidae	Medium-fast / Rocks and gravel have light smothering	Plantation (coffee, mangosteen, and cloves) / Non natural	Argotirto Village and Sumberagung Village	Light degradation
A, B, C, H, and I (16 sites)	Hydropsychidae, Baetidae, Chironomidae, Heptageniidae, Coenagrionidae, Thiaridae, Simuliidae, Caenidae, Leptophlebiidae, Amphipterygidae, Lumbriculidae, Tipulidae, Muscidae, Elmidae, Cordulegastridae, Grapsidae, Neritidae, Gammaridae, Nannochoristidae, Atyidae, Perlidae, Gomphidae, Philopotamidae, Gerridae, Leptoceridae, Coenagriidae, Pyralidae, Athericidae, Limoniidae, Lumbricidae, Scirtidae, Perlodidae, Aeshnidae	Slow-fast / Rocks and gravel have moderate smothering	Secondary forest, plantation (sugar cane, coffee, and bananas), settelements, mining, and livestock / Non natural	Argotirto Village, Sumberagung Village, and Sidodadi Village	Moderate degradation
D and G (7 sites)	Hydropsychidae, Baetidae, Thiaridae, Chironomidae, Tipulidae, Simuliidae, Heptageniidae, Elmidae, Amphipterygidae, Cordulegastridae, Pyralidae, Planaridae, Gerridae, Veliidae, Naididae, Limnephilidae, Lepidostomatidae, Lampiridae, Athericidae, Coenagrionidae, Caenidae, Perlidae, Gomphidae, Philopotamidae, Lumbricidae, Leptoceridae, Libellulidae, Sundathelphusidae, Noctuidae, Dytiscidae, Ceratopogonidae, Glossosomatidae, Empididae, Grapsidae, Tabanidae, Lumbriculidae, Richardsonianidae, Muscidae	Medium-fast / Rocks and mud have high smothering	Plantations (coconut, banana, clove, and mangosteen)	Argotirto Village and Sumberagung Village	High degradation

A. Light Degradation

Site groups E and F contained 2 observation sites (see Tabel 1) in Argotirto Village and Sumberagung Village, 20 macroinvertebrate taxa were found, include Amphipterygidae, Leptophlebiidae, Athericidae, and Lepidostomatidae (classified as high sensitivity), include Hydropsychidae, Baetidae, and Planariidae (classified as light sensitivity), include Tipulidae, Simuliidae, and Gerridae (classified moderate sensitivity) and include Caenidae, Muscidae, Nepidae, and Cordulegastridae (classified tolerant sensitivity). Macroinvertebrates found in this site group had a light sensitivity level (30%) greater than a moderate sensitivity level (20%), current velocity ranged from medium to fast, rock and gravel substrates experienced light smothering, land use contained plantations (coffee, mangosteen, and cloves).

Caenidae are widespread and common in a variety of lotic and lentic habitats, including streams of all sizes, spring seeps, marshes, ponds, and lakes. Here they often settle and are often partially covered by silt. Caenidae at this site group have gill covers on their stomach as a pattern of adaptation to bad conditions [22]. The gill covers help keep mud from accumulating between the gills, as mosses often reside where they collect in large numbers. Gill covers may also be used to facilitate oxygen exchange. This is what makes Caenidae able to survive and be found in polluted waters [23], [24].

Muscidae larvae reside in slow-flowing and fast-flowing boundaries. They can be found in moss or other vegetation where they often sink. The Muscidae at this site group have additional respiratory tracts as their adaptation pattern for surviving in adverse conditions [25], [26]. Most of the larvae have a pair of very short caudal respiratory tubes, a pair of abdominal tubes on the last abdominal segment that are longer than the respiratory tube, and often crawl along the rest of the stomach. This is what makes Muscidae able to survive and be found in polluted water conditions [22]. The results of observations above show that site group E and F experienced light degradation.

B. Moderate Degradation

Site groups A, B, C, H, and I contained 16 observation sites (see Table 1) in Argotirto Village, Sumberagung Village, and Sidodadi Village, 33 macroinvertebrate taxa were found, include Leptophlebiidae, Perlidae, Philopotamidae, and Elmidae (classified high sensitivity), include Hydropsychidae, Baetidae, Scirtidae, and Leptoceridae (classified light sensitivity), include Thiaridae, Simuliidae, Tipulidae, and Chironomidae (classified moderate sensitivity), and include Lumbriculidae, Caenidae, Pyralidae, and Cordulegastridae (classified tolerant sensitivity). Macroinvertebrates found in this site group have moderate sensitivity level (22%) which is greater than a light sensitivity level (14%), current velocity ranges slow to fast, rock and gravel substrates experienced moderate smothering, land use contained secondary forests, plantations (sugar cane, coffee, and bananas), settlement, mining, and animal husbandary.

The majority of Lumbriculidae are adapted to live in sediments ranging from sand to mud. They can be found in such sediment pockets in rocky habitats as well as in lowland streams, lakes, and ponds where soft substrates are normal. This is why Lumbriculidae is found in polluted waters [27].

Cordulegastridae larvae live in small rivers where they reside under sand and mud. The presence of Cordulegastridae at this site group is because they have an adaptation pattern to gravel and sand substrate [22]. Cordulegastridae larvae almost bury themselves in sand or mud because they act as predators to catch their prey. This causes Cordulegastridae to be found on sandy substrates [28]. The result of the observations above show that site group A, B, C, H, and I experienced moderate degradation.

C. High Degradation

Site groups D and G contained 7 observation sites (see Table 1) in Argotirto Village and Sumberagung Village, 38 macroinvertebrate taxa were found, include Heptageniidae, Glossosomatidae, Limnephilidae, and Lepidostomatidae (classified as high sensitivity), include Hydropsychidae, Baetidae, Lampiridae, and Leptoceridae (classified as light sensitivity), include Empididae, Ceratopogonidae, Gomphidae, and Tipulidae (classified as moderate sensitivity), and include Naididae, Richardsonianidae, Muscidae, and Lumbriculidae (classified as tolerant sensitivity). Macroinvertebrates found in this site group had a tolerant sensitivity level (36%) greater than a sensitive level (28%), current velocity ranged from medium to fast, rock and gravel substrates experienced high smothering, land use contained plantations (coconut, banana, clove, and mangosteen).

Naididae are often found in large number in sandy and muddy rivers. The existence of Naididae at this site has an adaptation pattern where they are able to survive by having gills that resemble feathers on the back of their bodies [25], [30]. Naididae have gills at the rear end of the body, usually closed in a gill chamber which is able to survive in low oxygen conditions. This is what makes Naididae able to survive in polluted waters [27], [29].

The majority of Lumbriculidae are adapted to live in sediments ranging from sand to mud. They can be found in such sediment pockets in rocky habitats as well as in lowland streams, lakes, and ponds where soft substrates are normal. This is why Lumbriculidae is found in polluted waters [27]. The result of observations above show that site group D and G experienced high degradation.

IV. CONCLUSION

The macroinvertebrate found in the Penguluran River and Mbambang River in Sumbermanjing Wetan District at 25 sites were 50 taxa, consisting of 11 orders (Trichoptera, Ephemeroptera, Diptera, Odonata, Plecoptera, Hemiptera, Lepidoptera, Coleoptera, Mecoptera, Decapoda, and Malacostraca) and 4 classes (Gastropoda, Hirudinea, Tricladida, and Oligochaeta).

TWINSPAN analysis obtained 3 groups based on macroinvertebrates and environmental factors, categorized light degradation located at Argotirto Village and Sumberagung Village macroinvertebrate types were found including Leptophlebiidae, Lepidostomatidae, and Caenidae with land use plantations (coffee, mangosteen, and cloves), rock and gravel substrates that experienced light smothering. Categorized moderate degradation located at Argotirto Village, Sumberagung Village, Sidodadi Village macroinvertebrate types were found including Tipulidae, Simuliidae, and Lumbriculidae with land use secondary forests, plantations (sugar cane, coffee, and bananas), settlements, mining, and livestock, rock and gravel substrates that experienced moderate smothering. Categorized high degradation located at Argotirto Village and Sumberagung Village macroinvertebrate types were found including Naididae and Richardsoniidae with land use plantations (coconut, banana, clove, and mangosteen).

Suggestions that can be given from this research are controlling plantation and mining activities in Argotirto Village, Sumberagung Village, and Sidodadi Village, Sumbermanjing District.

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