Jurnal Ilmu Alam dan Lingkungan 16 (1), (2025). 1 - 8

Jurnal
Ilmu Alam dan Lingkungan

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Distribution of Macroinvertebrates for Bioassessment in Sampean River System, East Java-Indonesia

Widyanti Yuliandari[1*]

[1]*UIN Raden Mas Said Surakarta Jawa Tengah 57168, Indonesia*

[*]*Email: widyanti_yuliandari@staff.uinsaid.ac.id*

Abstract

Water quality degradation in the Sampean River will increase from year to year due to the increase in wastewater production as well as land degradation resulting from population growth and economic developments. Runoff from intensive agricultural systems can impair the quality of catchment waters, with potential ecological implications. Bioassessment of river water using benthic macroinvertebrates is common in developed countries. However, using bioassessment as part of regular monitoring programs in developing countries is scarce. Assessment of river water pollution in Indonesia is mainly conducted by comparing the physico-chemical parameters of water and the standards regulated by law. This study aims to identify the macroinvertebrate community in the Sampean River. Macroinvertebrate data can provide information about the potential application of bioassessment in this river system using macroinvertebrates as bioindicators. Sampling was conducted at 10 locations with two replications. Physico-chemical methods are carried out using parameters: temperature, pH, BOD, ammonium, nitrite, nitrate, and phosphate. Macroinvertebrates were obtained with kick sampling using a standard handset (500 µm pore size) and an adequate 5-minute collection time. Found 21 taxa of Plecoptera. Based on the macroinvertebrate community found in this study, bioassessment is a potential method to be applied in the Sampean River system. However, further research is needed to understand the most suitable approach.

Keywords*: Bioassessment, macroinvertebrates, Sampean River*

INTRODUCTION

Bioassessment is widely used in developed and developing countries such as Thailand and Vietnam. Nevertheless, bioassessment has not been commonly used in Indonesia. Monitoring the river's water quality is usually carried out by physical-chemical method, according to the laws and regulations in Indonesia. However, the physical-chemical method has several disadvantages, such as momentary measurement results, since they only represent when the sample is taken. Therefore, the measurements must be repeated in a time series (Rahayu et al., 2009). The number and type of organisms found in water can reflect the water quality based on where they were taken (Islam et al., 2018; Adesakin et al.,

P ISSN: 2086 - 4604
E ISSN: 2549 - 8819

2023). According to Tarnawski & Baran (2018), bioassays, which are cost-effective and rapid tools, enable real assessment resulting from multiple chemical stressors in bottom sediments, their bioavailability, toxicity, and interaction. Therefore, Bioassessment can be used with physical-chemical methods, complementing one another (Serpa et al., 2014; Li et al., 2023). Macroinvertebrates are bio-indicators, the most widely used in bio-assessment (Mir et al., 2021; Al et al., 2022). Therefore, macroinvertebrates are highly suitable for assessing site-specific conditions in upstream and downstream environments. Different taxa can exhibit distinct responses to environmental pressures (Krajenbrink et al., 2019; Li et al., 2024). Macroinvertebrates are easily identifiable at the familial level. A collection of macroinvertebrates consists of various taxa that reflect the broad trophic level and pollution tolerance, thus providing strong cumulative information. Sampling is relatively easy, does not require much power, and is relatively harmless to other biota (Miranda, 2015; Oguma & Klerks, 2017; Gao et al., 2023; Orozco González, 2023).

The watershed of the Sampean River is a regional river with an area of 1,277,388 km^2 covering the Bondowoso and Situbondo districts. The upstream area is the Argopuro and Raung mountain areas, Bondowoso districts. The estuary is in the Panarukan district of the Situbondo Regency. The upstream of the Sampean River is about 800 mdpl, while its estuary is 3 mdpl. With a river length of 73 km, the high difference makes the river gradient quite tilted. In normal conditions, the river flow is classified as heavy. Besides being influenced by the quality of the river water, macroinvertebrates' existence and life are also strongly influenced by morphological and hydrological factors. This study was conducted to determine the composition and distribution of macroinvertebrates in the Sampean River system. This data is expected to be preliminary information to assess the potential application of bioassessment in determining the quality of Sampean River water.

METHODS

Location and Study Time

The location of this research was the Sampean River. The sampling would be conducted at 10 sites from 5 different river orders on the Sampean River system. The determination of order was done using the Strahler method. Five order rivers were obtained based on the Strahler method, and two sampling locations represented each order. Site selection also considered the land use around the river and the sources of pollutants (Figure 1). Sampling was conducted from March to May 2018.

Measurement of Physical-Chemical Water Parameters

Sampling of river water was done by using a horizontal water sample composite. The measurements of physical-chemical parameters included pH, temperature, DO, BOD, phosphate, nitrite, and nitrate. The pH, temperature, and DO were measured directly at the sampling site.

Macroinvertebrate Collection and Identification

Macroinvertebrate was taken by kick sampling using the 500 µm hand net standard. The net was placed facing toward the flow, and then the substrate in front of the net was stirred with the feet. The obtained macroinvertebrate samples were cleared and separated from mud or other objects. Wood, garbage, and plants on the banks of the river were also taken to obtain inherent macroinvertebrates. The samples were preserved with 70 percent alcohol. Packing and labeling were carried out in the laboratory. The macroinvertebrate samples were identified immediately in the laboratory. This was to prevent damage to the sample, causing difficulties and misidentification. The sample was placed on a 500 µm sieve and rinsed under running water to remove any remaining small particles. Identification was done at the family level.

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E ISSN: 2549 - 8819

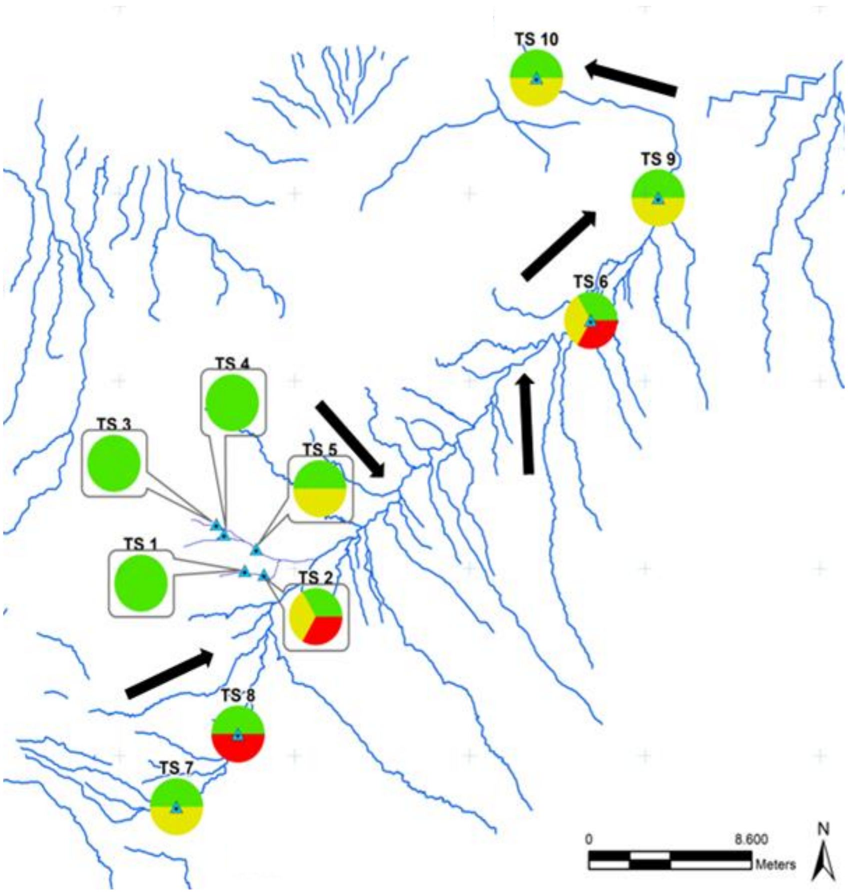

Figure 1. Sampling Point and Pollution Source.
(Red: industry, Green: agriculture, yellow: domestic).

RESULTS AND DISCUSSION

Physical-Chemical Parameters of Water

The results of physical-chemical parameter measurements at 10 sampling sites are shown in Table 1.

Table 1. The Results of Measurement of Physical-Chemical Parameters

Parameters	Standard	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6	TS 7	TS 8	TS 9	TS 10
Temp (°C)		27.50	29.50	28.50	29.50	29.00	29.50	28.50	28.50	30.00	29.50
pH	6-9	6.56	6.91	6.91	7.03	6.82	7.14	6.91	6.98	7.69	7.37
DO (mg/l)	3	5.31	3.66	6.12	6.07	5.93	5.82	6.37	6.41	6.63	6.17
BOD (mg/l)	6	3.99	38.02	4.22	3.50	3.83	4.00	3.66	3.35	3.78	3.66
Nitrite (mg/l)	0.06	0.12	0.08	0.10	0.09	0.08	0.12	0.05	0.20	0.14	0.08
Nitrate (mg/l)	20	12.99	3.03	5.17	3.95	4.18	7.78	11.07	22.86	8.07	12.08
Phosphate (mg/l)	1	0.14	0.09	0.08	0.10	0.07	0.23	0.14	0.15	0.22	0.21

In general, the measurement results of several physical parameters of chemicals still meet the quality standard by applicable regulations in Indonesia. However, TS 2 for BOD and DO parameters did not meet the quality standard. The average BOD and DO rates at TS 2 were 38.02 mg/l and 3.66 mg/, while the standard quality of BOD and DO was 6 mg/l and 3 mg/l). The high input of organic material at this location comes from the waste of the home industry tofu, which is discharged into the

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E ISSN: 2549 - 8819

water without being treated first. Tofu wastewater has high BOD and COD characteristics. The range of BOD for tofu wastewater is 3,500-4,500 mg/L and BOD 5,000-8,500 mg/L. Tofu waste discharged into the environment without being treated first causes odor in river water (Faisal et al., 2015). This was also found at TS 2; some local residents complained about the smell of the river water at this location. Organic materials also come from domestic waste disposal from residential settlements along the rivers near the site. According to Margayan (2016), the high disposal of domestic waste into the river will cause the quality of the river to deteriorate, one of which is marked by the high number of BODs. The river flow between point 1 and point 2 is about 1.5 kilometers through densely populated residential areas. Based on the observations, the area around the sampling of point 2 also has poor sanitary conditions. It is not only the gray water discharged directly into the river but also the practice of open defecation directly to the river that is still found around this sampling site. The average nitrate content was 0.05-0.14 mg/l (the quality standard for class 3 river nitrite is 0.06 m/l). At all sampling sites except TS 7, nitrite content exceeded the quality standard. Nitrite (NO_2^-) is usually absent or present in relatively small concentrations compared to nitrate (NO_3^-) in natural waters because it is a thermodynamically unstable intermediate in microbial-mediated microbial cycles. Nitrite is rapidly converted to nitrate in oxygenated water and reduced to ammonia under anoxic conditions (Wieben, 2013). High nutrient levels of nitrite are common in rivers that flow through agricultural areas (De Mello et al., 2017; Solis et al., 2018). This is due to the conditions of the study area, where 68.82% of the Sampean watershed is in the form of agricultural and plantation land.

Macroinvertebrate Composition

There are 21 families found in the research study as shown in Table 1, namely Plecoptera: Perlidae, Ephemeroptera: Heptageniidae, Ephemeroptera: Baetidae, Odonata: Gomphidae, Ephemeroptera: Canidae, Crustacea: Palaemonidae, Crustacea: Parathelpusidae, Trichoptera: Hydropsychidae, Diptera: Tipulidae, Diptera: Thaumalidae, Mollusca: Thiaridae, Mollusca: Pilidae, Annelida: Hirudinea Arachnidae: Hydrachinidae Coleoptera: Elmidae, Coleoptera: Dytiscidae, Megaloptera: Corydalidae Hemiptera: Gerridae, Lepidoptera: Pyralidae and Diptera: Chironomidae. Research on benthic macroinvertebrates' taxonomic and functional diversity has provided valuable insights into ecological assessments. Studies conducted in various regions, including South Korea (Lee et al., 2023), Costa Rica (Kohlmann et al., 2021), Lake Kivu in East Africa (Hyangya et al., 2022), and Iran (Stojković Piperac *et al*., 2024), indicate that taxonomic and functional metrics help evaluate the impact of human activities on aquatic ecosystems. Based on the study of Kartikasari et al., (2013), the better the quality of the river is, the higher the diversity of the macroinvertebrates will be. The sampling site with the most significant taxa is TS 1, with 11 families. While TS 2 has the lowest diversity because it is only found in Diptera: Chironomidae at that location. In this study, TS 1, which has the highest diversity, is the water in order 1, which is very close to the water source in the form of a spring. The pollutant comes only from agriculture and from slight domestic activity by the community. Meanwhile, TS2 receives pollutant load from the tofu industry, agriculture, and domestic sectors. An abundance of tolerant macroinvertebrates also indicates the poor quality of the water. At TS 2, more than 1500 individuals of Chironomidae from the *Chironomus* genus show a high abundance of tolerant macroinvertebrates. This is also the case in a study of the Papuan Nimbai River, which was contaminated by organic waste derived from palm oil processing. At highly contaminated organic sites, it indicates a high abundance of tolerance macroinvertebrates (Leatemia et al., 2017). The sampling sites that also have only a few types of macroinvertebrates are TS 3 (4 types), TSt 9 (4 types), and TS 10 (2 types). This is because, upstream of point 3, a weir can be a disruption factor. The substrate in this section is also mud, which is an unstable substrate type, and it is usually a tiny type of macroinvertebrate that can be found within. At point 10, which is very close to the estuary, Palaemonidae and Mollusca: Thiaridae are only found.

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E ISSN: 2549 - 8819

Table 2. Macroinvertebrate Composition in the Study Site

No	Family	Number									
		TS 1	TS 2	TS 3	TS 4	TS 5	TS 6	TS 7	TS 8	TS 9	TS 10
1	Plecoptera: Perlidae	-	-	-	45	-	-	134	66	-	-
2	Ephemeroptera: Heptageniidae	2	-	-		-	-	-	-	-	-
3	Ephemeroptera: Baetidae	-	-	-	-	37	1	-	-	4	-
4	Odonata: Gomphidae	-	-	-	-	-	-	-	2	-	-
5	Ephemeroptera: Caenidae	2	-		21	47	-	21	39	38	-
6	Crustacea: Palaemonidae	-	-	-	-	-	-	-	-	-	949
7	Crustacea: Parathelpusidae	20	-	3	-	-	1	28	8	-	-
8	Trichoptera: Hydropsychidae	2	-	-	5	4	5	209	14	3	-
9	Diptera: Tipulidae	2	-	1	-	-	4	3	1	-	-
10	Diptera: Thaumalidae	-	-	-	-	-	-	-	1	-	-
11	Mollusca: Thiaridae	2	-	128	3	-	-	8	55	-	10
12	Mollusca: Pilidae	1	-	-	1	-	-	2	-	-	-
13	Annelida: Hirudinea	-	-	-	-	-	-	-	1	1	-
14	Arachnidae: Hydrachinidae	1	-	-	-	-	-	-	-	-	-
15	Coleoptera: Elmidae	-	-	-	1	-	-	-	-	-	-
16	Coleoptera: Dytiscidae	2	-	-	-	-	-	-	-	-	-
17	Diptera: Culicidae	-	-	-	-	-	1	-	-	-	-
18	Plecoptera: Corydalidae	1	-	-	-	-	-	-	-	-	-
19	Hemiptera: Gerridae	17	-	-	-	72	-	-	-	-	-
20	Lepidoptera: Pyralidae	-	-	-	2	-	-	-	-	-	-
21	Diptera: Chironomidae	2	>1500	-	3	28	46	9	-	-	-
		54	>1500	133	80	181	60	414	187	48	959

Salinity is one of the factors that influence macroinvertebrate life. Some taxa are very sensitive to high salinity, while others are tolerant. The Baetidae family is among the most sensitive ones to high salinity, followed by Chironomidae, Gastropoda, Ephemeroptera-Non Baetidae, Plecoptera,

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Trichoptera, Hemiptera, and Coleoptera. While crustaceans are taxa with the best salinity tolerance (Kefford et al., 2012). Members of the Palaemonidae family exhibit a broad range of salinity tolerance, supported by their well-developed osmoregulatory mechanisms. Many species within this family are capable of hyperosmotic regulation at low salinities and hypoosmotic regulation at higher salinities, enabling them to thrive in diverse aquatic environments from freshwater to brackish estuaries and even hypersaline habitats (Giraldes et al., 2024).The above study's findings may explain the abundance of the Palaemonidae family at TS 9, the area near the estuary. While other families are only Mollusca: Thiaridae found at this point. It is because other families cannot survive. Plecoptera is commonly associated with swiftly flowing water habitats (Amaral et al., 2015). Plecoptera from the Perlidae family in this study were found in considerable numbers at TS 4, TS 7, and TS8 (as many as 45, 134, and 66 individuals). The Sampean River generally includes a river with a significant slope, and under normal conditions, the flow is relatively rapid. At 10 sampling points, the measured flow velocity is 0.5 to 1.2 m/sec. Trichoptera: Hydropsychidae is found in abundant quantities (209 individuals) at TS 7. Trichoptera is commonly found in fast-flowing waters. Rapid flow is important for respiration and food collection since it is a filterer (Waringer et al., 2021). At TS 7, the flow velocity is 0.5 m/s. The abundance of Hydropsychidae is also related to food availability at this point. Organic materials in the form of leaves, especially bamboo leaves, are found in this location, plus organic material comes from garden or kitchen waste dumped by people around the river. Hydropsychidae is found in parts of the river with a pile of leaves on the bottom.

CONCLUSION

Based on the type and the distribution of taxa found, bioassessment is considered to have the potential to be applied to the Sampean River system. The selection of the sampling location, the type of substrate, and the morphological conditions of the river need to be considered to obtain reliable bioassessment results. Further study is required to determine the most appropriate approach for bioassessment in this river system.

REFERENCES

Adesakin, T. A., Erhomosele, E. I., Ogunrinola, O. F., Oloyede, O. O., Adedeji, A. A., Odufuwa, P. T., Aimienoho, A., Aduwo, A. I., and Adewumi, E. A., 2023. *Using Benthic Macroinvertebrates as Bioindicators to Evaluate the Impact of Anthropogenic Stressors on Water Quality and Sediment Properties of A West African Lagoon.* Heliyon. 9(9): e19508. DOI: https://doi.org/10.1016/j.heliyon.2023.e19508.

Al, M. A., Akhtar, A., Kamal, A. H. M., AftabUddin, S., Islam, M. S., and Sharifuzzaman, S. M., 2022. *Assessment of Benthic Macroinvertebrates as Potential Bioindicators of Anthropogenic Disturbance in Southeast Bangladesh Coast.* Marine Pollution Bulletin. 184: 114217. DOI: https://doi.org/10.1016/j.marpolbul.2022.114217.

Amaral, P. H. M., Silveira, L. S. da, Rosa, B. F. J. V., Oliveira, V. C. de, and Alves, R. da G., 2015. *Influence of Habitat and Land Use on the Assemblages of Ephemeroptera, Plecoptera, and Trichoptera in Neotropical Streams.* Journal of Insect Science. 15(1): 1–10. DOI: https://doi.org/10.1093/jisesa/iev042.

De Mello, K., Randhir, T.O., Valentec, R.A., and Vettorazzi, C. A., 2017. *Riparian Restoration for Protecting Water Quality in Tropical Agricultural Watersheds.* Ecological Engineering. 108: 514–524.

Faisal, M., Mulana, F., Gani, A, and Daimon, H., 2015. *Physical and Chemical Properties of Wastewater Discharged from Tofu Industries in Banda Aceh City Indonesia.* Research Journal of Pharmaceutical, Biological and Chemical Sciences. 6: 1053-1058.

P ISSN: 2086 - 4604
E ISSN: 2549 - 8819

Gao, Q., Zhang, Q., Zeng, J., Yin, Z., Liu, J., Liu, G., and Peng, M., 2023. *Macroinvertebrate Community Structure, Pollution Tolerance, Diversity and Feeding Functional Groups in Polluted Urban Rivers Under Different Black and Odorous Levels*. Ecological Indicators. 156: 111148. DOI: https://doi.org/10.1016/j.ecolind.2023.111148.

Giraldes, B. W., Boughattas, S., Benslimane, F. M., Althani, A. A., Schubart, C. D., Huber, C. S. R., Utz, L. R. P., Al-Khayat, J. A. A., Sadooni, F. N., and Amado, E. M., 2024. *The Tale of an Endemic Shrimp's Exceptional Osmoregulation and the Ancient Athalassic Mangrove Oasis*. Scientific Reports. 14: 6677. DOI: https://doi.org/10.1038/s41598-024-56907-4.

Hyangya, B. L., Kankonda, A. B., Dusabe, M.-C., Murhimanya, J.-D. K., Kaningini, B. M., and Masilya, P. M., 2022. *Choice of Benthic Macroinvertebrate-Based Metrics for Assessing Water Quality in the Littoral Zone Under Anthropogenic Disturbance in Southern Lake Kivu (East Africa).* Ecohydrology. DOI: https://doi.org/10.1002/eco.2468.

Islam, M. S., Mahmud, Y., and Hossain, M. M., 2018. *Macroinvertebrates as Bio-Indicator of Water Quality in Estuaries.* Journal of Biodiversity and Environmental Sciences (JBES). 12(1): 324–332.

Kartikasari, D., Retnaningdyah, C., and Arisoesilaningsih, E., 2013. *Application of Water Quality and Ecology Indices of Benthic Macroinvertebrates to Evaluate Water Quality of Tertiary Irrigation in Malang District*. The Journal of Tropical Life. 3: 193-201.

Kefford, B. J., Hickey, G. L., Gasith, A., Ben-David, E., Dunlop, J. E., Palmer, C. G., Allan, K., Choy, S. C., and Piscart, C., 2012. *Global Scale Variation in the Salinity Sensitivity of Riverine Macroinvertebrates: Eastern Australia, France, Israel and South Africa.* Plos One. 7(5): e35224. DOI: https://doi.org/10.1371/journal.pone.0035224.

Kohlmann, B., Vásquez, D., Arroyo, A., and Springer, M., 2021. *Taxonomic and Functional Diversity of Aquatic Macroinvertebrate Assemblages and Water Quality In Rivers of the Dry Tropics of Costa Rica.* Frontiers in Environmental Science. 9. DOI: https://doi.org/10.3389/fenvs.2021.660260.

Krajenbrink, H. J., Acreman, M., Dunbar, M. J., Hannah, D. M., Laizé, C. L. R., and Wood, P. J., 2019. *Macroinvertebrate Community Responses to River Impoundment at Multiple Spatial Scales.* Science of the Total Environment. 650: 2648–2656. DOI: https://doi.org/10.1016/j.scitotenv.2018.09.264.

Leatemia, S. P. O., Manangkalangi, E., Theresia Lefaan, E. P., Peday, H. F. Z., dan Luky Sembel, L., 2017. *Makroavertebrata Bentos Sebagai Bioindikator Kualitas Air Sungai Nimbai Manokwari, Papua Barat*. Jurnal Ilmu Pertanian Indonesia (JIPI). 22: 25-33.

Lee, D.-Y., Lee, D.-S., and Park, Y.-S., 2023. *Taxonomic and Functional Diversity of Benthic Macroinvertebrate Assemblages in Reservoirs of South Korea.* International Journal of Environmental Research and Public Health. 20(1): 673. DOI: https://doi.org/10.3390/ijerph20010673.

Li, H., Zhang, Y., Wang, L., Zhou, M., Deng, W., and Liu, Y., 2023. *Response of Macroinvertebrate Community Structure and Biological Traits to Land Use and Physicochemical Parameters in a Karst River Basin.* Science of the Total Environment. 902. 168326. DOI: https://doi.org/10.1016/j.scitotenv.2023.168326.

Li, R., Li, X., Yang, R., Farooq, M., Tian, Z., Xu, Y., Shao, N., Liu, S., and Xiao, W., 2024. *Bioassessment of Macroinvertebrate Communities Influenced by Gradients of Human Activities.* Insects. 15(2): 131. DOI: https://doi.org/10.3390/insects15020131.

Margayan, P., 2016. *The High Disposal of Domestic Waste Into the River Will Cause the Quality of The River to Deteriorate, One of Which is Marked By The High Number of BODs*. Environmental Engineering and Management Journal. 53(2).

P ISSN: 2086 - 4604
E ISSN: 2549 - 8819

Mir, Z. A., Arafat, M. Y., and Bakhtiyar, Y., 2021. *Benthic Macroinvertebrates as Bioindicators of Water Quality In Freshwater Bodies. In Freshwater Pollution and Aquatic Ecosystems: Environmental Impact and Sustainable Management*. Chap. 7. Apple Academic Press. DOI: https://doi.org/10.1201/9781003130116-7.

Miranda, R., 2015. Why, Where and How: An Identification Guide of Macroinvertebrates. In R. Miranda, D. Galicia, and J. Oscoz (Eds.), *Identification Guide of Freshwater Macroinvertebrates of Spain*. pp. 1–16. Springer.

Oguma, A. Y., and Klerks, P. L., 2017. *Pollution-Induced Community Tolerance in Benthic Macroinvertebrates of a Mildly Lead-Contaminated Lake*. Environmental Science and Pollution Research. 24(23): 19076–19085. DOI: https://doi.org/10.1007/s11356-017-9553-9.

Orozco González, C. E., 2023. *A Comparative Analysis of Sampling Methods for Aquatic Macroinvertebrates*. Preprints. DOI: https://doi.org/10.20944/preprints202305.2026.v1.

Rahayu, S., Widodo, R.H., Van Noordwijk, M., Suryadi, I., dan Verbist, B., 2009. Monitoring Air di Daerah Aliran Sungai. World Agroforestry Centre, Bogor.

Serpa, D., Keizer, J. J., Cassidy, J., Cuco, A., Silva, V., Gonçalves, F., Cerqueira, M., and Abrantes, N. 2014. *Assessment of River Water Quality Using An Integrated Physicochemical, Biological and Ecotoxicological Approach*. Environmental Science: Processes & Impacts. 16(6): 1434–1444. DOI: https://doi.org/10.1039/c3em00488k.

Solis, M., Bonetto, C., Marrochi, N., Paracampo, A., and Mugni, H., 2018. *Aquatic Macroinvertebrates are Affected by Insecticide Application on The Argentine Pampas*. Ecotoxicology and Environmental Safety. 148: 11-16.

Stojković Piperac, M., Stojanović, K., Milošević, D., Cvijanović, D., and Živić, I., 2024. *Taxonomic and Functional Traits of Macroinvertebrate Community Along Fish Farming Pollution Gradient: Taxonomic Sufficiency for Reliable Bioassessment*. Science of the Total Environment. 955. DOI: https://doi.org/10.1016/j.scitotenv.2024.177128.

Tarnawski, M., and Baran, A., 2018. *Use of Chemical Indicators and Bioassays in Bottom Sediment Ecological Risk Assessment*. Archives of Environmental Contamination and Toxicology. 74(3): 395–407. DOI: https://doi.org/10.1007/s00244-018-0513-2.

Waringer, J., Vitecek, S., Martini, J., Zittra, C., Handschuh, S., Vieira, A., and Kuhlmann, H. C., 2021. *Hydraulic Niche Utilization by Larvae of the Three Drusinae Clades (Insecta: Trichoptera)*. Biologia. 76(5): 1465–1473. DOI: https://doi.org/10.2478/s11756-020-00648-y.

Wieben, C.M., Baker, R.J., and Nicholson, R.S., 2013. *Nutrient Concentrations In Surface Water and Groundwater, and Nitrate Source Identification Using Stable Isotope Analysis, in the Barnegat Bay-Little Egg Harbor watershed, New Jersey*, 2010–11: U.S. Geological Survey Scientific Investigations Report 2012–5287, 44 p.

P ISSN: 2086 - 4604
E ISSN: 2549 - 8819