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Analysis of Trent Biotic Index of The Cigalugur River, Purwakarta Regency, West Java, Indonesia

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ABSTRACT

As one part of a flowing freshwater ecosystem, Rivers can carry various elements or nutrients needed for life in and around its flow. This research was conducted on Thursday-Sunday 13-16 September 2021 on the Cigalugur River at Cihuni Irrigation Station, Warung Kadu Station, Central Nagri Station, and Cipaisan Station, Purwakarta, West Java. Benthos is taking with hand-sorting and surfer method. The results of monitoring the quality of waters along the Cigalugur river flow at four stations have the same Trent Biotic Index (TBI) value, an index of VIII. This situation shows that the level of pollution of the Cigalugur river waters is still low, species diversity is on average, and the community is stable.

Keywords: river, ecosystem, benthos, TBI, Cigalugur Rivier, West Java

1. INTRODUCTION

Rivers are flowing waters because the quality of the water constantly changes from time to time or is dynamic. [1-4] stated that freshwater ecosystems have significant importance in human life because freshwater ecosystems are the most practical and inexpensive source to meet domestic and industrial interests. Therefore, the river is one type of public aquatic ecosystem that plays a role in the life of biota and human needs for various activities such as

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agriculture and industry, which are influenced by many factors, both by natural activities and human activities in the Watershed. As one part of a flowing freshwater ecosystem, Rivers can carry various elements or nutrients needed for life in and around its flow. Although the area of the river and the amount of water flowing in it is minimal compared to the area and amount of water in the sea, rivers have an essential role directly for human life and other individuals [1-6].

Cigalugur River is one of the rivers in the Purwakarta Regency. Cigalugur River starts from the Cihuni irrigation, a tributary of the Cikao river. The upstream of the Cigalugur River from the village of Warung Kadu flows through the city to the village of Nagri Tengah to the village of Cipaisan as the downstream river then flows into the Cikao River.

The Cigalugur River has a length of about 2.5-kilometers, a river width of 3m with an average maximum discharge of 4 m^3/s, and a minimum water discharge of 0.02 m^3/s. The Cigalugur River has the function of irrigating rice fields and fisheries. This function requires the preservation of the water quality of the Cigalugur river. The upstream area of the Cigalugur River is an area of relatively dense vegetation, and the riverbank is overgrown with shrubs. The mid-river area is a rice field with riverbanks overgrown with cassava trees. Downstream is the dominant area with a residential population. The surrounding community uses the Cigalugur River for food needs, income generation, and other interests, both for biological and non-biological resources.

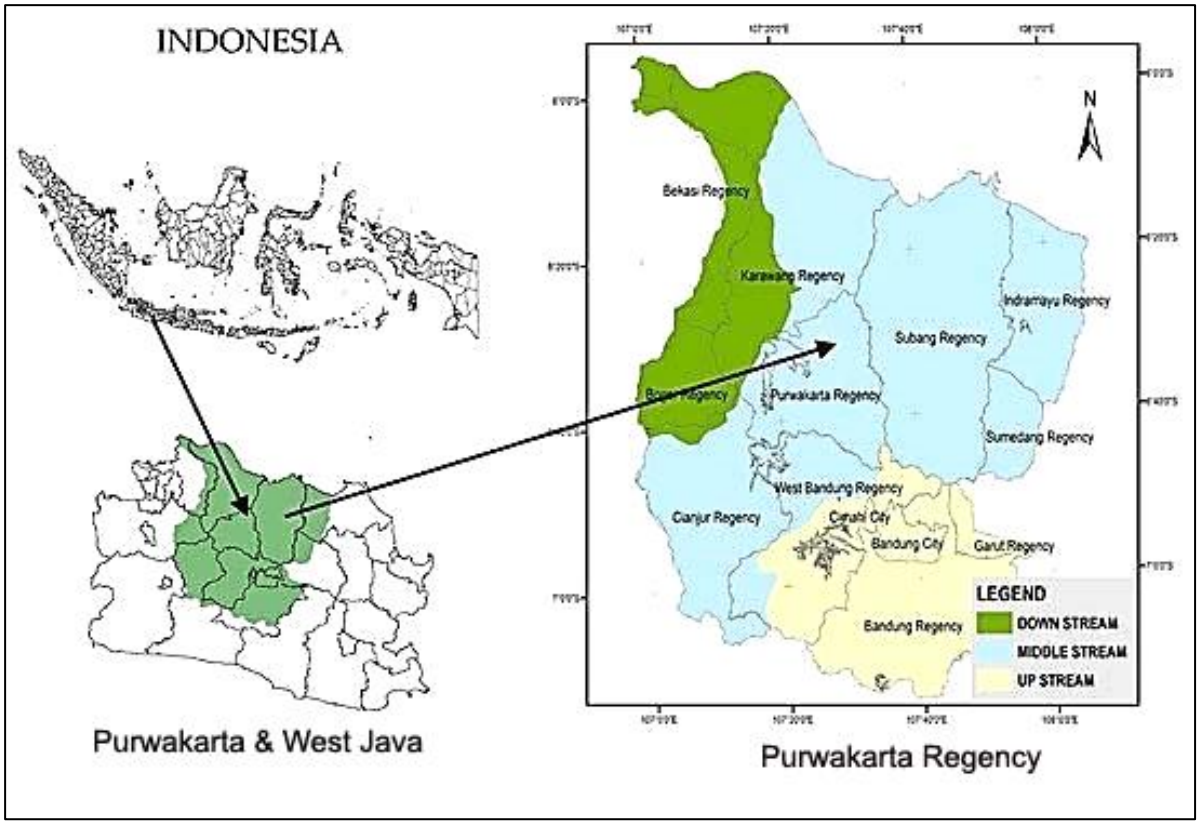

Figure 1. Map of Purwakarta Regency, West Java Province

Benthos lives on the bottom of the water and inhabits a certain depth. [6-12] suggested that benthic organisms inhabit intertidal areas of varying depth. By studying the various types of benthos, the living things in marine waters will be known. Various factors influence the life of benthos. The influencing factors are sediment, salinity, and depth below the surface to create a diversity of benthic species that inhabit the waters [7-9]. Benthic organisms include sea stars, sea urchins, gastropods, cucumbers, bivalves, and snake stars [10-14].

Ecosystems with high levels of species diversity are more stable and less affected by external pressures than ecosystems with low diversity [13-18]. Species diversity is a parameter that is often used to determine the level of stability that characterizes the species richness and balance of a community. According to [7-8], the main factors that affect the number of benthos, species diversity, and dominance, among others, are the destruction of natural habitats, chemical pollution, and climate change.

The purpose of this research is to determine the analysis of the water quality of the Cigalugur River at Cihuni Irrigation Station, Warung Kadu Station, Nagri Tengah Station, and Cipaisan Station, Purwakarta Regency using the Trent Biotic Index (TBI) method.

2. MATERIALS AND METHODS

This research was conducted on Thursday-Sunday 13-16 September 2021 at Cigalugur River Cihuni Irrigation Station, Warung Kadu Station, Central Nagri Station, and Cipaisan Station, Purwakarta, West Java. The tools needed are plastic (enough), vials (10), Surber (2), mine, stationery, labels, trays, and a microscope. The materials needed in this research are benthic macroinvertebrates and 10% formalin.

Benthos is taking with hand-sorting and surfer method. Hand sorting is done using a 1 × 1 m transect, placing the transect in the river body, and taking gastropods in a square. Sampling was carried out three times at three different points, namely the two banks of the river and the middle of the river. Gastropods that have been taken are put in plastic. For the Surber method, the Surber tied with a rope is attached to a tree, waiting for 1 hour. Pick up the source. After first being labeled, samples were put into plastic (name of order and time). The sample is identified by the Laboratory of Biological Resources Management (data on sample names must be complete and precise) Faculty of Fisheries and Marine Sciences of Universitas Padjadjaran. Samples that are microscopic in size are seen using a microscope for the results of the source method. The identification results are written on the observation sheet.

2. 1. Data analysis

Shannon-Wiener Diversity Index (H')

The diversity of aquatic biota can be determined using the following formula [2, 3]:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \qquad (1)$$

H'= value of S-W diversity index.

pi = proportion of individuals in the ith species.

ln = natural logarithm.

Evenness Index

Uniformity is the individual components of each species contained in a community, to calculate the uniformity index using the Evenness formula [2, 3]:

$$E = \frac{H\prime}{Ln\ S} \qquad (2)$$

E = Evennes Index

H' = diversity index

S = Number of species

Dominance Index (D)

The dominance index can be calculated using the Index of Dominance formula from Simpson's formula [2, 3]

$$D = \sum \left(\frac{n_i}{N}\right)^2 \qquad (3)$$

D = dominance index

Ni = Number of Individuals of Each Type

N = Number of Individuals of All Kinds

3. RESULTS AND DISCUSSION

The approach using TBI is a qualitative approach, which only looks at the structure of the community. The composition and distribution of aquatic insects depend on several factors such as water quality, food availability, feeding behavior, habitat characteristics, and substrate composition. Changes in a river ecosystem will affect the composition and distribution of existing aquatic insects [14-20]. According to [7-16], distribution patterns of aquatic insects are strongly influenced by physical and chemical parameters because some species are highly susceptible to pollution while others may be more tolerant of environmental damage.

The sampling in the Cigalugur River was taken from 4 stations, namely Cihuni Irrigation Station, Warung Kadu Station, Nagri Tengah Station, and Cipaisan Station. The results of monitoring the water quality along the Cigalugur River flow at four stations have the same TBI value, which has an index of VIII; this is because the orders found are still very diverse. At the Cihuni irrigation station, 12 orders were found, namely Plecoptera, Ephemeroptera, Trichoptera, Coleoptera, Hemiptera, Diptera, Hymenoptera, Neuroptera, Annelids, Lepidoptera, Odonata, crustaceans with a total of 439 individuals. At the Warung Kadu station, 12 orders were found, the same as those found at the Cihuni Irrigation Station, with a total of 404 individuals. At Nagri Tengah station, 12 orders were found, the same as orders at Cihuni Irrigation Station and Warung Kadu Station, with 358 individuals. At Cipaisan station, ten orders were found, the same as those found at Cihuni Irrigation Station, Warung Kadu Station,

and Central Nagri Station, except for crustaceans and Odonata not found, with a total of 276 individuals.

Table 1. Trent Biotic Index (TBI) Results for Each Station.

No	Taxonomy	Cihuni Irrigation Station	Warung Kadu Station	Nagri Tengah Station	Cipaisan Station
1.	Plecoptera	117	60	4	45
2.	Ephemeroptera	33	53	43	33
3.	Tricoptera	47	146	161	102
4.	Coleoptera	116	64	37	28
5.	Hemiptera	72	19	25	15
6.	Diptera	23	16	33	22
7.	Hymenoptera	11	15	28	14
8.	Neuroptera	2	18	2	9
9.	Annelida	7	7	14	7
10.	Crustacea	2	2	6	0
11.	Odonata	6	2	1	0
12	Lepidoptera	3	2	4	1
Total		439	404	358	276

Table 2. TBI at Every Station.

Station	Ordo	Diversity	Group	Index
Banjasari	Plecoptera	More than one species	16+	VIII
Warung Kadu	Plecoptera	More than one species	16+	VIII
Nagri Tengah	Ephemeroptera	More than one species	16+	VIII
Cipaisan	Plecoptera	More than one species	16+	VIII

The total number of orders obtained is three orders which are indicators of good river water quality, namely the Order Ephemeroptera (Liebebiella sp), Plecoptera (Neoperla darlingi), and Trichoptera (Chimarra aterrima and Glossosoma nigrior). So that from each station the water quality is still good because it still covers the three orders. According to [18-20], aquatic insects' diversity, abundance, and distribution can be used as bioindicators related to physical and chemical factors in a water habitat. When a habitat in waters begins to change, the diversity and abundance of aquatic insects found in that location can explain the quality of the waters.

According to [16-22], the EPT group (Ephemeroptera, Trichoptera, Plecoptera) is a component that can be used as an indicator in an ecosystem to determine the conditions of pollution that occur in an ecosystem, especially in rivers. The EPT order has also been known as a bioindicator of good water quality and the most sensitive to environmental changes.

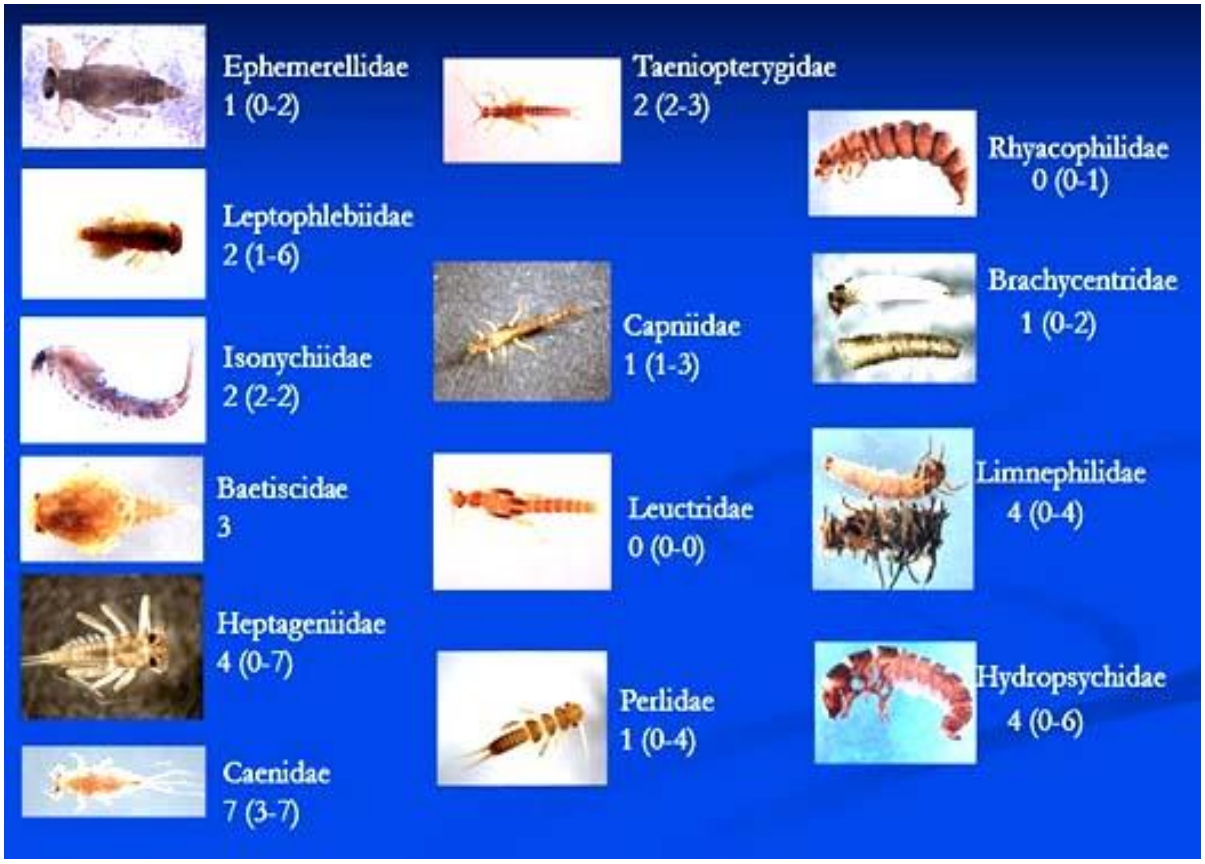

Figure 2. EPT Tolerance of Family (Species range)

Aquatic macroinvertebrates or benthic macroinvertebrates are mainly aquatic insects that spend most of their lives in freshwater ecosystems. Aquatic insects are ubiquitous in stream ecosystems and present throughout a wide range of environmental conditions, making them a successful and appropriate model group for investigation at different levels of the process, including at the individual, populational, and community level [2-6]. At multiple spaces (spatial) and time (temporal) scales, the variation in the structure and organization of the aquatic

insect communities are greatly influenced by abiotic environmental conditions, biotic conditions, and dispersal processes [2-4].

The physical, chemical, and biological conditions of streams directly influence aquatic insects, making them good indicators for stream water quality [3-5]. The three major aquatic insects that can be found abundantly in freshwater systems are Ephemeroptera, Plecoptera, and Trichoptera (EPT) [2, 3]. EPT is considered an essential taxonomic group due to its wide distribution range with high abundance and species richness [3-5]. According to [3-5], EPT makes up a rich collection of taxa in low and medium-order streams, which occur primarily in clean and well-oxygenated water. The diversity and composition of EPT, which functions as indicator species, make it possible to determine aquatic system water quality [1-4]. EPT is highly sensitive towards any anthropogenic and environmental disturbances, which allow them to become excellent indicators in evaluating and accessing the water quality of streams [3-5]. Thus, EPT can be considered the critical aquatic insect order as they play vital roles in the aquatic ecosystems.

Aquatic insects commonly found in aquatic habitats are the orders Coleoptera, Diptera, Hemiptera, Lepidoptera, Odonata, Ephemeroptera, Plecoptera, and Trichoptera [2, 3]. Aquatic insects can be used as an indicator of water quality. The orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) are a group of insects that are often found in clean waters and are very sensitive to changes in water physicochemical factors [3, 4]. Meanwhile, insects from the orders Coeloptera, Hemiptera and Odonata were found in moderate to clean water, while Diptera was often found in dirty waters [1]. Due to various kinds of human activities around the waters [5]. In addition, changes in water physicochemical factors are closely related to seasons [4, 6]. Water physicochemical factors, water substrate conditions, current velocity, and aquatic plants' presence can affect the distribution and population of aquatic insects [7]. The diversity of aquatic insects in pristine waters is relatively higher than in polluted (dirty) waters.

Furthermore, in unclean or polluted waters, the distribution of individuals is uneven and tends to be dominated by certain species. If there is a decrease in the population of aquatic insects in water, it indicates a decrease in the quality of the waters, either biological, physical, or chemical.

Table 3. Shanon Winner's Calculation Results.

No.	Station	Diversity Index	Dominance Index	Evenness Index
1.	Irigasi Cihuni	3.778	0.189	1.520
2.	Warung Kadu	1.893	0.203	0.762
3.	Nagri Tengah	1.753	0.255	0.705
4.	Cipaisan	1.886	0.201	0.819

The abundance of an organism in water can be expressed as the number of individuals per unit area or volume. At the same time, the relative density is the ratio between the abundance

of individuals of each species with the total number of individuals caught in a community. The dominance index value will also be obtained by knowing the relative density value. At the same time, the density of species is the nature of a community that describes the diversity of the types of organisms in the community. Species density depends on the distribution of individuals in each species. Species density in a community is considered low if the distribution is uneven [17-24].

The diversity index (H') can be interpreted as a systematic depiction that describes the structure of the community and can facilitate the process of analyzing information on the type and number of organisms. In addition, the diversity and uniformity of biota in water are very dependent on the number of species in the community.

The more species found, the greater the diversity, although this value is highly dependent on the number of individuals of each species [19-25]. This opinion is also supported by [22-30], which states that the more the number of individual members and evenly distributed, the higher the diversity index will be. The diversity index (H') is a number that does not have units with a range of 0-3. The level of diversity will be high if the value of H' is close to 3, so this indicates good water conditions. Conversely, if H' value is close to 0, the diversity is low, and the water conditions are not good [10-12]. According to [8-9], a uniformity index is the composition of each individual in a species contained in a community. The uniformity index (e) is an excellent estimate to determine dominance in an area. If one or several species are more abundant than others, the uniformity index will be lower. [8-9] states that if the uniformity index value exceeds 0.7, it indicates a high degree of community uniformity.

The Shannon-Wiever Diversity Index (H') can be used to characterize the relationship between genera groups in a community. The diversity index is the Shannon Wiever index [8-10].

Evenness Uniformity Index (E) To determine community balance, uniformity index is used, which measures the similarity of the number of individuals between species in a community. The more equal the number of individuals between species (the more evenly distributed), the greater the balance. The smaller the diversity index value (H') than the uniformity index (e) will also be smaller, indicating one species' dominance over other species.

The benchmark values for the diversity index according to [2, 3] are grouped as follows:

1) If H" < 1, then diversity is low, poor, productivity is very low as an indication of heavy pressure and an unstable ecosystem.
2) If 1.0 < H' < 3.322, then the diversity is moderate, the productivity is sufficient, the ecosystem condition is quite balanced, the ecological pressure is moderate.
3) If H' > 3.322, then high diversity, stable ecosystem stability, high productivity, resistance to ecological pressure.

According to [2-6], H‟ <1.0 is classified as very low. The low diversity is caused by anthropogenic pollution (organic matter and Hg). The uniformity index value close to 1 indicates that the uniformity between species can be evenly distributed, or the number of individuals in each species is almost the same. Species diversity is high if many species are present in a community, and the value of diversity will be low if only one or a few species are present in it and dominate the area [2-6, 11-13].

The diversity index of the Cigalugur River at four stations, namely the Cihuni Irrigation station, is 3.778, so H'> 3 so that the species diversity is high. The diversity index at Warung Kadu station is 1.893, then 1 < H' < 3, so the species diversity is moderate. The diversity index

at Nagri Tengah station is 1.753, so 1 < H' < 3 so that the species diversity is moderate. The diversity index at the Cipaisan station is 1.886, so 1 < H' < 3 so that the species diversity is moderate.

The dominance index (C) is used to determine the extent to which a group of biota dominates another group. A large enough dominance will lead to an unstable or depressed community. The greater the value of the dominance index (C), the greater the tendency for certain species to dominate.

The dominance index at the Cihuni irrigation station is 0.189. The dominance index at Warung Kadu station is 0.203. The dominance index at Nagri Tengah station is 0.255. The dominance index at the Cipaisan station is 0.201. This number means that the tendency for certain species to dominate is from Cihuni Irrigation Station, Cipaisan Station, Warung Kadu Station, and Nagri Tengah Station.

The evenness index of the Cigalugur River at the Cihuni Irrigation Station is 1.520, so 0.75 <E<1.00 the community is stable. The evenness index at Warung Kadu station is 0.762, so 0.75 < E < 1.00 the community is stable. The railway index at Nagri Tengah station is 0.705, so 0.75 < E < 1.00 the community is stable. The railway index at Cipaisan station is 0.819, so 0.75 < E < 1.00 stable community.

Table 4. Physics-chemical *parameters of Cigalugur* River

Physics-chemical parameters	Station			
	Cihuni Irrigation	Warung Kadu	Nagri Tengah	Cipaisan
Temperature (°C)	26	26	26	30
Water Clarity (cm)	30.3	30.7	35.7	60
Water current velocity (m/s)	0.5	1.88	0.26	0.714
DO (dissolved oxygen)	7	6	6.6	6.2

The condition of the waters of the Cigalugur river with physical parameters, namely temperature, at Cihuni Irrigation Station 26 °C, Warung Kadu Station 26 °C, Nagri Tengah Station 26 °C, and Cipaisan Station 30 °C. Physical parameters (temperature) can be a determining factor or controlling the life of aquatic flora and fauna. The amount of sunlight that enters the waters can also increase the temperature of these waters to affect aquatic life. The brightness at Cihuni Irrigation Station is 30.3 cm, Warung Kadu Station is 30.7 cm, Nagri Tengah Station is 35.7 cm, and Cipaisan Station is 60 cm. The measurement of clarity aims to determine how much sunlight can penetrate the depths of the waters. Water current velocity at Cihuni Irrigation Station is 0.5 m/s, Warung Kadu Station is 1.88 m/s, Nagri Tengah Station is 0.26 m/s, and Cipaisan Station is 0.714 m/s. The condition of the waters of the Cigalugur river with chemical parameters, namely DO at Cihuni irrigation station 7 mg/L, Warung Kadu station 6 mg/L, Nagri Tengah station 6.6 mg/L, and Cipaisan station 6.2 mg/L. According to [19-22],

DO measurement is influenced by physical, chemical, and biological factors. The amount of dissolved oxygen in water generally does not exceed 10 ppm. According to the National Water Quality Standard No. 82 the Year 2001, water quality management and water pollution control are still in the range of 4-9 ppm.

The results of measurements of environmental parameters in the Cigalugur river show that the surface temperature of the water, in general, is in the temperature range suitable for the hydrological conditions of benthos. Air temperature and pH are factors that affect the life of biota, both metabolic activity, movement, and distribution of benthic organisms. The water temperature is suitable for the life of organisms in the sea, which is between 27-37^0 C so that the results of measuring air temperature in the waters of the Cigalugur river are still within the range that can provide tolerance for biota to survive and show that the environment around the waters of the Cigalugur river is still natural.

Various factors influence the life of benthos. The influencing factors are the type of sediment, salinity, and depth below the surface so that various types of benthos inhabit the waters [19-20, 25-34]. Benthic organisms include sea stars, sea urchins, gastropods, sea cucumbers, bivalves, and snake stars [2-4, 8].

4. CONCLUSION

The research results found that sampling in the Cigalugur River was taken from 4 stations, namely Cihuni Irrigation Station, Warung Kadu Station, Nagri Tengah Station, and Cipaisan Station. The results of monitoring the water quality along with the Cigalugur river flow at four stations, the total number of orders obtained is three orders which are indicators of good river water quality, namely the Order Ephemeroptera (Liebebiella sp), Plecoptera (Neoperla darlingi), and Trichoptera (Chimarra aterrima and Glossosoma nigrior). So that from each station the water quality is still good because it still covers the three orders.

The cooperation of the community and related agencies needs to preserve benthos in the area so that the preservation of benthos in the Cigalugur river area can be maintained, namely by reducing all forms of business that can damage the Cigalugur river. For activities in the laboratory, it would be better if the facilities used were adequate, such as microscopes, so that that research could take place more effectively and efficiently.

References

[1] Anggoro, S. Assessment of Water Pollution at Polder Tawang Semarang Seen from the Saprobity Aspect. *Journal of Management of Aquatic Resources*. 2 (3) (2019) 109-118

[2] Monaghan KA. Four Reasons to Question the Accuracy of a Biotic Index; the Risk of Metric Bias and the Scope to Improve Accuracy. *PLoS ONE* 11(7) (2016): e0158383. https://doi.org/10.1371/journal.pone.0158383

[3] Ian F. Spellerberg, and Fedor Peter J. A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity, and the 'Shannon–Wiener'Index. *Global Ecology and Biogeography*, 12(3) (2003) 177-179

[4] Vilmi, A., Zhao, W., Picazo, F., Li, M., Heino, J., Soininen, J., Wang, J., Ecological processes underlying community assembly of aquatic bacteria and macroinvertebrates under contrasting climates on the Tibetan Plateau. *Sci. Total Environ*. 702 (2020). 134974. https://doi.org/10.1016/j.scitotenv.2019.134974

[5] Wang, J., Liu, Q., Zhao, X., Borthwick, A.G.L., Liu, Y., Chen, Q., Ni, J., Molecular biogeography of planktonic and benthic diatoms in the Yangtze River. *Microbiome* 7 (1) (2019). https://doi.org/10.1186/s40168-019-0771-x

[6] Wang, L., Tong, J., Li, Y. River Chief System (RCS): An experiment on cross-sectoral coordination of watershed governance. *Front. Environ. Sci. Eng*. 13 (4) (2019). https://doi.org/10.1007/s11783-019-1157-9

[7] Wang, P., Wang, X., Wang, C., Miao, L., Hou, J., Yuan, Q. Shift in bacterioplankton diversity and structure: Influence of anthropogenic disturbances along the Yarlung Tsangpo River on the Tibetan Plateau, China. *Sci. Rep* 7 (1) (2017)

[8] Rizal A, Nurruhwati I, Khan AMA. Economic Contribution of Southern West Java Province Marine Fisheries. *World Scientific News*, 119 (2019) 204-217

[9] Pimm SL, Jenkins CN, Abell R, Brooks TM, Gittleman GL, Joppa LN, et al. The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, 6187 (2014) 987-992

[10] Birk S, Bonne W, Borja A, Brucet S, Courrat A, Poikane S et al. (2012) Three hundred ways to assess Europe‘s surface waters : An almost complete overview of biological methods to implement the Water Framework Directive. *Ecol Indic*. 18 (2012) 31-41

[11] Derner, J., Briske, D., Reeves, M., Brown-Brandl, T., Meehan, M., Blumenthal, D., Travis, W., Augustine, D., Wilmer, H., Scasta, D., Hendrickson, J., Volesky, J., Edwards, L., Peck, D. Vulnerability of grazing and confined livestock in the Northern Great Plains to projected mid- and late-twenty-first century climate. *Clim. Change* 146 (1-2) (2018) 19-32

[12] Guo, B., Luo, W, Wang, D.L., Jiang, L. Spatial and temporal change patterns of freeze-thaw erosion in the three-river source region under the stress of climate warming. *J. Mater. Sci.* 14 (6) (2017) 1086-1099

[13] Jafarian, Z., Kargar, M., Tamartash, R., Jalil Alavi, S. Spatial distribution modeling of plant functional diversity in the mountain rangeland, north of Iran. *Ecol. Ind.* 97 (2019) 231-238

[14] Ji, B., Qin, H., Guo, S., Chen, W., Zhang, X., Liang, J. Bacterial communities of four adjacent fresh lakes at different trophic status. *Ecotoxicol. Environ. Saf*. 157 (2018) 388-394

[15] Rizal A, Andriani Y, Kusumartono FXH, A Strategic Environmental Assessment for Southern Coastal of West Java Province, Indonesia. *World Scientific News* 137 (2019) 188-209

[16] Luo, Y., Lü, Y., Fu, B., Zhang, Q., Li, T., Hu, W., Comber, A. Half-century change of interactions among ecosystem services driven by ecological restoration: quantification

and policy implications at a watershed scale in the Chinese Loess Plateau. *Sci. Total Environ*. 651 (2019) 2546-2557

[17] Matono, P., Bernardo, J.M., Oberdorff, T., Ilh´eu, M. Effects of natural hydrological variability on fish assemblages in small Mediterranean streams: Implications for ecological assessment. *Ecol. Ind.* 23 (2012) 467-481

[18] Zuzy Anna, Asep Agus Handaka Suryana, Ine Maulina, Achmad Rizal, Purna Hindayani. Biological parameters of fish stock estimation in Cirata Reservoir (West Java, Indonesia): A comparative analysis of bio-economic models. *Biodiversitas*, 18 (4) (2017) 1468-1474

[19] A. Rizal, I. Nurruhwati. Diversity of Sea Cucumber Based on the Characteristics of Habitat Sikakap Strait Water Area, Mentawai Island District, Indonesia. *World Scientific News*, 145 (2020) 379-396

[20] A. Rizal, IM. Apriliani, H. Herawati, L. Paradhita. Distribution and Condition of Coral Reefs in the Waters of Biawak Island, Indramayu Regency, West Java, Indonesia. *World Scientific News*, 144 (2020) 141-157

[21] Newton, R.J., McLellan, S.L. A unique assemblage of cosmopolitan freshwater bacteria and higher community diversity differentiate an urbanized estuary from oligotrophic Lake Michigan. Front. *Microbiol.* 6, (2015) 1028

[22] Niu, L., Li, Y., Wang, P., Zhang, W., Wang, C., Li, J., Wu, H. Development of a microbial community-based index of biotic integrity (MC-IBI) to assess the ecological status of rivers in the Taihu Basin, China. *Ecol. Ind*. 85 (2018) 204-213

[23] Rizal A, Kusumartono F.X.H, Zaida. Analysis of Fisheries Sector Contribution in Nabire District of West Papua Province. *World Scientific News* 133 (2019) 71-84

[24] Niu, L., Li, Y., Wang, P., Zhang, W., Wang, C., Wang, Q., Voordouw, G. Understanding the Linkage between elevation and the activated sludge bacterial community along a 3,600-meter elevation gradient in China. *Appl. Environ. Microbiol*. 81 (19) (2015) 6567-6576

[25] Sanz-Lázaro, C., Malea, P., Apostolaki, E.T., Kalantzi, I., Marín, A., Karakassis, I. The role of the seagrass Posidonia oceanica in the cycling of trace elements. *Biogeosciences*, 9 (2012) 2497-2507

[26] Schroeder, P.B., Thorhaug, A. Trace metal cycling in tropical-subtropical estuaries dominated by the seagrass Thalassia testudinum. *American Journal of Botany*, 67 (1980) 1075-1088

[27] A Rizal, Z Anna. The Effect on Mangrove Density with Sediment Transport Rate in Sikakap Coastal Area of Mentawai Island District, West Sumatera Province, Indonesia. *World Scientific News*, 146 (2020) 202-214

[28] A. Rizal, Subiyanto, Juahir, H., Lananan, F. Freshwater governance on limboto lake in Gorontalo province of Indonesia, *Indian Journal of Public Health Research and Development*, 10 (4) (2019) 782-787

[29] F. Ahmad, LP Dewanti, G.L. Arnenda, Achmad Rizal. Length-weight relationship and catch size of bigeye tuna (Thunnus obesus) landed in Benoa, Bali, Indonesia. *World News of Natural Sciences*, 23 (2019) 34-42

[30] R. Rostika, A. Rizal. Monosex barb (Osteochilus hasselti) Culture reduces economic efficiency and cost reduction at the net cage in Cirata Reservoir. *Current Research in Agricultural Sciences*, 4 (1) (2017) 7-13

[31] LP Dewanti, SF Rahmahningrum, A Rizal, A Khan, R Rostika. Length catch and growth analysis of hairtail fish (Trichiurus spp.) in southern off West Java Sea (Case study: Pangandaran fishing base). *International Journal of Fisheries and Aquatic Research*, 4 (1) (2019) 13-16

[32] Rumatoras. H, Taipabu M.I, Lesiela L, Male Y.T. (2016). Analisis Kadar Merkuri (Hg) Pada Rambut Penduduk Desa Kayeli, Akibat Penambangan Emas Tanpa Ijin di Areal Gunung Botak, Kab. Buru-Provinsi Maluku. *Ind. J. Chem. Res*, 3 (2016) 290-294

[33] Ocana, F.A., Pech, D., Simoes, N. and Hernandez-Avila, I. Spatial assessment of the vulnerability of benthic communities to multiple stressors in the Yucatan Continental Shelf, Gulf of Mexico. *Ocean Coast. Manage*, 181 (2019)

[34] FX Kusumartono, A. Rizal. An integrated assessment of vulnerability to water scarcity measurement in small islands of Indonesia. *World News of Natural Sciences*, 24 (2019) 117-133