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The Diversity of Macrozoobenthos as a Bioindicator of Water Quality in the Upper Cikapundung River

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ABSTRACT

Macrozoobenthos are aquatic organisms that live on the bottom of the water. Currently, the upstream Cikapundung River is indicated to be polluted by garbage, household waste, industrial waste, agricultural waste and livestock manure. This study aims to determine the diversity of macrozoobenthos as a bioindicator of water quality in the upstream Cikapundung river based on physical, chemical and biological parameters. This research was conducted in April 2023. The research used the exploration method. Macrozoobenthos sampling consists of five locations namely; Curug Omas, Curug Lalay, Kidang, Curug Koleang and Curug Dago. The results of the data analysis of the calculation of the Diversity Index, Abundance and Dominance indicate that the upstream Cikapundung river is classified as moderately polluted. This is evidenced by the diversity value obtained, which falls within the range of 1.94 - 2 (<2.0). The high abundance index value is observed in location 2, while the dominance index value is $0.50 < D \leq 0.75$. A total of nine species were identified in the benthic samples, which were classified into four classes, nine families, and seven genera. The dominating benthos of the five locations is *Planaria* sp. Based on an analysis of biotic and abiotic components, the upstream Cikapundung river is classified as exhibiting minimal pollution.

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1. INTRODUCTION

A river ecosystem comprises biotic and abiotic components that interact and influence each other. These components are integrated to form a single energy flow. Rivers are a ubiquitous feature of human activity, serving a multitude of purposes in both domestic and industrial contexts. This is due to the fact that rivers are flowing bodies of water, readily accessible to humans. They are classified as flowing open waters (lotic), with the potential to receive discharges from a multitude of human activities, including residential, agricultural, and industrial operations in the surrounding area (Zuhrayani *et al*., 2023).

The utilisation of the river as a disposal area for the rest of human activities results in the river becoming rapidly silted and the quality of the water therein being significantly degraded. If the input load of dissolved materials exceeds the river's capacity for self-purification, a significant issue arises: water pollution. This negatively affects the life of aquatic biota and the health of those who use the river water. In essence, water quality is a measure of the quality or condition of water associated with a particular activity or purpose (Zaghloul *et al*., 2020).

Aquatic life is not solely confined to the aqueous environment; it is also found on the solid water bottom. The limited availability of nutrients at the bottom of the water column results in a paucity of life forms. Consequently, the animals that inhabit the water are those that are capable of thriving with restricted levels and varieties of nutrients, as well as exhibiting tolerance (Zuhrayani *et al*., 2023).

Biotic components can provide an overview of the physical, chemical and biological conditions of a body of water. One of the biological parameters that can be employed to assess the condition of a water body is the biota. One of the biota that can be used as a biological parameter in determining the condition of a water body is benthos. As organisms that live in waters, benthos are very sensitive to their composition and abundance. This depends on tolerance to environmental changes, so these organisms are often used as indicators of the level of pollution of a body of water. Macrozoobenthos is one of the most important groups in aquatic ecosystems due to its role as a key organism in the food web (Kumar *et al.,* 2017).

Macrozoobenthos can be employed as an indicator of environmental quality on the basis of the value of biological quality and biodiversity. It possesses the following characteristics: 1. It must demonstrate sensitivity to changes in the aquatic environment and a rapid response, 2. It has a complex life cycle throughout the year or more, and if environmental conditions exceed the tolerance of these biota, they will die, 3. It is sessile (benthic), and 4. These organisms are not young and migrate rapidly (Purba, 2022).

The existence of macrozoobenthos groups that live sedentary (sessile) and adaptability varies to environmental conditions, making benthos a useful indicator of water quality. In addition, the level of diversity found in the aquatic environment can be used as an indicator of pollution (Zaghloul *et al*., 2020).

A number of researchers have conducted research on macrozoobenthos diversity as a bioindicator of river water quality. The diversity of benthic species in the Mruwe River in Yogyakarta has been found to be a determinant of water quality, with gastropods being the most dominant (Septiani *et al*., 2011). The water quality of the Mruwe River in Yogyakarta, as defined by the 2001 Indonesian government regulation (PP No. 28), is classified as lightly polluted and falls within the second-class water category. In the water area of Mount Ciremai Palutungan, the climbing route (Cigowong River, Cibunian River, and Putri waterfall) was found to have a significant effect on the index of macrozoobenthos diversity, as calculated by the values of DO (Dissolved Oxygen) and BOD (Biochemical Oxygen Demand) (Purnama *et al*., 2015).

In this study, macrozoobenthos is employed as a bioindicator based on the quality of its organisms and the ecological quality of macrozoobenthos, as indicated by factors such as dominance index and diversity index. The quantity of ecology is closely related to environmental factors, including dissolved oxygen (DO), pH, temperature, colour and turbidity, depth and speed of water flow. Consequently, the presence or type of macrozoobenthos may change in response to varying levels of pollution in aquatic ecosystems. This is the rationale behind the use of macrozoobenthos as a bioindicator of water quality.

The Cikapundung River is a river that serves as a defensive barrier for the city of Bandung, with its source located at Mount Bukit Tunggal. It then flows through nine sub-districts, namely Cidadap, Coblong, Bandung Wetan, Cicendo, Sumur Bandung, Regol, Lengkong, Margacinta and Bandung Kidul, and encompasses 13 villages before finally merging with the Citarum River. Curug Omas is a waterfall with a height of up to 30 metres and a water depth of up to 10 metres in the Ir. H. Djuanda Grand Forest Park. It is a meeting point for two streams, namely the Cikawari river and the Cigulung river, which unite to form the upstream Cikapundung river. The Cigulung and Cikawari rivers are used extensively by residents of nine sub-districts and 13 villages for the disposal of domestic and agricultural waste, including vegetable waste, rice husks, and straw, as well as industrial waste. The majority of residents in Lembang are engaged in cattle farming, and thus represent a significant source of water pollution from livestock faeces. This is due to the fact that livestock manure is not treated and is discharged directly into the river. In addition to Curug Omas, there are several other notable waterfalls in this river system, including Curug Lalay, Curug Kidang and Curug Koleang. These waterfalls have heights of approximately 15 m, 14 m and 16 m, respectively. Curug Dago is situated at an altitude of 800 metres above sea level, with a waterfall height of approximately 12 metres.

It is imperative to conduct research on the Cikapundung river at the earliest possible stage, as the findings will serve as the foundation for monitoring the condition of river water bodies, particularly in relation to aquatic biota. The sampling area comprised a single region, namely the upstream Cikapundung area, which is situated within the boundaries of the Ir. H. Djuanda Grand Forest Park. This area was subdivided into five sampling locations, designated as Curug Omas, Curug Lalay, Curug Kidang, Curug Koleang and Curug Dago. Macrozoobenthos sampling was conducted in the shallow water area in the vicinity of the waterfall.

The state of the Cigulung and Cikawari rivers that meet into the Cikapundung upstream river which looks a lot of garbage and the presence of human activities around the river is the background to make the presence of benthic animals in the Cikapundung upstream river water as an object of research by examining water quality there. Based on this description, the results of research on macrozoobenthos diversity as a bioindicator of water quality in the upper reaches of the Cikapundung river are reported.

2. METHODS

This is a quantitative descriptive research using the exploration method. The exploration method is direct sampling at several research locations. Benthic sampling was conducted in

April 2023 at five waterfall points, namely Curug Maribaya, Curug Lalay, Curug Kidang, Curug Koleang and Curug Dago. The benthic samples were subsequently identified at the Ecology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia, Bandung.

2.1. Tools and materials

The tools used in this study are: surber net, DO meter, water quality tester (WQC), secchi disk, digital camera, stereo microscope, tape measure meter, sample bottle (glass bottle), and identification book. The materials used are: Formalin 4%, Aquades, 70% alcohol, macrozoobenthos samples and soil substrate.

2.2 Research procedure

Station determination was carried out in November 2022. This sampling is done by Non Probability Sampling technique, purposive random sampling method and based on topographic considerations of environmental conditions and land use functions to determine the position of the side location measured using GPS (Global Positioning System).

Biological data collection is in the form of benthic diversity in the upstream Cikapundung river conducted at five points, namely Curug Omas, Curug Lalay, Curug Kidang, Curug Koleang and Curug Dago with one repetition. Sampling is done at the lowest ebb time in the morning with the reason to facilitate sampling, not constrained by currents and waves and temperature in the river. The method of sampling macrozoobenthos is holding the iron pole of the surber net against the direction of the current, stirring the sediment with two hands together to remove the sediment from the bottom of the water so that the benthos will stay in the surber net, washing the macrozoobenthos sample and put in a sample bottle that has been filled with 4% formalin solution diluted using distilled water. Benthic observations in the Ecology laboratory, for small benthos can be observed directly with the help of a binocular microscope and the shape and type of benthos observed can be matched with the benthic identification book to find the type of benthic species observed. All specimens were identified using a microscope and a macrozoobenthos species identification book (Ramadini *et al.*, 2021). The keys to identification are; Overall body shape (not size), Case made of twigs, leaves and stones, Foot locomotion, No gills and location of gills, No cersi (tail) and location of cersi, Head capsule, Uncommon locomotion and Movement (crawling, side - side swimming; up - down).

The chemical parameters measured were acidity (pH) and dissolved oxygen (DO). The acidity (pH) measurement used pH meter paper. The pH paper was dipped into the river and matched to the indicator table until the pH of the water was known, while DO was measured using a DO meter.

The physical parameters observed were temperature, current speed, water brightness, colour, smell, taste and bottom substrate. The temperature of the river water was measured using a thermometer. The thermometer was dipped into the river water and left to stand until a constant reading was displayed on the thermometer. The temperature reading was then recorded. The current speed was measured using a stopwatch and a wooden branch. The water brightness was assessed using a Secchi disc, with the depth of the disc's visibility and invisibility recorded. The upstream Cikapundung river water was observed to be clear visually. The smell of the Cikapundung river was found to be odourless, with the same method used to assess the smell. The upstream Cikapundung river substrate was found to be basic, comprising sand, stones, and gravel.

2.3 Data analysis

The diversity index (H') uses the state of the population of organisms mathematically to make it easier to analyse the formation of the number of individuals of each species in a community. For this reason, the calculation is carried out using the equation of Shannon-Wiener (Michael, 1984; Magurran, 1988), with the formula:

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

Where:
H' = The diversity index
Ni = Number of individual/species
N = Total number of individuals

Abundance is the number of individuals per unit area or per unit volume. The abundance of a living thing is influenced by the relationship by all physical and chemical factors, the level of natural resources that can be obtained from the life cycle of living things. Then to calculate the abundance can use the Important Value (IV) with the formula:

IV = Relative Density + Relative Frequency

Where:
Relative Density (RD) = Density of a species × 100% total spesies
Relative Frequency (RF) = Frequecy of a spesies × 100% total frekuensi

The Dominance Index was calculated using Simpson's dominance index formula (Odum, 1971):

$$D = \sum (ni/N)^2$$

Where:
D = Simpson's Dominance Index
Ni = Total individual of a species
N = Total individual of all species

In the dominance index, the dominance index (C) categories are: 0.00 < D ≤ 0.50 low, 0.50 ≤ 0.75 medium and 0.75 < D ≤ 1.00 high. Classification of pollution levels based on the species diversity index according to Shannon-Wiener (H') and chemical physical factors is presented in **Table 1**.

Table 1. Classification of pollution levels based on species diversity index and physical and chemical parameters.

Pollution levels	H'	DO (ppm)
Unpolluted	> 2,0	> 6,5
Low polluted	2,0 – 1,6	4,5 – 6,5
Moderately polluted	1,5 – 1,0	2,0 – 4,4
Heavily polluted	< 1,0	< 2,0

Source: Fachrul (2007)

3. RESULTS AND DISCUSSION

3.1. Physical quality

The upstream Cikapundung River located in the Ir. H. Djuanda Grand Forest Park area is a combination of two different rivers, the first Cikawari River and Cigulung River meet together to form Curug Omas then the flow converges into the Cikapundung River, the mouth of these two rivers that flow called the upstream Cikapundung River and empties into the Citarum River which is identified as polluted aquatic ecosystems. The upstream Cikapundung River is a river whose sediments consist of sand, rocks and gravel. Physical parameter data measured include temperature, current speed, water brightness, colour, odour and bottom substrate, presented in **Table 2.**

Table 2. Physical parameter data.

Parameters	Location					Quality Standard* (Optimum Value)
	1	2	3	4	5	
Temperature (°C)	23°C	21°C	24°C	22°C	21°C	20 – 30 °C
Flow Speed	0,26 m/s	0,5 m/s	0,5 m/s	0,01 m/s	0,27 m/s	-
Water clarity	41 m	42 m	36 m	65 m	30 m	>6
Color	Clear	Clear	Clear	Clear	Clear	Clear
Smells	No smell	No smell	No smell	No smell	No smell	No smell
Substrate	Sand, stone, and gravel	Sand, stone, and gravel	Sand, stone, and gravel	Sand, stone, gravel, and slightly muddy	Sand, stone, gravel, and slightly muddy	Stone

*(PP No. 82, 2001)

Table 2 presents the results of six physical parameters measured at each location. Notably, the water quality parameters at locations 1 and 5 are identical, while those at locations 2 and 3 are comparable. However, location 4 exhibits a distinct pattern. Temperature is a crucial factor in the growth and development of aquatic organisms. In essence, aquatic biota refers to a group of organisms, both animals and plants that live partially or wholly in water. The group of organisms can be classified as benthic, periphytic, or free-swimming. In this study, measurements were taken in April 2023 between the hours of 07:00 and 09:00 West Indonesia Time (WIB). The water temperature was recorded at each location, with the following readings obtained: location 1, 23 °C; location 2, 21 °C. The temperature of the water at location 3 was recorded at 24 °C, while location 4 showed a temperature of 22 °C. Location 5 displayed a temperature of 21 °C. These readings indicate that the waters of the Cikapundung River upstream remain within the limits specified in the water quality standards.

The velocity of the river flow at the five research locations exhibits considerable variation. At location 1, the current speed is 0.26 minutes per second, while at location 2, it is 0.5 minutes per second. At location 3, the current speed is 0.01 minutes per second, at location 4, it is 0.27 minutes per second, and at location 5, it is 0.5 minutes per second. The current speed at location 1 is 0.5 minutes per second, at location 2 it is 0.5 minutes per second, at location 3 it is 0.5 minutes per second, at location 4 it is 0.01 minutes per second, and at location 5 it is 0.27 minutes per second. This demonstrates that the current speed at locations 2 and 3 is greater than that at locations 1, 4 and 5. The current speed at locations 1 and 5 is moderate, while location 4 exhibits a slower current due to the presence of a hydropower dam. To calculate the current speed of river water, wooden branches were used in conjunction with nylon rope and a stopwatch to determine the time required for the movement of the wooden branches.

The results of the study indicate that the water clarity value in the upstream Cikapundung River ranges from 30 to 65 cm. The measurement of water brightness was conducted using a Secchi disc. Subsequently, the brightness value was calculated using the aforementioned formula, resulting in the highest brightness value being observed at location 4, with a value of 65 cm. Location 1 exhibited a brightness value of 47 cm, location 2 exhibited a brightness value of 42 cm, location 3 exhibited a brightness value of 36 cm, and location 5 exhibited a brightness value of 30 cm. Water brightness is a measure of the clarity of a body of water. The higher the brightness of the water, the deeper the light penetrates into the water. The degree of water brightness determines the thickness of the productive layer. A reduction in water brightness will result in a decline in the photosynthetic capacity of aquatic plants. Furthermore, it can also impact the physiological activities of aquatic biota. In this context, materials entering a body of water, particularly in the form of suspensions, can diminish water brightness (Apriliansyah, 2018). The presence of suspended matter in water, which scatters and absorbs light, is the cause of turbidity. The turbidity values observed in rivers range from 2 to 200 mg/L SiO_2.

The presence of watercolour is attributed to the dissolution of minerals, colouring matter or humic acid derived from plants. Additionally, environmental decomposition can also result in the formation of coloured compounds. Furthermore, the activities of paper mills and fabric dyeing have been identified as significant contributors to the alteration of dye effluents. Such effluents, which contain iron, magnesium and plankton, can also impart colour that can be filtered through a 0.45 µm filter paper. The second term is "apparent colour," which refers to the colour-causing material in solution, along with other unfilterable material. The unit of measurement for this parameter is mg/L platinum. To illustrate, a river may exhibit a colour concentration between 5 and 200 mg/L platinum. In the absence of organic or inorganic chemical compounds, water is odorless. However, the presence of these compounds, including algae and other organisms, can result in the production of an odor. Hydrogen sulfide (H_2S), a byproduct of anaerobic decomposition, is a common contaminant in underground and wastewater. Its odor can be quantified by dissolving a sample in odor-free water until a threshold concentration is reached. The lowest odor threshold is 1.

3.2. Chemical quality

In the upstream Cikapundung river, the environmental parameters measured in this study were pH and DO (**Table 3**). **Table 3** provides a summary of the data.

Table 3. Chemical parameter data

Parameters	Location					Quality Standart* (Opitmum Value)
	1	2	3	4	5	
pH	6,82	6,85	6,80	6,60	7,23	6 – 8,5
DO	6,7 mg/L	6,7 mg/L	6,7 mg/L	6,0 mg/L	6,6 mg/L	> 5

*(PP No. 82, 2001)

The pH measurements of the Cikapundung upstream river water indicate an improvement in water quality due to an increase in macrozoobenthos diversity. The optimal pH value for environmental quality is between 6 and 8.5. The pH range of the Cikapundung river has an average pH value of 6.60 to 7.23. The lowest pH value is observed in location 4, which is in areas with less water movement. At a pH value of 7, the water is considered to be neutral. pH values below 7 indicate acidic conditions, while values above 7 are alkaline. This indicates that the five locations can be classified as acidic or alkaline.

The pH value of water is a crucial parameter in the monitoring of water quality. The ability of aquatic organisms to tolerate changes in water pH varies considerably. It is more frequently observed that death is caused by low pH than by high pH. Macrozoobenthos demonstrate a range of tolerance to different pH levels. For instance, gastropods are found in waters with a pH above 7. In the insect group, the pH range is above 8.5. This statement is appropriate because it demonstrates that the presence of organisms or benthos in the Cikapundung river upstream in locations with a higher pH, specifically locations 2 and 3, is associated with a greater species diversity. Additionally, the activities conducted in these locations exert a significant influence on the macrozoobenthos present. The pH values in locations 2 and 3 are notably higher than those observed in locations 1, 4, and 5.

Another chemical parameter employed is DO (Dissolved Oxygen), which is utilised to ascertain the dissolved oxygen content in water. A higher value of dissolved oxygen in water is indicative of a superior quality of life for the organisms present. The DO value at location 1, 2, 3, 4 and 5 was found to be 6.7 mg/L. It can be observed that the lowest value at location 4 is situated in an area where water movement is very slow due to the hydropower dam. The value obtained for the DO parameter in the upper Cikapundung river, with a range of values between 6.0 and 6.7 mg/L, is below the quality standard of 25 mg/L as set out in the quality standart (PP No. 82, 2001)*. This indicates that the DO in the upper Cikapundung river is conducive to the survival of macrozoobenthos.

3.3. Biological quality

The results of the identification and analysis of the presence of macrozoobenthos in the upper Cikapundung river, comprising individuals from several macrozoobenthos classes, are presented in **Table 4**. Macrozoobenthos individuals found in the upstream Cikapundung river while for the lowest number of macrozoobenthos individuals found in location 1 with a total of 6 macrozoobenthos individuals and the largest number in location 2 with a total of 28 benthic individuals while the composition of benthic animals found in *Planaria* sp. from the Annelida class in Cikapundung waters.

The biological parameters of water quality, as determined by the type of individuals obtained from five locations, indicate that the upstream Cikapundung river is classified as a river that has not been polluted. The individual results obtained indicate that one species, *Planaria* sp., can be used as an indicator of the upper Cikapundung river's water quality. This is evidenced by the species presence in **Table 4**, which lists animal types as indicators of water pollution. The results show that only one species was found, indicating that the Cikapundung river upstream is in the class of water that has not been polluted.

Locations that obtained a greater number of macrozoobenthos in locations 2 and 3. Where in locations 2 and 3 are locations that condition of the basic substrate (sediment) rocks and fine gravel, so there are a large number of species obtained. The basic substrate in the form of flat stones and gravel is a good environment for macrozoobenthos animals, so it has a high density and diversity. From the individual results obtained on one individual used as an indicator to assess water quality. At locations 1, 2, 3, 4 and 5 obtained *Planaria* from the Annelida class. These animals are able to survive in muddy substrate areas. This is also in accordance with the DO conditions at sites 1, 2 and 3 compared to sites 4 and 5. Therefore, it is in accordance with the conditions of sites 4 and 5 which are slightly muddy.

Tabel 4. Biological parameter data

No	Class	Order	Family	Species	Location				
					1	2	3	4	5
1	Gastropoda	Mesogastropoda	Thiaridae	*Thiara scabra*	1	0	0	0	0
2	Turbellaria	Tricladida	Planariidae	*Planaria* sp.	5	8	9	6	4
3	Annelida	Pulmonata	Lymnatidae	*Lumbricus* sp.	0	0	0	0	3
4	Insecta	Trichoptera	Hydropcyshidae	*Hydropsyche* sp.	0	5	5	0	0
5	Insecta	Trichoptera	Philopotamidae	*Polycentropus* sp.	0	5	4	0	1
6	Insecta	Diptera	Chironomidae	*Clinotanypus* sp.	0	4	3	0	0
7	Insecta	Ephemeroptera	Heptageniidae	*Pseudocloeon* sp.	0	1	0	0	0
8	Insecta	Ephemeroptera	Caenidae	*Caenis* sp.	0	4	3	0	1
9	Insecta	Lepidoptera	Pyralidae	*Parapoynix* sp.	0	1	0	0	0
Total					**6**	**28**	**24**	**6**	**9**

The existence of macrozoobenthos animals that can survive in the upstream areas of one of them *Planaria* from the Annelida class, which is found in all river bodies, this animal is included in one of the animals that are indicators of water quality at the level of pollution. Discovery of *Planaria* in each sampling location is indeed a marker of an unpolluted area. Based on the diversity of macrozoobenthos which is used as a biotic factor, from the results of the number of individuals obtained dominates the upstream Cikapundung river area is classified as unpolluted. While based on biotic factors, from the results of the number of individuals obtained dominate then the upstream Cikapundung river area is not polluted. Therefore, based on the relationship of biotic and abiotic components to water quality, the upper Cikapundung river is categorised as unpolluted.

Each parameter certainly has a tendency to affect the life of macrozoobenthos. A picture of the physical and chemical parameters in a body of water can also explain that whether the habitat of the biota is in a dangerous condition or not. Based on the results of research from researchers, the upstream Cikapundung river is categorised as unpolluted. Based on the results of research on the types of individuals obtained that at temperatures ranging from 21 °C - 24 °C which indicates that there is feasibility for the life of organisms. The temperature interval that is suitable for the life of freshwater organisms is between 20-30 °C (Zohary *et al.*, 2020).

3.4. Macrozoobenthos

The results of the calculation, expressed as the number of populations of each individual in each of the five locations, are presented in **Table 5**. These results are based on the index of diversity (H'), abundance and dominance.

The Shannon-Weiner diversity index value demonstrates the number of each location, with location 1 having a value of 1.99, location 2 a value of 1.94, location 3 a value of 1.993, location 4 a value of 2, and location 5 a value of 1.99. The lowest diversity index is observed in location 2, while the highest is in location 3. This indicates that the diversity The benthic species in the upper Cikapundung river are characterised by low diversity, with a limited number of species present at each location. The calculated diversity index values indicate that the river is moderately polluted, with a diversity value of 1.94–2 (less than 2.0).

The value of abundance in the five locations varies considerably. In location 1, the value of abundance is 34.23, in location 2 it is 156.88, in location 3 it is 133.14, in location 4 it is 32.86 and in location 5 it is 52.77. Location 2 exhibits the highest value of abundance.

Table 5. Diversity, abundance and dominance index of macrozoobenthos.

No	Location	Diversity index (H')	Abundance (IV)	Dominance index
1	Omas waterfall	1,99	34,23	0,25
2	Lalay waterfall	1,94	156,88	0,36
3	Kidang waterfall	1,993	133,14	0,53
4	Koleang waterfall	2	32,86	0,68
5	Dago waterfall	1,99	52,77	0,56

The number of benthos that dominate is determined by employing the dominance index formula. The purpose of the dominance index is to ascertain whether there are benthic organisms or other living things that exert a dominant influence in a given area or habitat. The results of the calculation of the dominance index for the upstream Cikapundung river are as follows: location 4 obtained 0.68, location 3 obtained 0.53, location 1 obtained 0.25, location 5 obtained 0.56 and location 2 obtained 0.36. It is notable that in location 1, a lower number of individuals was observed, yet the dominance index value obtained was 0.25. The results of the calculation of the dominance index, as presented in the table, are in accordance with the Simpson formula in the Odum (1971) dominance index category (D). The dominance index category is defined as follows: $0.00 < D \leq 0.05$ low, $0.50 < D \leq 0.75$ medium and $0.75 < D \leq 100$ high (Odum, 1971).

Macrozoobenthos in a single family tend to exhibit similar levels of sensitivity to environmental influences or pollutants. This implies that if a family is exposed to pollutants and is unable to resist or survive if exposed to pollutants, it will have a detrimental impact on the river ecosystem. Potential negative consequences may include the displacement of non-resistant families to less polluted areas, a reduction in the number of individuals within the family, and the eventual demise and disappearance of the family from the aquatic ecosystem. The loss of one or more families from the aquatic ecosystem will result in a reduction in diversity value and an increase in dominance value for the remaining families that are resistant to the pollutant. The survival of a small number of individuals in a non-resistant family can affect the uniformity value in the river ecosystem.

The number of individuals in each location may vary due to differences in the types and levels of pollutants present in the environment. Based on the results of diversity, abundance and dominance analysis, it can be concluded that the upstream Cikapundung river, when viewed from the perspective of existing biological indicators, is included in the category of lightly polluted rivers. The number of individual and species for each family shows in **Table 6.**

Table 6. Number of Individuals and Species of each order and family of benthos obtained at five sampling sites.

No	Species	Location 1		Location 2		Location 3		Location 4		Location 5	
		∑Ind	∑ Sp	∑ Ind	∑Sp	∑Ind	∑Sp	∑Ind	∑Sp	∑Ind	∑Sp
1	*Thiarascabra sp*	1	1	0	0	0	0	0	0	0	0
2	*Planaria sp*	5	1	8	1	9	1	6	1	4	1
3	*Lumbricus sp*	0	0	0	0	0	0	0	0	3	1
4	*Hydropsyohe sp*	0	0	5	1	5	1	0	0	0	0
5	*Polycentropus sp*	0	0	5	1	4	1	0	0	1	1
6	*Clinotanypus sp*	0	0	4	1	3	1	0	0	0	0
7	*Pseudocloeon sp*	0	0	1	1	0	0	0	0	0	0
8	*Ceanis sp*	0	0	4	1	3	1	0	0	1	1
9	*Parapoynix sp*	0	0	1	1	0	0	0	0	0	0
	Total	**6**	**2**	**28**	**7**	**24**	**5**	**6**	**1**	**9**	**4**

Based on the indicators used in this water quality study, there is no difference between the results obtained from biological, chemical and physical indicators. The chemical and physical indicators, as evidenced by the measurement results of DO, pH, temperature, current speed, water brightness, colour, odour and bottom substrate, suggest that the upstream Cikapundung river has not been polluted. This is due to the fact that the physical and chemical indicators measured are susceptible to change at any given moment, dependent on a number of factors including the intensity of rainfall, water volume, the quantity of pollutants present and the heat of the sun. In contrast, the biological indicators employed indicate that the upstream Cikapundung river is not polluted. This is because the biological indicators utilised are long-term indicators, which means that these biological indicators will undergo change if exposed or affected by pollutants over an extended period of time. This conclusion is corroborated by the findings of an interview with one of the officers in charge of the area, as well as with local residents. They attest to the continued presence of *Planaria* in the region. The results of these interviews, along with the available data, indicate that the upstream Cikapundung river has not been polluted for an extended period, and that the macrozoobenthos found in it have not been affected (Ramadini *et al.*, 2021).

4. CONCLUSION

Macrozoobenthos were identified at five locations in the upper Cikapundung river. The identified species were classified into four classes, nine families and seven genera. The order Mesogastropoda (Thiaridae) and Turbellaria (Planariidae) were also observed. The following invertebrate groups were identified: monata (Lymnatidae), trichoptera (Hydropcyshidae and Philopotamidae), diptera (Chironomidae), ephemeroptera (Heptageniidae and Ceanidae) and lepidoptera (Pyralidae). A total of 73 individuals were identified. The diversity index is comprised of the following values: location 1 (1.99), location 2 (1.94), location 3 (1.993), location 4 (2) and location 5 (1.99). At all locations, the diversity index was categorised as moderate and the pollution level was mild. The abundance of the species was as follows: location 1 (34.23), location 2 (156.88), location 3 (133.14), location 4 (32.86) and location 5 (52.77). All sites were classified as having an abundance of species capable of surviving in unpolluted and polluted rivers. The five sites exhibited the following dominance patterns: The values were 0.25, 0.36, 0.53, 0.68 and 0.56. The five locations were categorised as exhibiting a medium dominance index, which led the researchers to conclude that the upstream Cikapundung river is unpolluted based on the biotic and abiotic components. The biological parameters obtained from the individual types varied in each location. There was an individual marker of no pollution, namely *Planaria* sp, at all location points. This species was found to be very abundant and dominant, which indicates that the upstream Cikapundung river is not polluted.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

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