



Spatial Distribution of Macrozoobenthos as Bioindicators of Organic Material Pollution in the Citanduy River, Cisayong, Tasikmalaya Region, West Java, Indonesia

Dimas Sulaeman^{1*}, Isni Nurruhwati¹, Zahidah Hasan¹ and Herman Hamdani¹

¹*Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Jl. Raya Bandung - Sumedang KM 21, Jatinangor, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. Author DS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IN and Author ZH managed the analyses of the study. Author HH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The Cisayong area of Tasikmalaya Regency is an area that is passed by the Citanduy River. Citanduy River has received a variety of inputs, that affect the river water quality and cause pollution. Macrozoobenthos can be used as an indicator of water pollution. This research aims to determine the spatial distribution of the macrozoobenthic community as a bioindicator of organic matter pollution in the Citanduy River, Cisayong Tasikmalaya Region, West Java. This research was conducted on January 2 - March 3, 2020. The research method used a field survey method. The data collection technique used purposive sampling by determining 4 stations based on environmental factors and land use around the river flow. The results of the macrozoobenthic spatial distribution along the Citanduy River were different at each observation location. At station

*Corresponding author: Email: dimasthend7@gmail.com;

1 several intolerant species *Heptagenia* sp., *Leptophelbia* sp., and *Hydropsyche* sp. Were found, station 2 found several facultative species *Melanoides tuberculata*, *Lymnea* sp., *Tarebia granifera*, *Sulcosfira testudinaria*, *Filopaludina javanica*, and *Pomacea canalicuta*, station 3 found several tolerant species *Chironomus* sp., and *Tubifex* sp., station 4 were found several species of facultative and tolerant macrozoobenthos *Melanoides tuberculata*, *Lymnea* sp., *Tarebia granifera*, *Sulcosfira testudinaria*, *Filopaludina javanica*, *Pomacea canalicuta*, and *Tubifex* sp. The abundance of macrozoobenthos in the Citanduy River ranges from 1460-2540 ind/m². Diversity index ranges from 1.53 to 1.79. The uniformity index ranges from 0.45 to 0.53. Species deficits at each station are different. The Morisita index ranges from 0.48 to 1.12 representing uniform categories and groups.

Keywords: Citanduy; indicators; macrozoobenthos; spatial distribution; pollution.

1. INTRODUCTION

The Citanduy River Basin has the main river, namely the Citanduy River which crosses the two provinces of West Java and southern Central Java. The upstream part of the Citanduy River area originates from Mount Cakrabuana in Tasikmalaya Regency, and its downstream reaches the Segara Anakan Lagoon, Cilacap Regency. According to the Decree of the Minister of Forestry RI Number: SK. 328 / Menhut-II / 2009, the Citanduy watershed is one of the priority watersheds in Indonesia. This watershed has five sub-watersheds, namely the Citanduy Hulu, Cimuntur, Cijalong, Ciseel, and Cikawung sub-watersheds [1].

The amount of input from agricultural, domestic and industrial wastes which are disposed of directly into the rivers without prior treatment makes the river water highly polluted [2]. The water conditions in the Citanduy Cisayong River have also been affected by household waste, tofu factory waste, and disposal of agricultural products. The waste disposal directly in the river, results in the pollution of Citanduy river.

One indicator that can be used to see water pollution is macrozoobenthos. Macrozoobenthos plays a very important role in the ecosystem of waters. The existence and diversity of macrozoobenthos can be used as bioindicators of water pollution, because macrozoobenthos has relatively permanent living habitats (sesile). Changes in water quality and living substrate greatly affect the abundance and diversity of macrozoobenthos. This abundance and diversity is very dependent on tolerance and sensitivity to environmental changes. The use of macrozoobenthos as bioindicators of water quality can be used to determine pollution originating from both domestic and industrial

waste as well as waste originating from agricultural, fishery and livestock waste[3].

The existence of benthic animals in a waters is highly influenced by various environmental factors, both biotic and abiotic. Biotic factors that influence include producers, which are a source of food for benthic animals and species interactions and life cycle patterns of each species in the community. The abiotic factors are physical-chemical quality of water, including temperature, current, dissolved oxygen (DO), biological oxygen demand (BOD), as well as nitrogen (N) content, water depth, and substrate [4].

2. MATERIALS AND METHODS

2.1 Research Sites

This research was conducted in the Citanduy River, Cisayong Tasikmalaya Region, West Java. The method used in this research is a field survey method. The data collection technique used purposive sampling. The research was conducted at 4 sites, such as stations 1, 2, 3, and 4 (Fig. 1). Determination of stations was based on environmental factors and land used, as well input of waste into the river.

- Station 1: The location is in Cireungit which is the upstream part of the river and has not been exposed to waste input, located at coordinates 7°15'37.717" SL 108°10'57.85" EL.
- Station 2: The location is in Cidap and the Fish Market Complex which are part of the river that has received input from household waste, because it is in a residential area, located at coordinates 7°15'47.996" SL 108°11'11.02" EL.

- Station 3: The location is in Cibodas, which is a part of the river that has received waste input from the tofu factory, located at coordinates 7°15'24.986" SL 108°11'15.1" EL.
- Station 4: The location is in Gresik Tasikmalaya which is a part of the river that has received input from agricultural waste, located at coordinates 7°15'47.048" SL 108°11'30.542" EL.

2.2 Sampling and Measurement

Water and macrozoobenthos samples were taken once every 7 days for 6 weeks, and for substrate samples taken once in the 5th week. The water samples analyzed consisted of 8 parameters, namely, temperature, transparency of light, turbidity, depth, current velocity, pH, DO, and BOD₅ carried out in-situ and ex-situ. Ex-situ analysis of water parameters and macrozoobenthos observations were carried out at the Laboratory of Aquatic Resources, Faculty of Fisheries and Marine Sciences, Padjadjaran University. Whereas substrate analysis consisted of 5 parameters, namely, substrate texture,

COrganic, N-Organic, C/N ratio and pH of the substrate conducted ex-situ at the Soil Chemistry and Plant Nutrition Laboratory, Faculty of Agriculture, Padjadjaran University.

2.3 Macrozoobenthos Sampling

Macrozoobenthos at each station were taken using a 25x40 cm surber mesh with 3 repetitions, macrozoobenthos and substrate were separated using a 1 mm mesh filter, inserted into labeled plastic containers and the type of fixative used is formaldehyde 10%. Macrozoobenthos samples were cleaned and identified at the Aquatic Resources Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University.

2.4 Data Analysis

Data analysis was carried out in a descriptive comparative manner at each station to provide an overview of the state of the research object. The present data in the form of diagrams from each research station, to determine the level of pollution of the Citanduy River with macrozoobenthos, water quality and substrate texture.

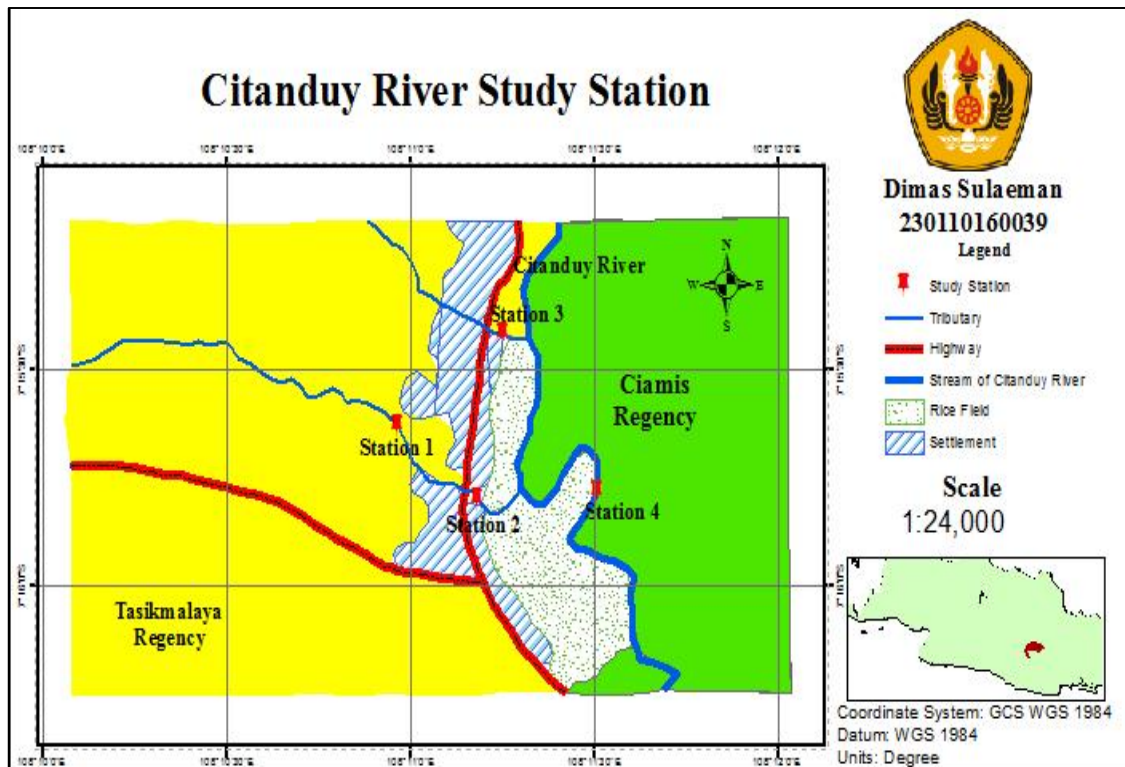


Fig. 1. Research location Map

2.4.1 The abundance of macrozoobenthos

Abundance is the number of individuals and the number of species found in the specific area of observation. Abundance is calculated by the formula:

$$Di = \frac{Ni}{A}$$

Information,

In : The abundance of macrozoobenthos (ind / m).
 Ni : Number of individuals (ind).
 A : Area.

2.4.2 The diversity of macrozoobenthos

Diversity index shows the richness of species in a community and also shows a balance in the distribution of numbers per individual per species. Diversity index can be calculated with the Shannon-Wiener index.

It also shows a balance in the distribution of numbers per individual per species. Diversity index can be calculated with the Shannon-Wiener index:

$$H' = - \sum_{i=1}^S (Pi \ln Pi) \text{ with } Pi = \frac{ni}{N}$$

Information,

H' : Shannon-Wiener Diversity Index.
 ni : Number of individuals of the ith species.
 Pi : ni / N or the number of individuals of each type (i = 1,2,3,).
 N : Total number of individuals.
 S : Number of species.

The Shannon-Wiener Diversity Value has a certain range of values, namely:

H' < 1 : Low diversity.
 1 < H' < 3: Moderate diversity.
 H' > 3 : High diversity.

2.4.3 The uniformity of macrozoobenthos

Uniformity is calculated using the Shannon Wiener uniformity index formula.

$$E = \frac{H'}{H_{max}}$$

Information,

E : Uniformity Index.
 H' : Diversity Index.

Hmax : Ln-S.
 S : Number of species.

2.4.4 Deficit species

Species deficit is a comparison of abundance of macrozoobenthos by looking at the comparison of abundance at stations downstream with stations upstream. Species deficits are calculated by the formula:

$$I = \frac{Su - Sd}{Su} \times 100$$

Information,

I: Species deficit.
 Su: Number of Species upstream.
 Sd: The number of Species is downstream.

2.4.5 Morisita's dispersion index

To determine the distribution pattern of macrozoobenthos, Morisita dispersion index is used. This index is calculated by using the formula:

$$Id = n \left[\frac{\sum X^2 - N}{N(N-1)} \right]$$

Information,

Id = Morisita Spread Index
 n = Amount take-off unit (plot)
 X = Number of individuals in each plot
 N = Amount total individual biota

The distribution pattern criteria are as follows:

Id = 1, then the population distribution is a random category
 Id > 1, then the population distribution is a clustered / grouped category
 Id < 1, then the population distribution is uniform.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Parameters of Water

Physical parameters observed during the study were parameters of temperature, transparency, turbidity, depth and current. Chemical parameters observed during the study were parameters of degree of acidity (pH), DO and BOD. The measurement results can be seen in Table 1. The substrate parameters during the study can be seen in Table 2.

Table 1. The quality of water in research stations

Parameter	Unit		Station			
			1	2	3	4
Temperature	°C	Average	25.75 ± 1.1	25.33 ± 0.5	26.08 ± 0.7	25.33 ± 0.5
		Range	24-27	24.5-26	25-27	25-26
Light Transparency	cm	Average	25.92 ± 1.02	64.58 ± 1.83	68.42 ± 2.78	42.75 ± 1.64
		Range	24.5-27	62.5-67.5	64.5-72.5	41-45.5
Turbidity	NTU	Average	29.69 ± 6.38	35.47 ± 5.35	26.27 ± 4.98	92.98 ± 2.44
		Range	18,2-35,70	29,40-41,30	16,80-30,40	90.30-95.90
Depth	m	Average	0.32 ± 0.005	1.04 ± 0.03	1.14 ± 0.03	0.70 ± 0.06
		Range	0.31-0.32	0.99-1.08	1.1-1.18	0.63-0.78
Flow Velocity	m / s	Average	0.21 ± 0.00	0.18 ± 0.01	0.41 ± 0.03	0.27 ± 0.01
		Range	0.21-0.22	0.17-0.18	0.37-0.45	0.26-0.28
pH	-	Average	7.70 ± 0.07	7.76 ± 0.14	7.45 ± 0.22	7.33 ± 0.17
		Range	7,63-7,8	7,6-7,95	7,16-7,75	7,15-7,52
DO	mg / L	Average	6.18 ± 0.24	6.50 ± 0.65	6.20 ± 0.37	6.57 ± 0.52
		Range	5,8-6,4	5,4-7,1	5,7-6,6	5,8-6,9
BOD5	mg / L	Average	11.63 ± 3.46	21.91 ± 5.40	25.42 ± 3.66	26.23 ± 3.47
		Range	6.5-14.6	16.25-25.95	19.45-29.2	21.1-29.2

The temperature of the Citanduy River ranges from 24 ° –27 ° C. Stations 2 and 4 have the same mean temperature value of 25.33 ± 0.51 ° C which is the average value of the lowest temperature and the highest temperature, namely at station 3 with an average of 26.08 ± 0.664 °C. Overall, the water temperature in the Citanduy River research station is still within the tolerance value for aquatic organisms, especially macrozoobenthic. Factors that cause differences in the results of temperature measurements at each station include sunlight intensity, temperature exchange between water and air, geographic altitude, the presence of shade from trees growing on the river bank [5].

The difference in temperature along the Citanduy River is caused by several factors, including the measurement time and the geographical location of the sampling site. The temperature at station 4 has a lower temperature range than at other stations, this is because the water sampling time which is carried out in the morning is different from stations 1, 2 and 3 which are held during the day. The time of measurement affects the variation in the value of water temperature. This occurs because the intensity of sunlight entering the morning sample is lower than during the daytime sampling. Factors that cause differences in the results of temperature measurements at each station include the intensity of sunlight, the temperature exchange between water and air, geographical altitude, the presence of trees that grow on the banks of the river [6].

Measurement of light transparency on the Citanduy River varies from station to station, ranging from 24.5–72.5 cm (Table 1). Station 3 with the highest average light transparency of 68.42 ± 2.782 cm, and station 1 with the lowest average light transparency of 25.92 ± 1.02 cm, this can happen because station 1 still has a small amount of pollutants entering the body the river and sunlight at this station can penetrate to the riverbed with a shallow river depth with an average of 0.32 ± 0.005 m. Low transparency causes the inhibition of sunlight penetration into the waters so that the photosynthesis process cannot run properly [7]. Overall, the research station has varied river depths so that the light transparency value does not differ much from the average depth of the river.

Turbidity in the Citanduy River ranges from 16.80-95.90 NTU (Table 1). Turbidity may be determined on the large number of suspended particles in the water. The lowest turbidity at station 1 ranges from 18.20–35.70 NTU with an average of 26.6387 ± 6.387 NTU, the low level of turbidity at station 1 is due to the absence of waste input from anthropogenic activities around the river, not much different from the turbidity value at the station 3. The highest turbidity at station 4 ranges from 90.3–95.9 NTU with an average of 92.88 ± 2.442 NTU. The high level of turbidity at station 4 is due to the input of organic and inorganic materials from household activity waste and tofu factory waste which is carried away from other stations, besides that the turbidity level is influenced by the rainy season

and the type of substrate at each station, the turbidity level is different every week. -different because the sampling was carried out in the rainy season. Water turbidity is generally caused by suspended and dissolved organic and inorganic materials such as fine sand, organic and inorganic materials, the higher the suspended solids value, the higher the turbidity value [8].

The depth measurements on the Citanduy River varied between 0.31–1.18 m (Table 1). Overall river water depth is relatively shallow at each observation station and tends to increase in depth. This is because during the observation it was carried out during the rainy season, which made the river water discharge become large. Station 3 with the highest average depth of 1.14 ± 0.03 m, and station 1 with the lowest average depth of 0.32 ± 0.005 m. The depth of the waters will affect the distribution pattern or distribution of the macrozoobenthos in the waters [9].

Depth affects the type and amount of macrozoobenthos due to the penetration of light that enters the water. The depth of a water is related to the abundance of macrozoobenthos, where an increase in water depth is followed by a decrease in the abundance of macrozoobenthos, whereas the abundance of macrozoobenthos is higher in shallow water [10].

The current velocity of the Citanduy River ranges from 0.17 to 0.45 m / s (Table 1). The highest current velocity is at station 3 with an average of 0.41 ± 0.0285 m / s, and the lowest current velocity is at station 2 with an average of 0.18 ± 0.0054 m / s. Citanduy River is a river with moderate flow velocity, because the average current velocity of the Citanduy River in the Cisayong Region ranges from 0.18 ± 0.0054 - 0.41 ± 0.0285 m/s. Macrozoobenthos do not like heavy currents which can erode the nutrient content and reduce the food supply for macrozoobenthos [11].

The pH measurements of the Citanduy River varied between 7.15-7.95 (Table 1). The pH value is still safe and below the threshold so that it is still safe for the survival of the biota in the Citanduy River, especially macrozoobenthos. The highest pH value was at station 1 with an average of 7.77 ± 0.068 , and at station 4 with the lowest average pH value of 7.33 ± 0.167 . Overall, the pH value in the Citanduy River is still within the tolerance limit because the average pH value ranges from 7.52 ± 0.35 – 8.65 ± 1.35 . Each

organism has a different tolerance limit for pH. These changes can have an impact on every organism that comes into contact with water, one of which is macrozoobenthos. Most aquatic organisms will be sensitive to changes in pH, while the preferred pH range is around 7-8.5 [8].

The results of DO measurements during the study in the Citanduy River ranged from 5.4 to 7.1 mg / L. Station 4 is the station with the highest DO concentration of 6.57 ± 0.524 mg / L and station 1 which has the lowest DO concentration of 6.18 ± 0.24 mg / L. Dissolved oxygen concentration depends on: temperature, the presence of photosynthetic plants, the level of light penetration which depends on the depth and turbidity of the water, the hardness of the water flow, the amount of organic matter that is broken down in the water, such as garbage, dead algae, or industrial waste [12].

The range of average BOD concentrations in the Citanduy River was 11.63 ± 3.46 mg / L- 26.23 ± 3.469 mg / L (Table 1). The lowest BOD concentration was found at station 1 ranging from 6.5–14.6 mg / L with an average of 11.63 ± 3.46 mg / L. The highest BOD concentration at station 4 ranged from 21.1 to 29.2 mg / L with an average of 26.23 ± 3.469 mg / L. The high BOD concentration at station 4 reflects the high organic matter that can be degraded biologically. The amount of BOD value is determined by the activity of decomposing organisms such as bacteria in decomposing organic matter [4]. In addition, domestic and industrial waste that enters water bodies can also affect the BOD value [8].

3.2 Substrate

Substrate characteristics such as texture, pH, C-Organic, and N-Total in the waters of the Citanduy River, Cisayong Region (Table 2). Measurement of the pH of the substrate at the research station obtained a pH value of 7.05–7.68. The pH value of the substrate in the waters of the Citanduy River is neutral, so it is suitable for the macrozoobenthic life in it. The chemical concentration of the substrate, especially C-Organic at all research stations, was low <2.7%. The lowest C-Organic concentration was at station 1 at 0.11, while the highest C-Organic concentration was at station 3 at 2.7 this was due to the deposition of C-Organic at Station 3, as well as the input of tofu factory waste organic matter.

The type of sandy clay substrate at station 3 also makes a fairly high organic concentration, and at station 1 the type of clay sand. This type of sand and clay substrate is preferred by gastropod macrozoobenthos according to the abundance that exists at stations 1 and 2 more

than the gastropod class. The high and low organic matter content is influenced by the animals and plants that accumulate in the soil, as well as the waste that enters the water and the level of competition between macrozoobenthos itself [13].

Table 2. The content and characteristics of the research station substrate

Parameter	Station			
	1	2	3	4
pH	7.52	7.68	7.32	7.05
C-Organic	0.11	0.28	2.7	0.41
N-Total	0.02	0.04	0.33	0.04
C / N	7	7	7	10
Texture	Clay Sand	Clay Sand	Sandy clay clay	Sandy clay clay

Table 3. The abundance of Macrozoobenthos

Class	Species	Station (ind / m2)			
		Station 1	Station 2	Station 3	Station 4
Insect	<i>Heptagenia</i> sp. *	20	0	0	0
	<i>Tipula</i> sp.	0	0	30	10
	<i>Leptophelbia</i> sp. *	200	0	30	20
	<i>Polycentrophus</i> sp.	50	0	0	20
	<i>Enallagma</i> sp. *	0	0	0	0
	<i>Chironomus</i> sp. ***	0	0	1250	0
	<i>Hydropsyche</i> sp. *	120	0	30	0
	<i>Libellula</i> sp.	20	20	0	10
	<i>Callibaetis</i> sp.	0	0	40	0
	<i>Pseudocloeon</i> sp.	0	0	0	10
	<i>Ranatra nigra</i>	0	0	30	0
<i>Onychogomphus</i> sp.	0	0	10	0	
Malacostraca	<i>Gammarus</i> sp.	40	0	0	0
	<i>Parathelphusa convexa</i>	90	30	0	10
Gastropods	<i>Melanoides tuberculata</i> **	110	320	40	100
	<i>Lymnea</i> sp. **	0	30	140	40
	<i>Thiara scabra</i>	20	210	40	40
	<i>Phisastra</i> sp.	0	0	120	0
	<i>Tarebia granifera</i> **	570	690	240	410
	<i>Sulcosifira testudinaria</i> **	130	120	160	120
	<i>Filopaludina javanica</i> **	40	110	0	80
	<i>Pomacea canalicuta</i> **	0	40	0	60
	<i>Anentome</i> sp.	10	30	0	130
Bivalves	<i>Corbicula fluminea</i>	30	320	10	310
	<i>Pilsbryconcha exilis</i>	0	10	0	20
	<i>Anodonta</i> sp.	0	10	0	10
Clitellates	<i>Lumbriculus</i> sp.	0	40	20	10
	<i>Tubifex</i> sp. ***	0	110	270	30
	<i>Hirudinaria</i> sp.	10	10	80	30
total		1460	2100	2540	1470

The N-total value at all research stations is low <0.33%, the low N-total value content is also influenced by the texture of the sediment. Measurement of the Citanduy River substrate at

each station shows the C / N ratio ranges from 7–10. Station 4 has the highest C / N ratio of 10, stations 1, 2, and 3 have the lowest C / N ratio of 7. C and N ratios describe the level of fertility of

the sediment system. Various organic materials and substrates as well as human activities around the waters can have an influence on the macrozoobenthos that live in it [14].

3.3 Macrozoobenthos Community Structure

The abundance of macrozoobenthos found during the research varied at each station, with a range of values from 0-1250 ind/m². The calculation results can be seen in Table 3. The highest average abundance is occupied by the species *Tubifex* sp. of 1250 ind/m² and the lowest average abundance is occupied by the *Parathelphusa convexa* species of 10 ind/m². Station 1 which has the lowest abundance of 1460 ind/m², the species found at station 1 are from the insect and gastropod class, namely *Heptagenia* sp., *Leptoplebia* sp., *Polycentrophus* sp., *Hydropsyche* sp., *Libellula* sp., *Gammarus* sp., *Parathelphusa convexa*, *Melanoides tuberculata*, *Thiara scabra*, *Tarebia granifera*, *Sulcosfira testudinaria*, *Filopaludina javanica*, *Anentome* sp., *Corbicula fluminea*, and *Hirudinaria* sp. The abundance of intolerant macrozoobenthic class insects at station 1 indicates that the water conditions at station 1 are still good.

Macrozoobenthic species with the highest abundance was at station 3 with an abundance of 2540 ind / m², the species found at station 3 (Table 3) were *Tipula* sp., *Leptoplebia* sp., *Chironomus* sp., *Hydropsyche* sp., *Ranatra nigra*, *Onychogomphus* sp., *Melanoides tuberculata*, *Lymnea* sp., *Thiara scabra*, *Phisastra* sp., *Tarebia granifera*, *Sulcosfira testudinaria*, *Lumbriculus* sp., *Hirudinaria* sp. and *Tubifex* sp. However, the species with the highest abundance was *Chironomus* sp. amounting to 1250 ind / m² (Table 3). The abundance of *Chironomus* sp. because of the large amount of organic matter in the waters, and the condition of the station 3 waters is already polluted. Tolerant macrozoobenthos that can grow and are abundant in poor water quality include *Tubifex* sp, and *Chironomus* sp. which overflows at station 3 [15].

Gastropod classes that are mostly found at stations 2 and 4, such as *Melanoides tuberculata*, *Lymnea* sp, *Tarebia granifera*, *Sulcofira testudinaria*, *Filopaludina javanica*, *Pomacea canalicuta*, and *Corbicula fluminea*, are a group of facultative macrozoobenthos. Gastropod species have very good adaptability in

various substrates compared to other classes, such as clay clay, sandy loam, and clay sand that can be found at the three stations.

The diversity index in the Citanduy River ranges from 1.53 to 1.79 and the uniformity index value on the Citanduy River with the species level from each station ranges from 0.45 to 0.53 in Fig. 2. The calculation of the Shannon-Wiener (H') macrozoobenthos diversity index (H') shows that the diversity index at each research station in the Citanduy River, namely stations 1, 2, 3, and 4, is included in moderately polluted waters because it has a diversity index value ($1 < H' < 3$) (Fig. 2). This is because each of these research stations has a high concentration of organic matter.

The low diversity index value at station 3 with a value of 1.53 ± 0.62 , this is presumably because station 3 is a stream of the Citanduy River whose water quality has been polluted due to the input of tofu factory waste, which resulted in a decrease in water quality parameters such as temperature at station 3 it was higher than the other stations of 26.08 ± 0.66 mg / L, and the high concentration of BOD was 25.42 ± 3.8 mg / L. So that the macrozoobenthic group found at station 3 is only 17 species (Table 3) and is an intolerant type of macrozoobenthic group.

The uniformity index value on the Citanduy River with the species level from each station ranged from 0.45 to 0.53 (Fig. 2). The lowest uniformity index value is at station 3 with a value of 0.45. This is because there are species that dominate at station 3, namely *Chironomus* sp. and *Tubifex* sp. The dominance of *Chironomus* sp. and *Tubifex* sp. at station 3. This is because the water conditions at station 3 are heavily polluted and cause tolerant species that can live and grow in conditions of poor water quality. The highest uniformity index value is at station 4 of 0.53, this shows that the distribution of individuals for each species at station 4 tends to be evenly distributed and no individual dominates from certain species.

The deficit value of macrozoobenthic species in the Citanduy River can be seen in Table 4. The Morisita dispersion index value in the Citanduy River ranges from 0.605 to 1.406. The results of the calculation of the macrozoobenthic distribution pattern in the Citanduy River are in Fig. 3. Deficit species are suitable for determining the part of a water body that receives a lot of waste input, which in turn eliminates the presence of organisms

downstream. The average value of the percentage ratio of species at station 1 to station 2, station 1 to station 3, station 1 to station 4 (Table 4) shows that there are more downstream species than those in the upstream area. The

largest percentage in the comparison of station 1 to station 2 is thought to be because the input of organic matter from household waste makes several types of macrozoobenthos use it as food.

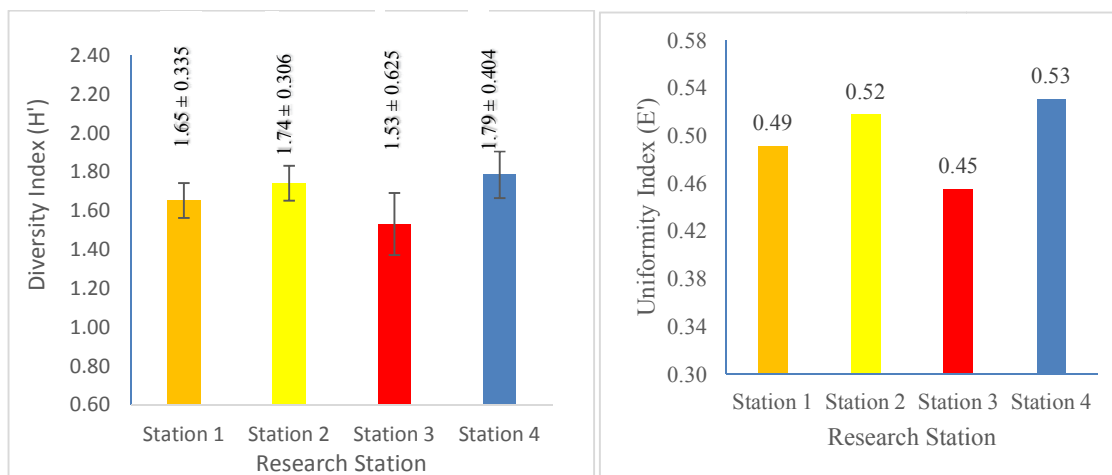


Fig. 2. Diversity and Uniformity Index

Table 4. Species of macrozoobenthos deficits

Station	Sampling to-						Average
	1	2	3	4	5	6	
1 to 2	-20%	-100%	-63%	-25%	11%	11%	-31%
1 to 3	-20%	-25%	-38%	-13%	33%	22%	-7%
1 to 4	-40%	-25%	-63%	-38%	11%	11%	-24%

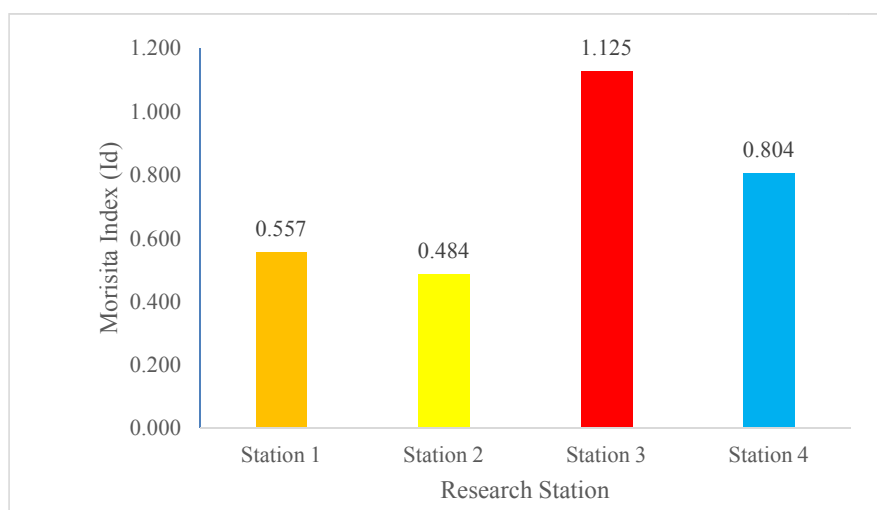


Fig. 3. Morisita index

The species of the insect class, which are intolerant macrozoobenthic groups found at station 1, were not found at other stations, while

the genera found at stations 2, 3, and 4 were more from the gastropod class. This is due to decreased water quality and less support for

species at upstream stations to live in downstream stations. Judging from the increasing temperature, decreasing DO concentration, and increasing BOD concentration at downstream stations.

Species that survive at station 3 are macrozoobenthic groups that are tolerant of polluted waters, among others, *Chironomus* sp. and *Tubifex* sp. which is one of the indicators of water pollution because the two types of organisms are resistant to environmental changes and can grow and develop in a bad water environment, seen from the physical and chemical conditions of the waters. Excessive loads from decomposed organic matter usually cause damage to the aquatic environment and affect river quality. In addition, the wastes that enter the waters can affect the existence of organisms that live in the waters [16].

The Morisita dispersion index value in the Citanduy River ranges from 0.605 to 1.406 (Fig. 3). The lowest distribution pattern of Morisita macrozoobenthos is at station 2, and the highest is at station 3. Stations 1 and 2 with a distribution pattern of 0.557 and 0.484 respectively, the Morisita dispersion index value has the criteria of $I_d < 1$, which is a uniform population category distribution. Uniform distribution is the result of negative interactions between individuals, for example, there is competition for food and space to grow.

Station 3 has a high Morisita distribution pattern of 1.125, the Morisita dispersion index value has the criteria $I_d > 1$, which is the population distribution of the group category. Station 4 has a Morisita distribution pattern of 0.804, the Morisita dispersion index value has a criterion of $I_d < 1$, which is a uniform population category distribution. A uniform distribution pattern that is rarely found in natural populations that is close to such a situation is when the uniform distribution pattern occurs as a result of competition between individuals that encourages the same distribution of living space. The nature of the random distribution pattern of reproductive activity will be low and the presence of the individual population in nature will be weak or less robust [17].

4. CONCLUSION

Based on the research that has been carried out, it can be concluded that the distribution of macrozoobenthos in the Citanduy River consists of 29 species and 5 classes of

macrozoobenthos. Station 1 consists of 15 species and 5 classes, so that the condition of station 1 waters is still good and not yet polluted. Station 2 consists of 16 species and 5 classes, of which are species of the facultative macrozoobenthos group, so that the condition of station 2 waters is moderately polluted waters. Station 3 consists of 17 species and 5 classes, including species of the macrozoobenthos group that dominate tolerant *Chironomus* sp., and *Tubifex* sp. so that the condition of station 3 waters is heavily polluted waters and station 4 consists of 20 species and 5 classes.

The Diversity Index in the Citanduy River ranges from 1.53 to 1.79 which shows that the diversity in the Citanduy River is classified as moderate diversity. The Uniformity Index in the Citanduy River ranges from 0.45 to 0.53 which indicates that the distribution of individuals for each type at each station tends to be even. The difference in deficit species values at each station is different. This is influenced by physical and chemical parameters in accordance with the environmental conditions of the water. The distribution pattern of macrozoobenthos in the Citanduy River based on the Morisita index is uniform and grouped.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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