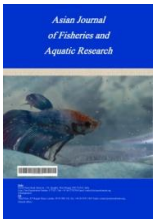

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Spatial Distribution of Plankton in Citanduy River, Cisayong Region, Tasikmalaya, West Java

Rinaldy Reza Adrian[1*], Zahidah[1], Mochamad Rudyansyah Ismail[1] and Heti Herawati[1]

[1]Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung – Sumedang KM.21, Jatinangor 45363, Indonesia.

Authors' contributions

This work was carried out in collaboration among all authors. Author RRA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors Zahidah and MRI 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. The condition of the waters in the Citanduy River in Cisayong area, has received various waste inputs which will affect the quality of the river waters and cause a decrease in water fertility. Plankton can be used as an indicator of water fertility. This study aims to determine the spatial distribution of plankton in the Citanduy River, Cisayong Tasikmalaya Region, West Java. This research was conducted from January 2020 to February 2020. The research stations are located in four locations which are determined based on environmental and land use factors with a sampling period span of once every seven days. This research was conducted using a survey method and the data were analyzed descriptively and comparatively. The results showed that there were 67 genera of plankton from 5 phytoplankton phyla and 4 zooplankton phyla with most of the phytoplankton groups found from the Bacillariophyceae class and the zooplankton group from the Tubulinea class. The total average abundance of phytoplankton was 11,534 ind / L and the total average abundance of zooplankton was 295 ind / L. The biological index values of the average diversity

**Corresponding author: Email: rezarinaldy61@gmail.com;*

and dominance of phytoplankton were 2.72 and 0.11, while the average values of diversity and dominance of zooplankton were 0.92 and 0.47. The results of the plankton spatial distribution show that the fertility of the waters in Citanduy River is classified as oligotrophic for station 1 and mesotrophic waters for stations 2,3, and 4.

Keywords: Citanduy River; plankton; spatial distribution.

1. INTRODUCTION

The water conditions in the Citanduy River in Cisayong area have been affected by household, industrial, and disposal of agricultural supporting materials such as the use of artificial fertilizers. This resulted in contamination of the waters in Citanduy River. The many types of waste input that are simply disposed of into the river flow without prior treatment, make river water polluted and affect the water quality of each river flow which causes differences in water fertility [1].

The existence of plankton can be used to determine the fertility of water, that is by counting the abundance and distribution of plankton. The existence of plankton is influenced by several factors, that is physical factors, chemical factors, and biological factors as well as the features of these organisms [2]. The physical and chemical quality of the waters is greatly influenced by environmental pollution. Pollution can change the structure of an ecosystem and can reduce the number of species in a community, so that its diversity is reduced. Thus, the diversity index of polluted ecosystems is always smaller than natural ecosystems [3]. Mulyanto [4], states that there are types of plankton that can be used as a guide to determine the biological condition of the waters.

2. MATERIALS AND METHODS

2.1 Research Location

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

- Station 1: The location is in Cireungit Village which is the upstream part of the river and has not been exposed to waste input, located at coordinates 108°10’57.85 “BT-7°15’37.717” LS.
- Station 2: The location is in Cidadap Village and Fish Market Complex which is part of the river that has received input from household waste, because it is in a residential area, located at coordinates 108°11’11.02 “BT-7°15’47.996” LS.
- Station 3: The location is in Cibodas Village, which is a part of the river that has received waste input from the tofu factory, located at coordinates 108°11’15.1 “BT-7°15’24.986” LS.
- Station 4: The location is in the village of Gresik Tasikmalaya, which is part of the river that has received input from agricultural waste, located at coordinates 108°11’30.542 “BT-7°15’47.048”LS.

2.2 Sampling and Measurement

A sampling of water and plankton was carried out every seven days with six sampling times at four stations. Water and plankton sampling at the four stations was carried out at the surface of water. Plankton sampling was done by filtering 10 L of water using a plankton net with a mesh size of 40 µm. The filtered water sample was put into a 50 ml plankton sample bottle and preserved using 1% lugol, until the color turned brownish-yellow. The plankton was identified down to the genus level. Plankton was counted by the census method and identified using plankton identification books, including Sachlan [5] and Prescott (1978). Water parameters measured include light transparency, temperature, current, BOD, DO, CO2, pH, NO3, PO4, and NH3.

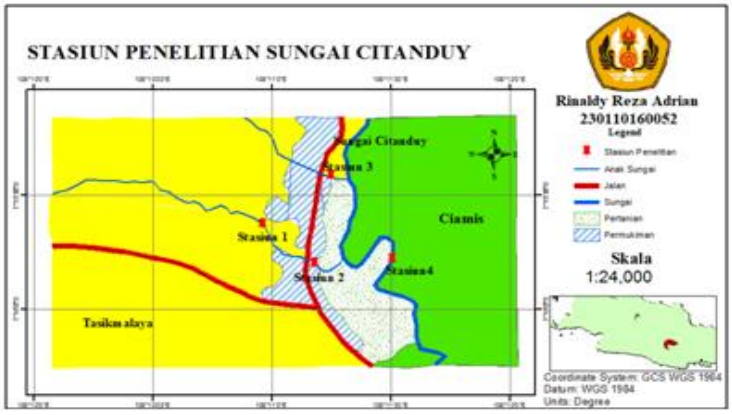

Fig. 1. Map of study location

2.3 Sample Analysis

Plankton data analysis was carried out using a comparative descriptive method at each station with the following observations.

2.3.1 Plankton abundance

Abundance is the number of individuals and the number of species found in the area of observation. Plankton abundance is calculated using a modified Sachlan formula [5] with the following equation:

$$N = n \times Vr / Vo \times 1 / Vs$$

Information:
N = Abundance (ind / L)
n = amount of plankton observed
Vr = The volume of plankton filtered (ml)
Vo = Observed plankton volume (ml)
Vs = Volume of filtered water (L)

2.3.2 Diversity index

Diversity index is used to determine the diversity of biota species at the research location using the Simpson Diversity Index [6] which is formulated as follows:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

Information:
n = Number of individuals of genus i
N = Total individuals

2.3.3 Dominance index

The dominance index [6] is calculated to see the presence of dominance by certain types of plankton in the plankton population in waters, calculated based on the following formula:

$$C = \Sigma (ni / N)^2$$

Information:
C = Simpson Dominance Index
ni = Number of individuals i-th
N = The total number of individuals of all types

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Parameters of Water

The physical and chemical parameters of the waters during study can be seen in Table 1. Light transparency greatly determines the presence of plankton. The higher the light transparency, the easier it is for light to enter the water. Otherwise, the lowest light transparency will inhibit the photosynthesis of plankton. The average of light transparency at station 1 has the highest value of 25.92 ± 1.02 cm or 86.4% of the river depth, indicating that the light transparency at station 1 is in a good category. This is because the river has a depth of only about 30 cm and the water is not cloudy, so that the water gets enough light. If the transparency of light in the waters is good, it will also have a good impact on phytoplankton for photosynthesis. According to Thoha [7], light transparency of 30 cm or less can affect plankton growth, because light entering the waters affects the photosynthesis process carried out by phytoplankton. The average light transparency at station 4 has the lowest value, that is 42.75 ± 1.64 cm or 35.6% of the river depth. The condition of the waters is dark brown and cloudy. The water conditions are not clear, so sunlight

cannot penetrate to the bottom of the water. According to Nurhasanah et al. [8], light transparency in water depends on color and cloudiness. Based on this statement, the more cloudy water is, the lower the light intensity that enters waters.

The lowest average temperature at station 2 is 25.33 ± 0.5°C and the highest temperature at station 3 is 26.08 ± 0.7°C. The lowest temperature at station 2, because it is influenced by the input of residential waste into the river. In addition, around the river is a forest area with lots of tall trees, so the transparency of light entering the water is low. According to Zahidah [9], light has a direct effect on temperature, meaning that high transparency of light will produce heat which in turn will increase the temperature. The high temperature at station 3 is due to the influence of tofu liquid waste entering the river. According to Sugiharto [10], the temperature produced from tofu liquid waste is generally higher than the raw water which ranges from 40-46°C, so that when the tofu liquid waste discharges into the river, it will increase the water temperature. In addition, the conditions around station 3 are not obstructed by trees, so that the transparency of light entering the water is quite high. The optimum temperature range for plankton growth, especially diatoms or Bacillariophyceae, ranges from 20-30°C and Chlorophyceae ranges from 30-35°C, while the Cyanophyceae class tolerates faster temperature ranges [11].

The lowest current speed is at station 2 with an average of 0.18 ± 0.01 m / s and the highest average current speed is at station 3, that is 0.41 ± 0.03 m / s. The low flow rate at station 2 is because there are many large rocks in the river flow. The high level of current velocity at station 3 is due to the fact that the riverbed in this research station has mossy small rocks and the absence of large rocks so that the river flow is not obstructed. According to Wijayanti [12], currents less than 0.1 m / s are considered very weak currents, while current speeds of 0.1-1 m / s are classified as moderate current speeds, current speeds > 1 m / s are classified as high current velocities. Therefore, the current speed of the Citanduy River is in the medium category.

The lowest average BOD_5 concentration at station 1 was 11.63 ± 3.46 mg / L and the highest average BOD_5 concentration at station 4 was 26.23 ± 3.47 mg / L. The lowest BOD_5 value at station 1 was because this research station is a part of the river that has not received anthropogenic waste input into the river body. According to Effendi [11] domestic and industrial wastes that enter the water bodies can also affect the BOD value. Meanwhile, station 4 is a river that has been exposed to various kinds of waste inputs such as agricultural, industrial, and residential wastes so that the BOD_5 concentration at this research station is the highest. Based on PP No. 82 of 2001, all research stations on the Citanduy River do not comply with class II and class III water quality standards, BOD_5 of all research stations exceeded the normal limit of water quality standards with a maximum BOD_5 limit of 10 mg / L. However, according to Lee et al. [13] criteria for the level of water pollution based on the BOD value are divided into 4, that is not polluted <3.0 mg / L, lightly polluted 3.0 - 4.9 mg / L, moderately polluted 4.9 - 15.0 mg / L, and heavily polluted> 15.0 mg / L, this indicates that the waters of the Citanduy River at station 1 are classified as moderate and station 2 to station 4 have been heavily polluted.

The lowest average dissolved oxygen at station 1 was 6.18 ± 0.24 mg / L and the highest average dissolved oxygen at station 4 was 6.57 ± 0.52 mg / L. At stations 2 and 3, the average dissolved oxygen is 6.50 ± 0.65 mg / L and 6.20 ± 0.37 mg / L. Dissolved oxygen levels at the four research stations are still classified as good for planktonic life, according to Wardoyo [14] good oxygen levels for aquatic organisms range from 2-10 mg / L and according to Wijayanti [12] plankton can live well at higher oxygen concentrations. Than 3 mg / L. While the range of dissolved oxygen values suitable for fishery activities according to the Government Regulation of the Republic of Indonesia No. 82 of 2001, which ranges from> 3 - 4 mg / L, so it can be concluded that the dissolved oxygen levels in the Citanduy River are following the class II and class III categories.

The lowest average dissolved carbon dioxide concentration at station 1 was 10.48 ± 3.51 mg / L and the highest average dissolved carbon dioxide concentration at station 2 was 14.67 ± 4.39 mg / L. At stations 3 and 4 the average carbon dioxide concentrations were 11.17 ± 2.16 mg / L and 13.27 ± 3.15 mg / L. Dissolved carbon dioxide concentrations at the four research stations are classified as good for plankton life. According to Barus [15], the optimum concentration of dissolved carbon dioxide for plankton life is 12 mg / L, so that aquatic life is not disturbed and the photosynthetic process can run smoothly. Phytoplankton is primary producers

in aquatic ecosystems that are highly dependent on dissolved carbon dioxide in the waters.

The lowest average pH value at station 4 is 7.33 ± 0.17 and the highest average pH value at station 2 is 7.76 ± 0.14. At stations 1 and 3, the average pH is 7.70 ± 0.07 and 7.45 ± 0.22. This value illustrates that the waters are in good condition for plankton growth because they are at a pH that is close to neutral and tends to be alkaline. According to Effendi [11], aquatic organisms can grow in a pH range of 7-8.5, and a pH value range that is suitable for fisheries activities according to the Government Regulation of the Republic of Indonesia No. 82 of 2001, which ranges from 6.00 - 9.00. Therefore, the pH conditions at each research station are classified as good for plankton growth. Water conditions that are very acidic or very alkaline will cause metabolic and respiration disorders [15].

The lowest average nitrate concentration value at station 1 is 0.193 ± 0.007 mg / L, and at station 4 the highest average nitrate concentration value is 0.214 ± 0.014 mg / L. At stations 2 and 3, the average nitrate concentrations were 0.200 ± 0.012 mg / L and 0.213 ± 0.008 mg / L. According to PP. 82 of 2001, polluted water has nitrate concentrations of up to 10 mg / L, this indicates that all research stations are still following quality standards. Sepriani et al. [16] stated that if the nitrate level in water is high or more than 0.2 mg / L, it can result in eutrophication which can stimulate the rapid growth of phytoplankton (blooming).

The research station with the lowest average ammonia concentration was at station 1 of 0.004 ± 0.002 mg / L and the research station with the highest average ammonia concentration was at station 2 of 0.006 ± 0.002 mg / L. The level of ammonia concentration in the Citanduy River is in a low condition because the value is far from the maximum limit, according to PP. 82 of 2001 the maximum limit of NH3 is 0.5 mg / L. This is confirmed by Mitsch and Gosselink [17], who state that at levels above 0.5 mg / L, ammonia has very high toxicity to plankton.

The research station with the lowest average phosphate concentration at station 1 was 0.188 ± 0.008 mg / L and the highest average phosphate concentration at station 2 was 0.221 ± 0.004 mg / L. At stations 3 and 4, the average phosphate concentration was 0.197 ± 0.013 mg / L and 0.200 ± 0.010 mg / L. The results of the phosphate concentration are at the limit when referring to PP. 82 of 2001, however, the range of average phosphate concentrations in the waters of the Citanduy River is still within limits that can be tolerated by phytoplankton. The optimal phosphate concentration for phytoplankton growth is in the range of 0.27 - 5.51 mg / L, while the phosphate content of less than 0.02 mg / L will be a limiting factor [18]. Overall, Citanduy River waters are included in the eutropic category when referring to the phosphate content in the waters.

3.2 Plankton Community Structure

The composition of plankton in the Citanduy River consists of 67 genera consisting of 57 genera of phytoplankton and 10 genera of zooplankton. The composition of phytoplankton in the Citanduy River consists of classes Bacillariophyceae, Chlorophyceae, Cyanophyceae, Zygnematophyceae, Euglenophyceae, Trebouxiophyceae, and Xanthophyceae. The composition of phytoplankton obtained at station 1 consisted of 51 phytoplankton genera, the highest percentage composition value was in the Bacillariophyceae class with an average abundance of 909 ind / L. The genus that dominates at station 1 with the highest average abundance is Cyclotella, amounting to 328 ind / L. The composition of the phytoplankton obtained at station 2 consisted of 50 phytoplankton genera, the highest percentage composition value was in the Bacillariophyceae class with an average abundance of 1,681 ind / L. The genus that dominates at station 2 with the highest average abundance is Cyclotella with a total of 616 ind / L. The composition of phytoplankton obtained at station 3 consisted of 52 phytoplankton genera, the highest percentage composition value was in the Bacillariophyceae class with an average abundance of 2,270 ind / L. The genus that dominates at station 3 with the highest average abundance is Cyclotella with a total of 1,166 ind / L. Station 1,2 and 3 dominate the same class and genus, namely the Bacillariophyceae class and the Cyclotella genus. According to Vuuren [19], the genus Cyclotella is a planktonic diatom that is common throughout the world and is widespread in lakes, rivers, seas, and brackish water.

Table 1. Water quality at study station

Parameter	Unit		Station			
			1	2	3	4
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
Temperature	^{o}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
Current	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
BOD_5	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
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
CO_2	mg / L	Average	10.48 ± 3.51	14.67 ± 4.39	11.17 ± 2.16	13.27 ± 3.15
		Range	8.38-16.76	8.38-20.95	8,38-12,57	8.38-16.76
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
Nitrate	mg / L	Average	0.193 ± 0.007	0.200 ± 0.012	0.213 ± 0.008	0.214 ± 0.014
		Range	0.185-0.203	0.189-0.218	0.199-0.219	0.196-0.227
Ammonia	mg / L	Average	0.004 ± 0.002	0.006 ± 0.002	0.005 ± 0.002	0.006 ± 0.002
		Range	0.002-0.007	0.004-0.009	0.002-0.008	0.003-0.009
Phosphate	mg / L	Average	0.188 ± 0.008	0.221 ± 0.004	0.197 ± 0.013	0.200 ± 0.010
		Range	0.179-0.197	0.217-0.226	0.182-0,213	0.19-0.217

Table 2. Average of plankton abundance (Ind / L)

Class	Observation Station			
	1	2	3	4
Phytoplankton				
Bacillariophyceae	909	1682	2270	912
Chlorophyceae	524	1353	1247	647
Cyanophyceae	122	303	254	234
Zygnematophyceae	61	236	177	229
Euglenophyceae	38	66	97	47
Trebouxiophyceae	27	28	19	25
Xanthophyceae	1	14	8	7
Sub-Total	1681	3682	4071	2100
Zooplankton				
Monogononta	3	12	16	12
Tubulinea	10	53	62	60
Imbricatea	9	18	18	10
Maxillopoda	0	1	1	0
Magnoliopsida	0	0	1	0
Oligohymenophorea	2	1	3	3
Sub-Total	24	85	101	85
Total	1705	3767	4172	2185

The identification results of the phytoplankton composition obtained at station 4 consisted of 45 phytoplankton genera, the highest percentage composition value was in the Bacillariophyceae class with an average abundance of 912 ind / L. The genus that dominates at station 4 with the highest average abundance is Scenedesmus, amounting to 275 ind / L. The Bacillariophyceae class has the most composition in each research station. According to Welch [20], the presence of the Bacillariophyceae class in waters often dominates and its abundance is very large, this happens because the body is covered with silica so that it has better survival than other phytoplankton classes.

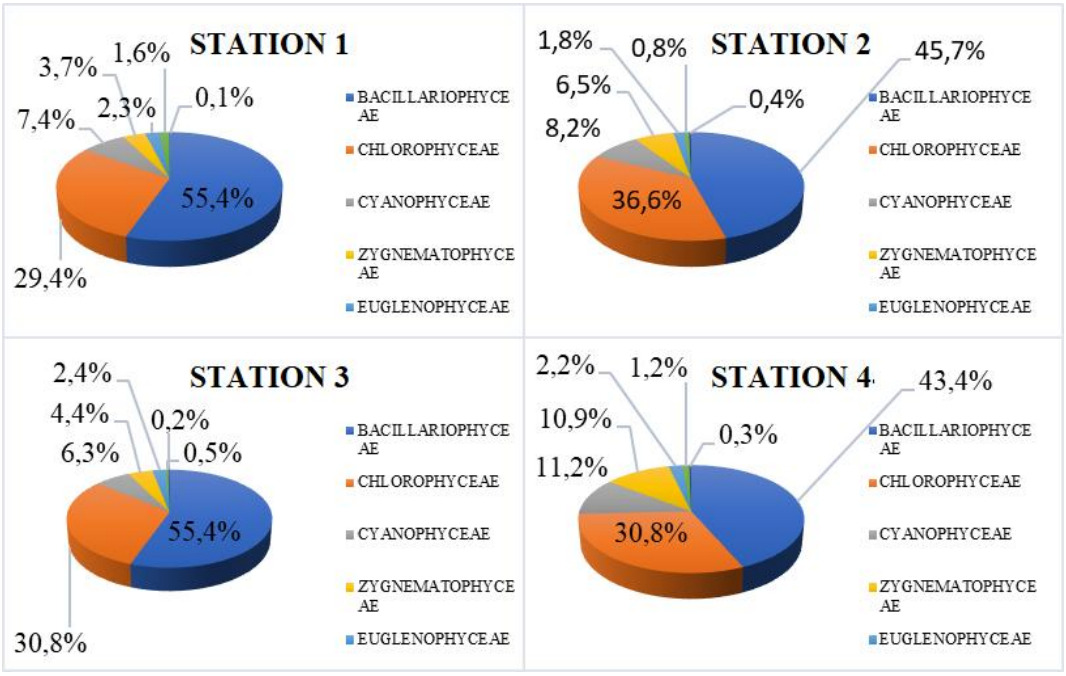

Fig. 2. Phytoplankton composition based on class

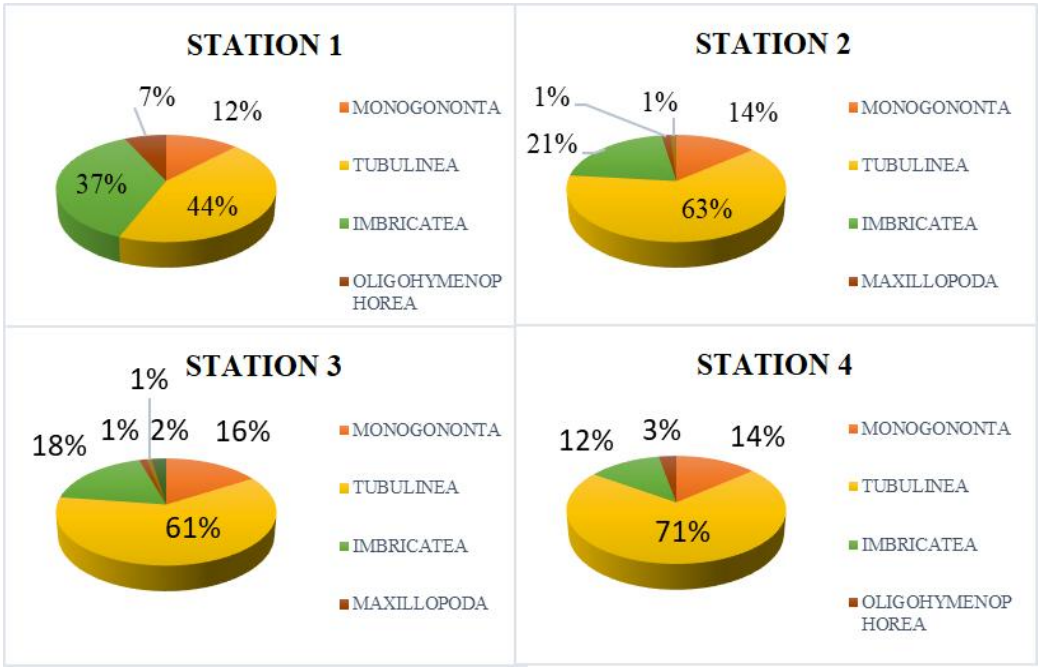

Fig. 3. Zooplankton composition based on class

The composition of zooplankton in the Citanduy River consists of the Monogononta, Tubulinea, Imbricatea, Maxillopoda, Magnoliopsida, and Oligohymenophorea classes. The zooplankton composition obtained at station 1 consists of 5 genera, station 2 consists of 8 genera, station 3 consists of 9 genera, station 4 consists of 7 genera. The percentage of zooplankton at station 1 to station 4 is mostly found in the Tubulinea class of the genus Difflugia, which is zooplankton from the phylum Rhizopoda. The phylum Rhizopoda has a better ability to tolerate

environmental conditions than other phyla. This is confirmed by Widyarini et al. [21], which states that Rhizopoda can defend itself against bad environments, and can utilize organic materials as food ingredients.

The lowest average plankton abundance at station 1 was 1,705 ind / L, because the research station had low concentrations of nitrate, phosphate, and ammonia. Station 1 is an area without human activity, so it receives little nutritional input from outside which will affect the nutrient content for plankton growth in these waters. The highest average plankton abundance at station 3 is 4,172 ind / L with the most common phytoplankton class being the Bacillariophyceae class, this is due to the presence of nutrients obtained from the tofu industrial wastewater, and also due to the influence of domestic waste and the activities of the incoming toilet to the river, thus affecting the high abundance of Bacillariophyceae at station 3. Zooplankton identified during research have an average abundance less than phytoplankton, although zooplankton eats phytoplankton to reach an abundant population, it takes longer than phytoplankton. The existence of lower zooplankton is a natural condition as a group of organisms that are at a trophic level above phytoplankton [22].

The abundance of plankton in the Citanduy River shows that these waters are classified as oligotrophic waters for station 1 and mesotrophic waters for stations 2,3 and 4. According to Landner [23], oligotrophic waters are waters with low fertility levels with an abundance of phytoplankton ranging from 0 - 2,000 individuals/liter, mesotrophic waters are waters with moderate fertility levels with an abundance of phytoplankton ranging from 2,000 - 15,000 individuals/liter, and eutrophic with plankton abundance levels of more than 15,000 individuals/liter.

The average value of the phytoplankton diversity index at station 1 to station 4 belongs to the high diversity category, with the highest value at station 4 of 0.92. This shows that the distribution of phytoplankton at each research station is evenly distributed, and the stability of the aquatic ecosystem is said to be good. According to Odum [6], the value of the Simpson diversity index ranges from 0-1. If the index value is close to 1, the distribution of individuals is evenly distributed, and the stability of the aquatic ecosystem can be said to be good. The average value of the zooplankton diversity index ranges from 0.51 to 0.63. The average value of the zooplankton diversity index at station 1 to station 4 belongs to the medium diversity category, with the lowest value at station 4 of 0.51. According to Sirait et al. [24].

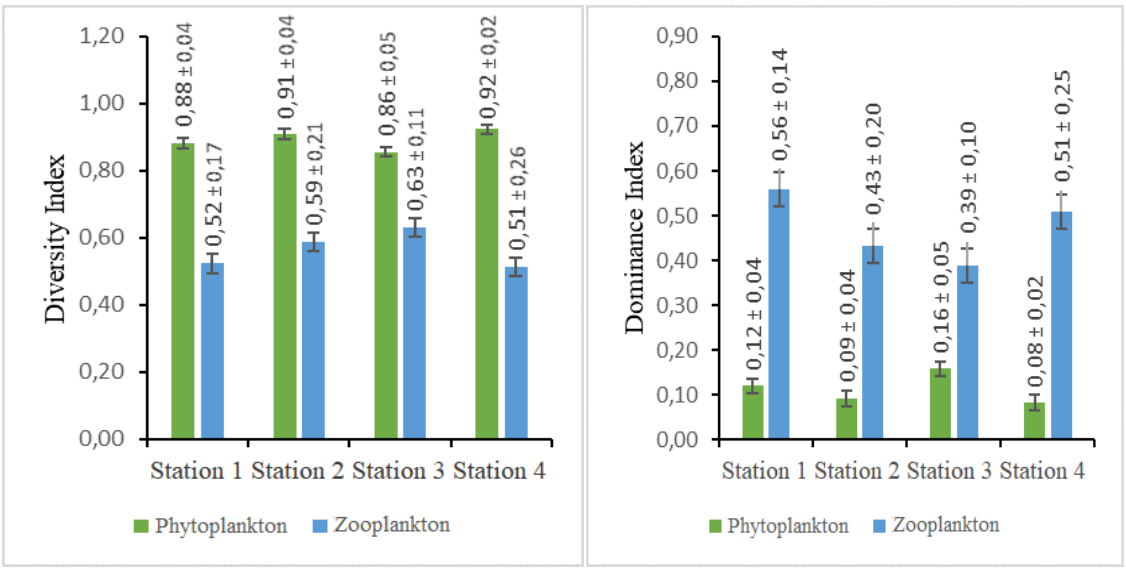

Fig. 4. Plankton diversity and dominance index

The average value of the phytoplankton dominance index ranges from 0.08 to 0.16 with the lowest dominance index value found at station 4 of 0.08, this indicates that the dominance of phytoplankton in the waters of the Citanduy River is low and no genus dominates at station 1 to station 4. While the average value of the zooplankton dominance index ranges from 0.39 to 0.56 with the highest dominance value is at station 1 of 0.56, which indicates that zooplankton dominance is moderate and some species dominate in the waters. Citanduy River. According to Dhahiyat et al. [25], if the dominance value ranges from 0.0-0.30, it indicates low dominance, 0.30-0.60 moderate dominance, and 0.60-1.00 high dominance.

4. CONCLUSION

The spatial distribution of plankton in the Citanduy River varies at each observation location. Based on the results obtained, the identified plankton were 57 genera of phytoplankton and 10 genera of zooplankton. The highest abundance of phytoplankton genus was genus Cyclotella from Bacillariophyceae class with an average of 1,165 ind / L and the highest abundance of zooplankton genus was the Difflugia genus of the Tubulinea class with an average of 53 ind / L. The results of the plankton spatial distribution show that the fertility of the waters in the Citanduy River is classified as oligotrophic for station 1 and the mesotrophic water category for stations 2,3, and 4.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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