Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 168 (2022) 81-98 EISSN 2392-2192

Water quality index based on interrelation between plankton and benthos in Cimanuk River, Majalengka District, West Java, Indonesia

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ABSTRACT

Water quality can be known from the value of WQI (Water Quality Index), a number that describes water quality based on measurements of water quality parameters. Plankton is an organism whose life is free to hover in the water, its ability to move is limited so that water currents easily carry it away. Benthos is an organism that lives on the seabed or river attached to water sediments (mud or sand). Benthos are used as bioindicators of water quality because life is attached to aquatic sediments. The presence of vegetation also improves the soil's physical, chemical, and biological properties, regulation of groundwater, and others. This research aims to study the characteristics of aquatic ecosystems and their limiting factors, to know the chemical, physical, and biological parameters that determine water quality, learn the techniques for collecting plankton and benthos, identify plankton and benthos, study species and the number of plankton and benthos as aquatic bioindicators.

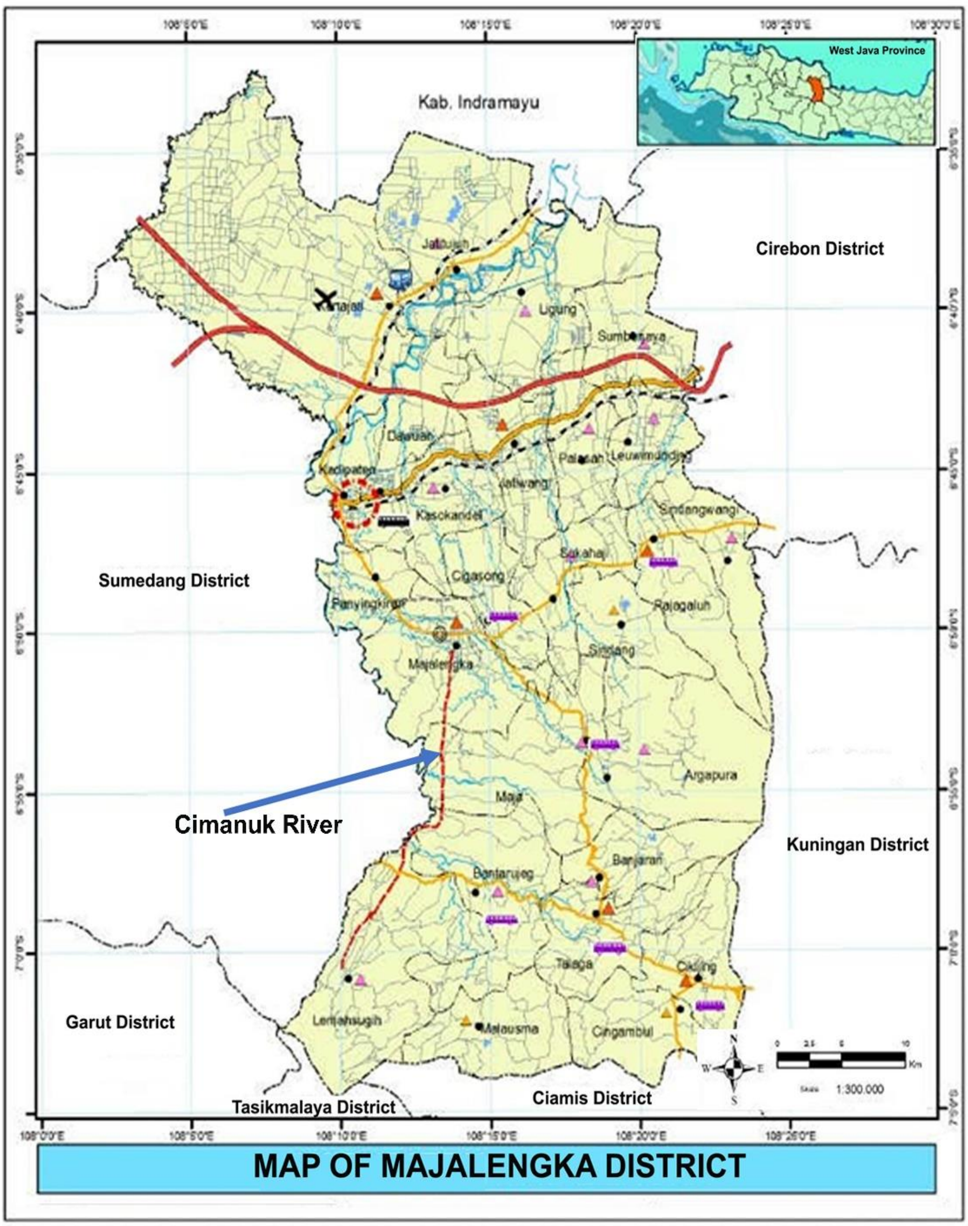
Keyword**:** Plankton, Benthos, Vegetasi, WQI, Cimanuk River, Majalengka District, West Java

1. INTRODUCTION

The territorial waters of Indonesia are more comprehensive than the land area. Aquatic ecosystems are divided into fresh, marine, and brackish waters such as those found in large

(Received 27 March 2022; Accepted 18 April 2022; Date of Publication 19 April 2022)

river estuaries. Of the three aquatic ecosystems, marine and brackish waters are the largest, which is more than 97%. The rest is freshwater with limited quantities and conditions but is needed by humans and many other living organisms for life [1]. One of the fresh waters that exist is a river. Rivers are widely used by humans, such as water reservoirs, irrigating rice fields, livestock purposes, industrial purposes, housing, water catchment areas, flood control, and irrigation [2-4].



Map 1. Cimanku River-Map of Majalengka District-West Java-Indonesia

Rivers have a specific capacity that can change due to natural and anthropogenic activities. River pollution can come from agricultural activities, land clearing, organic waste, and industrial waste. Based on its designation, it is necessary to test river water quality based on physical parameters (temperature, humidity, brightness, current), chemical (pH, DO, COD, BOD, salinity), and biology (abundance and diversity of river biota) [1-3].

The quality of water can be known from the value of WQI (Water Quality Index), a number that describes the quality of a water-based on the measurement results of water quality parameters. Water quality assessment with WQI will simplify information about the condition of waters, making it easier to determine proper water conditions to support the life activities of aquatic biota. The river ecosystem is inhabited by various groups of aquatic biota, including neuston, nekton, plankton (phytoplankton and zooplankton), benthos, and periphyton [2,4].

Plankton is organisms that live freely floating in the water, and their mobility is limited, so they are easily carried away by water currents [4,5]. Plankton is divided into two major groups, namely phytoplankton, and zooplankton. Phytoplankton is the primary water producer, while zooplankton is the primary consumer because they make phytoplankton food [4-7]. Zooplankton is a member of plankton that is animal, very diverse, and consists of various larvae and adult forms that represent almost all animal phyla [2-4]. Benthos are organisms that live on the seabed or rivers attached to water sediments (mud or sand). Benthos is used as a bioindicator of water quality because it lives attached to aquatic sediments and has low motility, so it is easy to identify [3-6]. Benthos plays a vital role in waters, one of which is in the process of decomposition and mineralization of organic material that enters the waters and occupies several trophic levels in the food chain. The abundance of benthos can affect water because the pattern of even distribution of the abundance of benthos in each river station is different. Healthy or unpolluted water will show a balanced number of individuals from almost all species present. On the other hand, in polluted waters, the distribution of the number of individuals is not evenly distributed, and there tends to be a species that dominates [2-5].

The presence of vegetation in an area will positively impact the balance of the ecosystem on a broader scale. Plants act as producers that can synthesize organic substances through photosynthesis. The presence of vegetation also improves the soil's physical, chemical, and biological properties, regulating groundwater management, and others. The influence of vegetation varies depending on the structure and composition of the vegetation that grows in the area it occupies [4-7]. Plants around the water play an important role in determining water quality. The ability of plants to fix nitrogen and utilize phosphorus is essential to reducing nutrient input into the waters. Root structure plays a role in reducing soil erosion. The plant canopy can also reduce the strength of rainwater that reaches the ground [6-8].

This research aims for the practitioner to study the characteristics of the aquatic ecosystem and its limiting factors, to know the chemical, physical, and biological parameters that determine water quality, to learn the techniques of plankton and benthic data collection, to identify plankton and benthos, to study the species and amount of plankton and benthos as a water bioindicator, as well as to make edge profiles.

2. MATERIALS AND METHODS

Data collection and sampling were carried out along the Cimanuk River, Majalengka, West Java (Map 1), on January 3, 2022. The sampling points were divided into six stations with an interval of 5 meters between stations along the river. The tools used in this research are DO meter, TDS, pH indicator, Conductivity meter, mercury thermometer, Water Sampler, turbidimeter, Winkler bottle, sample bottle, plastic sample, surgical board, caliper, plankton net, 1×1 quadrant. caliper, dropper, hemocytometer, and light microscope. While the material needed is a sample of gastropods found in the waters of the Cimanuk River. The materials used in this study were river water samples, benthos samples, 70% alcohol, and lugol.

2. 1. Measurement of Aquatic Physical-Chemical Factors

Measurements of physical and chemical factors carried out in this study include temperature, turbidity, TDS, brightness, water pH, dissolved O_2 content, conductivity, and river flow velocity. Water temperature was measured using a mercury thermometer, and water turbidity was measured using a turbidimeter. TDS was measured using a TDS meter, and water brightness was measured using a Secchi disk, water pH was measured using a digital pH meter, and dissolved O_2 content or DO was measured using a DO meter. The water conductivity is measured by a conductivity meter, and the velocity of the river current is measured using a tool in the form of a current pendulum.

2. 2. Sampling Techniques, Preservation and Plankton Analysis

Water samples were taken to identify phytoplankton using a plankton net by pouring 10 liters of water taken from the Cimanuk River, which was passed into the plankton net until the water filled the bouquet, then the sample was transferred from the bouquet to a sample bottle and given 2-3 drops of Lugol, then the sample bottle was stored at a low temperature ($T < 15$ °C). The samples obtained were analyzed for cell density with a light microscope and Haemocytometer. The sample was inserted as much as ± 1 mL on the sidelines of the Haemocytometer and closed with a cover glass. Samples were observed under a microscope with a magnification of 100x-400x. Plankton identification was carried out using the plankton identification guide book Freshwater Algae Identification and Use as Bioindicators.

2. 3. Sampling Techniques, Preservation, Identification, and Analysis of Benthos

Macrozoobenthos samples were taken using a 1×1 quadrant placed on the bottom of the water. Macrozoobenthos were taken that were in a square and then put in a plastic sample that had been labeled. Sampling was carried out every 1 meter along with the meter roll or transect. The samples were brought to the laboratory and stored in the refrigerator. Macrozoobenthos were identified, and their morphometric measurements were made. The Shannon-Wiener index analyzed the data obtained [5-9].

2. 4. Cross River Profile

At each station, the river's width was measured by spreading a roller meter from one river bank to the other and then measuring the river's depth at 1 m intervals. The vegetation of plant species on the riverbank was analyzed using a 1×1 m transect, then identified and recorded the number.

2. 5. Data analysis

The measurement data were then analyzed using the Shannon-Wiener index (H') used to calculate the diversity index (diversity index), Uniformity Index (E), Dominance Index (D), and Morisita index calculated according to [5-9] with the following formula:

a) Diversity Index (H')

$$H' = -\sum pi \ln pi$$

where:

H': Diversity Index
pi : The abundance of a type obtained
ni : Number of individuals in *i*-type
N : Total Individual

The Species Diversity Index describes the level of stability of a standing community. The higher the value of H', the higher the level of stability of the forest vegetation community. A community that has an H' value < 1 is said to be less stable (low species diversity). If the H' value is between 1 to 2, it is said to be a stable community (medium species diversity), and if the H' value > 2 is said to be a very stable community (species diversity). high) [10-13]. According to [9-11], species diversity in an area is influenced by the number of species and total individuals for all species.

b) Evenness Index (E)

$$E = \frac{H'}{Hmax}$$

where:

E : Evenness
H': Shanon-Wiener Index

The evenness index (E) shows the distribution pattern of the population of a species in a community, that is, evenly or not. If the value of E is higher, it indicates that the species in the community are increasingly spreading. E < 0.3 indicates that evenness is classified as low. E = 0.3 – 0.6 indicates evenness of species is classified as moderate. E > 0.6 means that the evenness of species is classified as high. The evenness index is used to determine the even distribution of individuals among species in a habitat. This index shows the distribution pattern of the population of a species in a community, that is, evenly or not. If the evenness value is relatively high, then the presence of each type of individual in a community is evenly distributed [14-18].

c) Type Dominance (D)

$$\lambda = \sum Pi^2 \text{ when } Pi = {}^{n}/_{N}$$

where:

λ : Simpson's Dominance Index
n : Number of individuals per species
N : Total individuals of species

The Dominance Index is used to determine the concentration and distribution of dominant species. If the dominance is more concentrated in a species, the dominance index value will increase, and vice versa. If several species dominate together, the dominance index value will be low [16-19].

d) Dispersion (MI)

$$MI = \frac{\mathrm{S}\ (\Sigma\ \mathrm{n2} - \mathrm{N})}{\mathrm{N}\ (\mathrm{N} - 1)}$$

where:

MI : Morisita Index
S : Total sum of squares
n : Number of individuals
N : Total individuals

3. RESULTS AND DISCUSSION

3. 1. Chemical Parameters – Physical Waters

The results of the measurement of the physical-chemical parameters of the Cimanuk river are shown in Table 1. The water temperature of the Cimanuk river ranges from 27 °C to 29 °C. Temperature is one of the limiting factors for the growth and distribution of aquatic biota, including benthos [17-20]. According to [17-18], the range of water temperatures suitable for the life of aquatic organisms is between 27 °C to 37 °C. So that the temperature measurement results are classified as suitable to support the life of aquatic biota such as benthos. The river temperature fluctuates following the flow of water from upstream to downstream, mainly influenced by air temperature patterns, sunlight intensity, geographical location, canopy (riparian vegetation), and internal water conditions such as turbidity, depth, current speed, and accumulation of organic matter at the bottom of the water. 15-19]. In addition to natural factors, anthropogenic factors can also influence air temperatures, such as the disposal of waste heat from industry and the deforestation of vegetation along the watershed, which causes the water temperature to increase [18-24].

Dissolved oxygen (DO) in water is needed to support the life of aquatic biota. The amount of dissolved oxygen in the waters is influenced by several factors, such as turbidity, temperature, salinity, and the movement of water masses such as currents, waves, and tides. DO measurement results at six stations on the Cimanuk River ranged from 6.8 to 26.9 ppm, with an average of 12.1 ppm (Table 1). [20-24] stated that the minimum DO content is 2 ppm. The DO level of Cimanuk river water is still within normal limits because it is above 2 ppm. DO levels are strongly influenced by temperature. The higher the water temperature making, the lower the oxygen solubility.

On the other hand, the solubility of oxygen will be higher if the water temperature is average. This fact is because water and free oxygen are physically bonded. Oxygen levels in water also indicate the quality of the water. The lower the water quality, the lower the oxygen content [22-26].

The results of the river TDS measurement ranged from 0.125 mg/l to 112 mg/l (Table 1). Increasing the concentration of Total Dissolved Solids (TDS) in the waters will increase the turbidity of the water, thereby reducing its brightness [20-27]. The brightness of the waters ranged from 11-45 cm (Table 1). According to [23-28], the productive brightness is 20-40 cm from the water surface. The measurement results are classified as brightness which is still tolerated by aquatic biota.

Conductivity (EC) is a numerical description of the ability of water to carry electricity. Therefore the more dissolved salts (minerals) that can be ionized, the higher the electrical conductivity value [25-29]. The measured conductivity value of Cimanuk river water ranges from 0-253 mS/cm with an average of 90 mS/cm. The conductivity value is high. High conductivity causes a decrease in the abundance of plankton because plankton is not robust against high conductivity [20-30].

The pH of the Cimanuk river water was measured between 6 to 7. [15-24] stated that the safe pH range for fisheries, agriculture, and animal husbandry is 6 to 9. [24-30] added that benthic organisms generally require a pH between 6.5 – 8.5 for survival and reproduction. Referring to the statement, the pH of the Cimanuk river water is considered normal for the life of aquatic biota. Waters that are strong acids or strong bases will endanger the survival of biota because they will interfere with metabolism and respiration [15-20]. Waters that become too acidic or alkaline lead to decreased resistance to stress in gastropods [14-20].

Table 1. Results of Measurement of Chemical – Physical Parameters of the Cimanuk River.

Chemical – Physical Parameters	Station						Mean
	1	2	3	4	5	6	
DO (mg/L)	8	7.9	6.8	14.1	26.9	8.9	12.1
Temperature (°C)	29	29	28	27	28	28	28.16667
TDS	84.6	0.125	25.9	112	86	107	69.27083
EC	253	0.263	26.1	0	53.1	208	90.07717
Turbidimeter	40.02	46.53	30.27	20.53	20.45	19.06	29.47667
pH	6	7	6	6	7	6	6.333333
Secchidisk (cm)	40.5	35.5	22	37	45	11	31.83333
River Width (cm)	680	517	603	594	570	920	647.3333
River Current (m/s)	0.33	2.39	1.27	0.43	0.083	0.313	0.802667

Currents play an essential role in the movement of nutrients in the waters. Based on the measurement results, the velocity of the water current in the Cimanuk River ranges from 0.083

to 2.39 m/s (Table 1). Current velocity is closely related to depth. As the depth increases, the surface current velocity decreases. In addition, the speed of the current is also influenced by the width of the river. The wider the river, the slower the water flow [17-25]. Currents act as food suppliers, oxygen solubility and removal of CO_2, and the remnants of marine biota products [25-30]. Based on the measurement results of the chemical-physical parameters of the waters, it is known that the mean temperature of the six stations is 28.17 °C. The mean value of the degree of acidity is 6.33. This value is still within the second-class water quality standard according to Law No. 82 of 2001. Dissolved oxygen content has a mean value of 12.1, and this value is still within the second-class water quality standard according to Government Regulation No. 82 of 2001. The mean value of total dissolved solids is 69.27. The mean value of conductivity is 90.07 mS/cm. The mean value of brightness is 31.83. The mean turbidity value is 29.47 NTU, and the river current velocity is 0.802 m/s.

Table 2. Cimanuk River Water Quality Index.

Water Quality Index (WQI)			
Parameter	**Ci**	**Pi**	**CiPi**
°C	12	0.10	1.2
pH	55	0.11	6.05
DO	8	0.17	1.36
TDS	86	0.07	6.02
Turbidity	54	0.08	4.32
Total		0.53	12.95
Σ WQI			24.43

Water Quality Index (WQI) is a method used to assess water quality based on physical, chemical, and biological parameters. There are five classes of water quality criteria based on water quality standards according to Law No. 20 of 1990 and Law No. 82 of 2001, namely very poor classification with a range of WQI values of 0-25, poor classification in the range of values 26-50, moderate classification in the range of values 51-70, good classification in the range of values of 71-90, while outstanding classification has a range of values between 91-100. Based on the calculation of the WQI value in Table 2, the WQI value is 24.43.

This value is included in the inferior classification group (0-25), so Cimanuk River water cannot be consumed as drinking water because the water is highly polluted.

3. 2. Phytoplankton Community

The presence of abundant phytoplankton in water is related to the level of fertility of the waters. Abundant phytoplankton can be influenced by chemical-physical factors such as DO and temperature [30-33]. In addition, currents play an essential role in the movement of nutrients in the waters. These nutrients are helpful for plankton growth [7-12]. Based on the measurement results, the velocity of the water current in the Cimanuk River ranges from 0.083- to 2.39 m/s. Current velocity is closely related to depth. As the depth increases, the surface current velocity decreases. In addition, wind power influences surface currents. It is utilized by phytoplankton as organisms that are not strong swimmers and supply food [29-32].

The most common type found was Mycrocystis sp. as many as 240 individuals. This fact indicates that Mycrocystis sp. dominates the phytoplankton community in these waters. According to [20-25], water pollution based on the diversity index (H') is divided into four types, namely heavily polluted rivers (H' < 1), lightly polluted rivers (H' = 1.0-1,6), polluted rivers medium (H' = 1.6 - 2.0), and the river is not polluted (H' > 2.0). The diversity index (H') of phytoplankton in the Cimanuk River is -2.9 and indicates that the waters of the Cimanuk River have been heavily polluted because of H' < 1.

One indicator of polluted waters is the abundance of Mycrocystis sp. in the waters. Other species that can be used as indicators of contamination of river waters are the presence of Naviculla sp., Oscillatoria sp., and Nitzschia sp. These four species can live in waters polluted by sewage to be used as indicators of poor environmental conditions [31, 32].

Based on the calculation results, phytoplankton's uniformity index (E) is -0.8. The uniformity index value (E) obtained in the Cimanuk River is less than 0.6 - 1 and indicates that the uniformity of each species is not the same because the distribution of phytoplankton for each species is uneven. The calculated dominance index (D) of phytoplankton is 1.8. D value > 0.5 indicates if there are types of phytoplankton that dominate in these waters. According to [14-24], the higher the dominance index value, the lower the uniformity index value, which indicates that there is a difference in density in each species and tends to be dominated by certain species, such as Mycrocystis sp., which dominates the waters of the Cimanuk River.

Morosita index (MI) shows the distribution pattern of phytoplankton in the Cimanuk River. Morosita index (MI) is independent of several types of distribution, value, and number of samples. According to [20-26], the distribution of a species based on the Morisita index (MI) is divided into three types, namely randomly (Id < 1), uniform (Id = 1), and in groups (Id > 1).

The index value of Morisita (MI) phytoplankton obtained after the calculation is 1.08. These results indicate that the distribution of phytoplankton in the Cimanuk River is in groups because the MI value is greater than 1.

Table 3. Phytoplankton Diversity and Diversity Index.

Species	**Σ individual**	**H'**	**E**	**D**	**MI**
Oschilllatoria	19	2.96	0.84	0.16	1.08
Chlorococcum	14				
Pleurosigma	3				
Mycrocystis	23				
Cylindrospermum	1				

Nitzschia sp.	4				
Nitzschia sigmoidea	1				
Oocytes	3				
Chlorella	11				
Chroococcus turgidus	2				
Cyclotella polymer	2				
Cyclotella meneghiniana	8				
Scenedesmus	1				
Spirogyra	1				
Synechococcus	2				
Lepocindis	2				
Navicula	3				
Zygnema	4				
Volvox	2				
Anacystis	16				
Fragilaria	7				
Pediastrum	1				
Actinastrum	1				
Moligeotiopsis	1				
Arthospira	4				
Cymbella	1				
Gomphonema	2				
Synura	3				
Dyctyosphaerium	2				
Cosmarium	2				
Pandorina	1				
Kirchneriella	1				

Cocconeis	1				
Micratinium	1				
Total Individual	**150**				
Hmax	**3.52**				

The total plankton species found were 34 species and 150 individuals; Mycrocistis had the highest number of individuals, namely 23 individuals. The phytoplankton diversity index shows a value of 2.96, and the evenness index shows a value of 0.84, so the diversity and the evenness in the waters are high. The dominance index shows a value of 0.16, while the distribution index shows a value of 1.08 (Table 3).

3. 3. Macrozoobenthos Community

Pomacea canaliculata, commonly known as the golden snail or apple snail, is a species of giant freshwater snail with gills and operculum, an aquatic gastropod mollusk in the family Ampullariidae. Native to South America, this species is considered the top 100 of the "World's Worst Invasive Alien Species". It is also considered the 40th worst alien species in Europe and the worst alien gastropod species in Europe [23-27].

The characteristics of this species are that it has a large shell with a round shape, with a peak angle of 85° to 90°. The surface is grooved and slightly shiny. Yellow or brown to dark brown with dark bands visible on the body parts. Axial growth lines appear thin, while spiral lines are not visible.

The apex of the shell is pointed but not sharp and is often damaged, and has a rounded oval shell mouth. The edge of the mouth of the shell is straight, continuous with breaks, and sharp. Columella's sides are thick and brown. The center of the shell is slit [20-26].

While P. insularum and P. maculata are closely related to P. canaliculata, the different names for the same species are because P. canaliculata is mostly found in flooded land, while P. insularum is mainly found in flooded land is mainly found in water with flowing currents. Based on examples of gold snails taken from several Southeast Asia, gold snails, including P. canaliculata Lamarck, come from several areas in South America, including Argentina [15-25].

The existence of Pomacea spp in the waters is strongly influenced by the pH factor and the type of substrate. Muddy substrates are suitable habitats for most benthic animals [15-17]. Besides that, this species is also found near banks with low current velocities, rich in organic content, and waters with relatively alkaline pH [23-26].

In addition, the temperature is also one of the parameters that affect the presence of macrozoobenthos. According to [30-32], the water temperature, which is not more than 30 °C, will not drastically affect the benthic life, while the critical temperature will occur at 30 to 40 °C.

The degree of acidity (pH) indicates that the Cimanuk River has a standard pH value for the survival of macrozoobenthos, in which the pH value ranges from 6 to 7. This fact follows the statement [31-32] that the pH, which ranges from 6.5 to 8.5, is still quite reasonable for the life of biota or organisms in the waters (Table 4).

Table 4. Macrozoobenthos Diversity and Diversity Index.

Station	Species	Number of Individual	Morphometry (cm)				
			Tc	Lc	S	Ta	La
1	*Pomacea canaliculata*	1	5.3	4.1	3.3	3.6	2.5
2	-	-	-	-	-	-	-
3	*Pomacea insularum*	1	4.43	3.16	3.88	2.78	2.43
4	*Pomacea maculata*	4	4.47	3.11	3.44	4.14	2.64
5	*Pomacea canaliculata*	3	3.93	2.86	2.9	3.83	3.36
6	-	-	-	-	-	-	-
Total Individual		8					
Diversity Index (H')		0.96496					
Evenness Index (E)		0.87835					
Dominance (D)		0.12165					
Dispersion (MI)		-2.25					

Based on the results obtained, it is known that there are three species of gastropod found in the waters of the Cimanuk river, including *Pomacea canaliculata*, *P. insularum*, and *P. maculata*. The index of macrozoobenthos diversity is around 0.96496, indicating that the level of macrozoobenthos diversity in the Cimanuk river is low. The evenness index of macrozoobenthos is around 0.87835, which indicates the low evenness of macrozoobenthos. Macrozoobenthos dominance index is around 0.12165, indicating low macrozoobenthos dominance. The distribution index of macrozoobenthos is around -2.25.

3. 4. Vegetation Analysis

The vegetation around the Cimanuk river basin found the most abundant species, Bambusa sp, a plant belonging to the Poaceae (grass) tribe [7-9]. Bamboo is an abundant resource and has a reasonably high diversity [7, 9-13]. From an ecological point of view, bamboo can maintain environmental balance because its root system can prevent erosion and regulate water systems [9-12]. This property makes bamboo suitable as a watershed conservation plant and maintains the stability of paddy fields around or along the riverbank against land erosion [9-11]. There is also a type of Colocasia esculenta (taro) plant related to environmental use and reforestation because it can grow on slightly watery land to dry land. According to research [8-13], taro plants can reduce the content of pollutants in water, such as phosphate, nitrogen, and carbon, so the presence of taro plants around the Cimanuk river can act as plants that can reduce organic pollutants. Strobilanthes crispa (vile shard) grows at an altitude of 50-1200 m above sea level and grows well on clay. Grows wild in the forest, on the left and right of rivers and cliffs. Keji shard is usually grown as an ornamental plant or medicinal plant [13-17]. Cocos nucifera is found in the vegetation of the Cimanuk river, which functions to prevent landslides so that the river banks do not widen because they are eroded by water [20-27]. Bintaro plants (Cerbera manghas) are generally 4–6-meters tall but sometimes reach up to 12 m. The leaves are dark green shiny oval in shape. It is widely distributed in the tropical Indo-Pacific region, including Indonesia. Its natural habitat is coastal areas and mangrove forests (mangroves). But now, Bintaro is widely planted as a reforestation tree that absorbs carbon dioxide (CO_2) and can withstand scouring or erosion of riverbanks, and be a source of energy for the river. The diversity of river vegetation is influenced by human activities along the river [20-30]. The index value of species diversity in the Cimanuk river is in the moderate category of 1.353 (Table 5) because, according to [7-13], if the species diversity index value is greater than 3, it indicates high or abundant species diversity, if between 1-3 species diversity is moderate if it is less than one it means the diversity is little or less. Diversity tends to be high in older communities and low in newly formed communities. Meanwhile, productivity or energy flow significantly affects species diversity. Bambusa sp has a density value more significant than other species, and the density value illustrates that species with high-density values have an enormous tolerance [27-32]. Plant communities that can grow along the right and left banks of rivers are called riparian vegetation [12-13]. The grouping of forest vegetation structure is divided into five strata, namely Stratum A (tree height 30-40 m), stratum B (tree 18-27 m), stratum C (tree height 8-14 m), stratum D (scrub to a height of 10 m) and stratum E (terna and seedlings). Vegetation strata around the waters are also forest vegetation strata which consist of layers I to V. Based on the criteria for the vegetation structure, the vegetation on the banks of the Cimanuk river is classified as strata D and E because there are no plants that are more than 10 meters high [29-43].

Table 5. Vegetation Diversity and Diversity Index.

Species	**Number of Individual**	**H'**	**Density (individual/m^2)**
Bambusa sp.	35	1,353	0.014
Cerbera manghas	1		0.0004
Cocos nucifera	1		0.0004
Colocasia esculenta	21		0.0084
Excoecaria cochinchinensis	4		0.0016
Rivina humilis	1		0.0004
Strobilanthes crispa	16		0.0064
Total	79		

Based on the results obtained, it is known that there are seven types of plants with 79 individuals in the vicinity of the Cimanuk river. The highest density values were Colocasia esculenta, and the lowest density values were Rivina humilis Cerbera manghas and Cocos nucifera. The diversity index shows a value of 1.35, indicating that this area has a low diversity value.

3. 5. Riverside Profile

A river profile is a way to describe the presence of vegetation around the river and its characteristics. According to [7, 8], the river profile is divided into three stages in the development process, namely the young period, the adult period, and the old period. The young period is found in the upstream area of the river, and the adult period is in the middle of the river and has a slower water flow rate than the young period. The old period is found in the downstream area with a low depth.

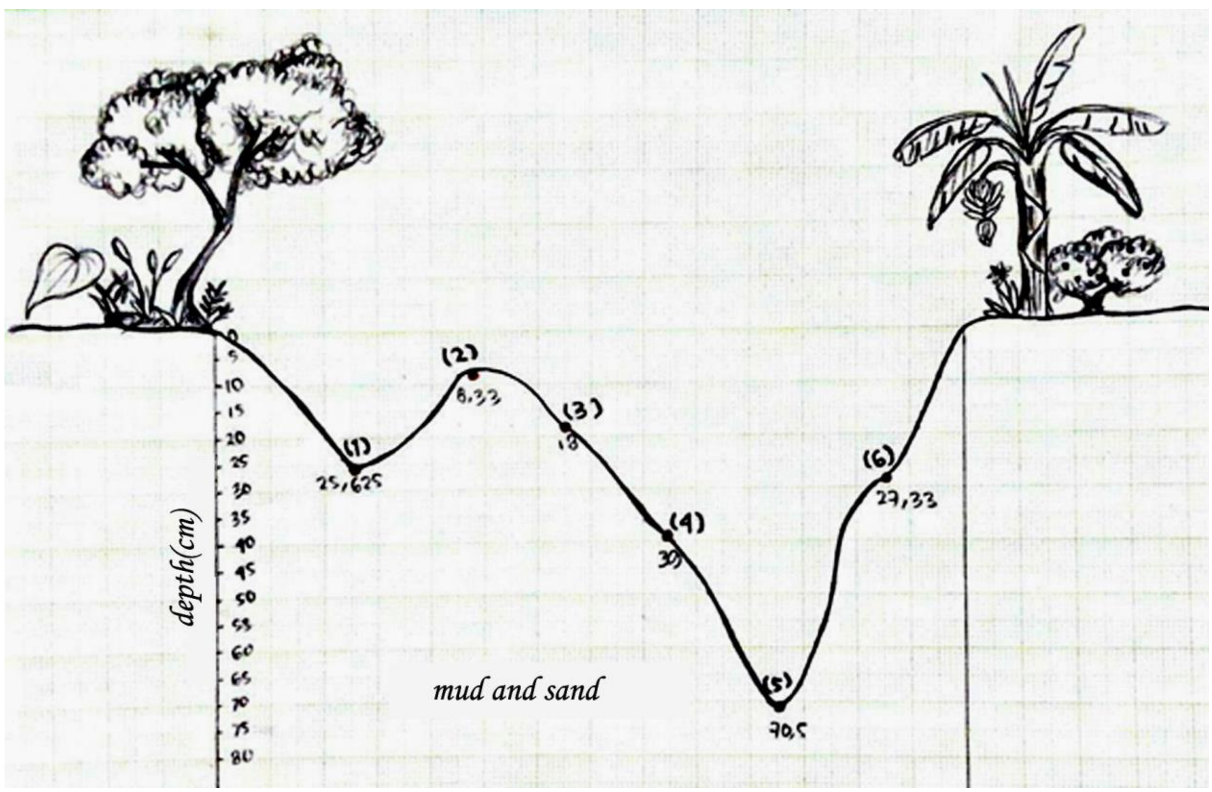


Figure 1. Cimanuk River Profile Diagram.

Based on the river profile data results, the river width data between stations ranges from 5.17 to 9.2 meters, with an average of 6.47 meters. Based on these data, the river's width varies greatly between stations. According to [7, 8], variations in river width can be caused by changes in water input, especially rainwater. In sloping watersheds, the river's width changes wider than in areas with steep riverbanks. Station 6 has river cliffs that are classified as sloping so that the cliffs are often eroded by rainwater and cause the river to be more comprehensive.

The bottom substrate condition of the Cimanuk river is dominated by sand and mud. The Cimanuk river is located in a residential area and is included in an urban area. [7, 8] stated that rivers in the city area have high silt due to erosion from the gerodon area. The erosion material will accumulate at the bottom of the water to form mud.

The depth of the Cimanuk river depicted in Figure 1 ranges from 8.3 to 70.5 cm, with an average of 31.38 cm. The water depth of the Cimanuk River is relatively shallow (only about the knee of an adult). There is a tendency to increase the depth, especially at station 5 of 70.5 cm. Sand and erosion material carried by river flows may not be evenly distributed, so the depth between stations varies. Depth affects the abundance of aquatic biota, especially benthos. According to [9-15], the water depth affects the number of macrozoobenthos species. The deeper the bottom of the water, the less the number of macrozoobenthos species because only certain macrozoobenthos can survive at the bottom of the deep waters. Because of this, only 1 type of benthos was found at station 5, namely Pomacea canaliculata.

4. CONCLUSION

Based on the results of the measurement of the WQI value, it is known that the Cimanuk river is included in the terrible category (WQI value: 24.43). The results of the identification of plankton obtained a diversity index (H') of 2.96 which indicates moderate diversity, and an evenness value (E) of 0.84, meaning that no species dominates. Benthos identification results obtained a diversity index value (H') of 0.965, which indicates moderate diversity, and an evenness value (E) of 0.878 is close to 1, meaning that no species dominates. The value of the diversity index (H') of vegetation around the river is 1.353, meaning that the diversity is classified as moderate.

Acknowledgment

The authors are grateful to the Faculty of Fishery and Marine Science of Padjajaran University, which supported the study through the annual research program.

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