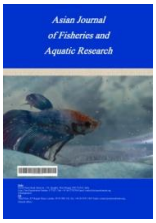

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Spatial Distribution of Plankton in Cikeruh River, Jatinangor District, West Java Province, Indonesia

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Authors' contributions

This work was carried out in collaboration with all authors. Author FU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ZH and AR 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

Cikeruh River is a Citarum tributary that has received a lot of waste inputs, so that will affect the quality of river water and cause differences in aquatic fertility. Aquatic fertility can be determined by calculating plankton abundance and distribution. The purpose of this study was to map the spatial distribution of plankton along the Cikeruh River. The study was conducted in June 2019 to August 2019 at five stations with the purposive sampling method. The parameters observed were physical and chemical parameters of waters, plankton abundance, diversity index, dominance index, species deficit, and Morisita index. The results showed that plankton was identified as many as 33 phytoplankton genera and six zooplankton genera, the spatial distribution of plankton in the Cikeruh River was different at each station, at station 1 consisted of 14 phytoplankton genera, station 2 27 phytoplankton genera, station 3 24 phytoplankton genera, station 4 25 phytoplankton genera, and at station 5 was found 22 phytoplankton genera. The abundance of plankton obtained ranges from 1823-5972 ind/L. Phytoplankton diversity index obtained from ranges 0.71-0.84, while the zooplankton ranges 0.17-0.32 with phytoplankton dominance index 0.16-0.35 and zooplankton 0.68-0.83. Phytoplankton morisita

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index obtained from ranges 1.37-2.17, while the zooplankton ranges 1.03-2.31. Physical-chemical parameters observed as follows: Temperature 18.58ºC – 27.77ºC, light transparency 16,68 cm - 31.92 cm, current 0.17 m/s -0.35 m/s, DO 3.35-8.05 mg/L, CO_2 8.36 -37.05 mg/L, pH 7.53 – 8.66, BOD_5 10.83 - 25.42 mg/L, Nitrate 0.18-0.26 mg/L, phosphate 0.18-0.26. The physical and chemical parameters qualify for Indonesian Government Regulation No. 82 of 2001 class II and III.

Keywords: Cikeruh; distribution; plankton; phytoplankton; zooplankton.

1. INTRODUCTION

Citarum River is now one of the rivers with the worst pollution levels in the world [1]. The pollution load comes from activities around the river flow and also input from Citarum tributaries. One of the 36 tributaries of the Citarum River is the Cikeruh River [2]. The condition of the Cikeruh River in the past 20 years has undergone many changes, this is caused by changes in land use around the Cikeruh River, particularly the increased use of residential or residential land and buildings which results in an increase in the rate of erosion and sedimentation rates in the river so that cause a decrease in water quality [2].

The amount of waste discharged into the Cikeruh River comes from different sources of waste input, which are agricultural waste, industrial waste, and domestic waste. The waste discharged directly into the river flow without prior treatment so the river water becomes polluted and affects the water quality of each river flow which causes differences in aquatic fertility. Aquatic fertility can be known by calculating the abundance and distribution of plankton. Phytoplankton is the first organism affected due to the input load received by the waters. This because phytoplankton is organisms that make direct use of the input load [3]. Phytoplankton constitutes the base of the aquatic food chain, producing organic and inorganic substances through carbon dioxide and photosynthesis. However, their composition, distribution, and abundance are largely influenced by various environmental factors from physical, biological and chemical changes. These factors include; pollution, urbanization, industrialization, anthropogenic activities, climate change, etc [4]. Pollution can change the structure of an ecosystem and can reduce the number of species in a community so that its diversity will decrease. Thus the diversity index of the polluted ecosystem is always smaller than the natural ecosystem [5].

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out on the Cikeruh River, jatinangor district, sumedang regency, west java. The method used in this study was purposive sampling. The study area falls within coordinates 06°53'22"and 06°57'22.9" SL 107 °45'51.9" and 107 °46'00.2" EL. The sampling station was divided into 5 stations such as 1, 2,3,4, and 5 (Fig. 1). Distribution of locations is distinguished based on the type of waste that enters the Cikeruh River.

- station 1, upstream of the Cikeruh River is in kiara payung conservation forest area
- station 2, part of the river that is indicated to get inputs from agricultural waste
- station 3, part of the river that gets input from waste from the tofu industry
- station 4, the part of the river that is indicated to get domestic waste input because the surrounding land use is a residential area.
- station 5, accumulation of various pollutant inputs from activities along the Cikeruh River.

2.2 Sampling and Measurement

Water sample for Physical-chemical waters analysis taken once every seven days for six weeks using a 1L sampling bottle and transported in coolbox to the laboratory for analyzing Physical-chemical parameters of waters analysis consisted of nine parameters that include temperature, light transparency, current, DO, CO_2, pH, BOD_5, Nitrate, and phosphate. Physical-chemical parameters analyzed in-situ and ex-situ. Ex situ analysis conducted at the Laboratory of Water Resource Management FPIK UNPAD.

2.3 Sampling of Plankton

Phytoplankton samples were taken by filtering 10 liters water using a plankton net mesh size

25 by using a bailer volume of 1L. The filtered sample water is put in a 50 ml sample bottle and preserved using Lugol 1% preservative of 10-15 drops or until colored tea. The plankton composition identified was calculated based on the number of genera for each type and list compilation according to the results of plankton identification up to the genera lev.

2.4 Sample Analysis

Data obtained from the study results were analyzed using comparative descriptive methods by comparing test parameters from upstream to downstream stations, and compared with applicable quality standards by the Indonesian Government Regulation No. 82 of 2001 on water quality management and water pollution control [6].

2.4.1 Plankton abundance

Plankton abundance is calculated quantitatively based on the abundance expressed in ind/L. Plankton abundance is calculated using the Sachlan modification formula.

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

Information:

N=Plankton abundance (ind/L)
n =Number of individuals or cells number-i species identified
Vs=Volume of water filtered liters (10 liters = 10.000 ml)
Vr = Volume of water filtered (50 ml)
Vo= Volume the observed sample (1 ml)

2.4.2 Diversity index

A plankton diversity index is the diversity of the genera of phytoplankton and zooplankton contained in water. The plankton diversity index can be calculated using the Simpson diversity index formula [7].

$$D = 1 - C$$

Information:

D = Simpson diversity index
C = simpson dominance index

2.4.3 Dominance index

The dominance index is used to determine the dominance of certain species in the plankton population. C values close to 0 indicate that no individual dominates. The dominance index is calculated using the Simpson dominance index formula [8].

$$D = \sum Pi^2$$

$$Pi = ni/N$$

Information:

D = Simpson dominance index
Ni = the number of individuals/cell number-i species which chopped up

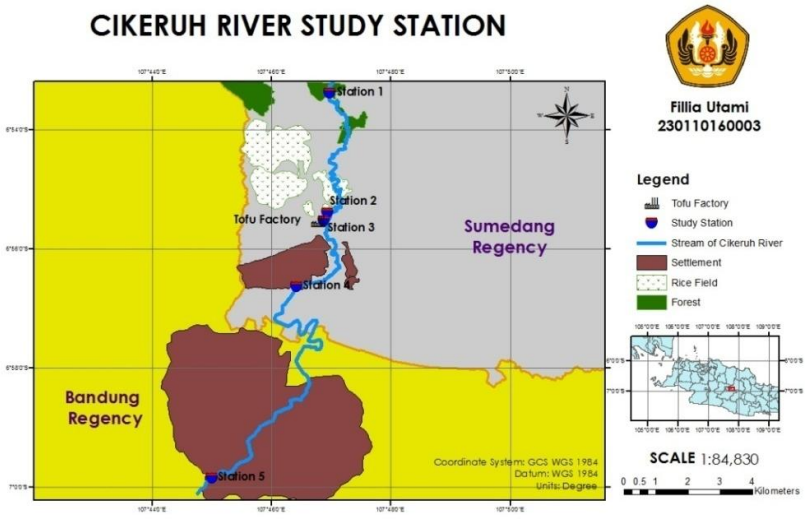

Fig. 1. Map of study location

2.4.4 Species deficit

Species deficit is a comparison of plankton abundance by looking at the comparison of the number of genera abundances at stations downstream with upstream.

$$I = \{(Su-Sd) / Su\} \times 100$$

Information:

I = Species deficit
Su = Number of genera upstream
Sd = Number of genera downstream.

2.4.5 Morisita index

The morisita index is an index used to determine the distribution pattern. This index is not affected by the sampling station area and is very good for comparing population distribution patterns

$$Id = n\sum xi^2 - N / N(N-1)$$

Information:

N = the sum of all individual organisms
n = number of sampling units
Xi^2 = the square of the number of individuals of a station

Criteria for Morisita index are as follows:

id = 1; random distribution patterns;
id < 1; uniform distribution patterns;
id > 1; group distribution patterns.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Parameters of Water

The physical and chemical parameters of water are presented in Table 1. The water temperature at station 5 is higher this is because when sampling at station 5 is conducted during the daytime at 14.00, so the light transparency is already high which results in the temperature at station 5 being hotter, the temperature difference in the Cikeruh River obtained also due to the influence of tofu liquid waste at station 3 and textile industry waste at station 5 that goes into the river. The temperature pattern of river ecosystems is influenced by various factors such as the intensity of sunlight, heat exchange between water and the surrounding air, geographical height, the canopy factor (vegetation closure) of trees growing on the edge of the water, and wastewater (sewage) that goes into the water body [7,9].

The highest light transparency in Cikeruh River is 31.92 cm at station 2 and the lowest is 16.68 cm at station 1, this is because the area at Station 2 is very open and no canopy blocks the entry of sunlight to the station unlike station 1, there are many trees around it and the width of the water is smaller than Station 2, but also because of the sampling at Station 1 conducted in the morning so that the transparency of incoming light is low.

The result of the current measurement during the study ranged from 0.17–0.35 m/s. Currents less than 0.1 m/s include very weak current speeds, while current speeds of 0.1-1 m/s are classified as moderate current speeds, current speeds> 1 m / s are classified as strong current speeds [10]. Thus the speed of the Cikeruh River flow with the results obtained is classified as a river with a moderate current that is due to many large rocks and has a different type of river base which is a barrier to the river flow.

The result of Do measurement ranged from 3.35 – 8.05 mg/L, these conditions are optimal for plankton life. Phytoplankton and zooplankton can live optimally at DO concentrations above 3 mg/L [10]. The range of DO values appropriate for fisheries according to Indonesian Government Regulation No. 82 of 2001 which ranged from > 3-4 mg /L.

The highest concentration of dissolved carbon dioxide is found in station 5, which is 37.05 mg/L, indicating that the waters of station 5 have been polluted and the station with the lowest carbon dioxide concentration is station 1 at 8.36 mg/L, the low concentration of carbon dioxide is because station 1 is the area without the presence of human activities thus receive little input from outside nutrients that affect the nutrient content at this station.

The result of pH measurement ranged from 7.53-8.66 and the condition was ideal for freshwater biota including plankton and still comply with the water quality criteria for fisheries according to Indonesian Government Regulation No. 82 of 2001 which is between 6.00 - 9.00. Aquatic organisms, especially plankton, can live ideally in a smaller pH range or slightly larger than a pH value of 7 [7].

Table 1. Water quality at study station

Parameters		Station				
		1	2	3	4	5
Temperature	Average	18,58±0,73	24,23±0,76	25,70±2,08	26,57±1,23	27,77±1,30
	Range	17,5-19,6	23,4-25,2	23,7-29,5	25,1-28,40	25,8-29,4
Light transparency	Average	16,68±1,40	31,92±8,04	30,33±7,4	18,57±4,06	17,95±2,40
	Range	14,4-18	25-46	24-47	15-26	15-20
Current	Average	0,25±0,16	0,32±0,11	0,35±0,07	0,23±0,03	0,17±0,03
	Range	0,14-0,57	0,24-0,53	0,25-0,44	0,17-0,26	0,12-0,21
DO	Average	7,92±0,53	8,05±0,60	7,38±0,40	6,15±0,62	3,35±1,39
	Range	7,2-8,6	7,3-9,1	6,9-7,8	5,5-6,8	2-5,2
CO_2	Average	8,36±0,00	10,48±2,32	11,19±2,19	20,99±7,53	37,05±11,35
	Range	8,36	8,36-12,6	8,36-12,6	8,36-29,4	16,8-50,2
pH	Average	7,81±0,24	8,66±1,35	7,67±1,14	7,86±0,65	7,53±0,35
	Range	7,47-8,10	7,89-11,4	5,43-8,47	7,31-9,12	7,21-8,20
BOD_5	Average	10,83±2,21	18,66±3,16	18,68±3.08	16,77±1,69	25,42±3,81
	Range	8,15-14,6	15-24	16,25-24,3	14,6-19,5	21,1-30,85
Nitrate	Average	0,19±0,04	0,20±0,05	0,26±0,05	0,18±0,02	0,22±0,05
	Range	0,18-0,30	0,14-0,26	0,19-0,32	0,17-0,21	0,16-0,25
Phosphate	Average	0,18±0,01	0,19±0,01	0,19±0,01	0,19±0,02	0,26±0,06
	Range	0,17-0,20	0,18-0,20	0,17-0,21	0,16-0,22	0,21-0,38

The range of BOD_5 value in the Cikeruh River is 10.83-25.42 mg/L. The highest BOD_5 concentration is at station 5, this is due to the existence of human activities that carry out agricultural activities, household waste, and the textile industry. The lowest BOD_5 concentration is at station 1 due to the lack of waste and the absence of human activity. According to Indonesian Government Regulation No. 82 of 2001all stations do not comply with class II and class III water quality standards and according to Minister of Environment Decree No. 51 of 2004 all stations also exceed normal water quality standards with a maximum BOD_5 limit of 10 mg/L.

The station with the highest nitrate concentration is station 3 at 0.26 mg/L, this is presumably because station 3 receives input of tofu liquid waste that has high organic matter. Tofu industry liquid waste contains high organic ingredients, especially protein and amino acids. The presence of these organic compounds causes tofu liquid waste containing high BOD, COD, and TSS [11]. Based on the measurement results, the Cikeruh River meets the requirements for class II and III water quality standards according to Indonesian Government Regulation No. 82 of 2001 which stipulates that concentrations of nitrate for class II and class III quality standards are respectively not more than 10 mg/L and 20 mg/L.

The result of phosphate measurement range from 0.18 – 0.26 mg/L, these conditions are optimal for plankton life. Optimal phosphate concentrations for phytoplankton growth are in the rage of 0.27 - 5.51 mg/L, whereas phosphate content of less than 0.02 mg/L will be a limiting factor [12]. Indonesian Government Regulation No. 82 of 2001 Class III states that the threshold values of phosphate in the water are equal to 1 mg/L.

3.2 Plankton Community Structure

Plankton compositions obtained during the study in Cikeruh River consisted of 39 genera of plankton consisting of 33 genera of phytoplankton and six genera of zooplankton. Phytoplankton consists of four phylum and five classes, zooplankton consists of two phylum and Five classes.

The percentage of phytoplankton at stations 1,2,3 and 4 were found in phytoplankton from the Bacillariophyceae and Chlorophyceae classes (Fig. 2). Phytoplankton groups that dominate freshwater generally consist of Bacillariophyceae and Chlorophyceae. Both phylum has a good ability to adapt to the environment and multiply rapidly [13] , while the percentage of phytoplankton composition at station 5 is found in phytoplankton from the Euglenophyceae and Cyanophyceae classes (Fig. 2). Euglenophyceae

generally live in waters that contain a lot of organic matter so that it can be used as an indicator of polluted waters [14].

The results of identification of phytoplankton composition obtained at station 1 consisted of 14 phytoplankton genera, the genera that dominated at station 1 with the highest average abundance was Surirella for 465 ind/L. At Station 2, 27 genera of phytoplankton were found. The genera that dominate at station 2 with the highest average abundance was Gyrosigma 1,370 ind/L. Station 3 has a similar composition to station 2 which consists of 24 genera of phytoplankton with the dominance of the same species which is gyrosigma 755 ind/L. At station 4 found 25 phytoplankton genera with genera that dominate at station 4 was Cyclotella with an average abundance of 3,670 ind/L. While at 5 found 22 phytoplankton genera with genera that dominate at station 5 was Euglena with an average abundance of 1,375 ind/L.

Percentage of zooplankton at stations 1,2,3 and 4 were most commonly found in zooplankton from the Lobosa genera Arcella class (Fig. 3), which is also zooplankton from the phylum of protozoa. While at station 5 zooplankton is found from the class Nassophorea genera Cilliata (Fig. 3) which is also zooplankton from protozoa phylum. Protozoa are found in freshwaters that contain lots of organic matter [15]. Arcella lives free in freshwaters and has the ability to defend itself against worsening environmental conditions, namely by forming cysts that are resistant to drought, cold, or heat [16]. Cilliata very easy to adapt to the aquatic environment even though it is polluted, even some members of this class live in dirty waters [15].

The abundance of phytoplankton during the study ranged from 1665 ind-5960 ind/l, while the abundance of zooplankton during the study ranged from 112-302 ind/l. The highest abundance value is at station 4, this is because of the nutrients obtained from tofu industrial wastewater at station 3 carried by the flow to station 4 because station 3 has a greater current speed compared to other stations. Plankton abundance has various values, this is caused by differences in the concentration of nitrate and phosphate at each station, nitrate, and phosphate needed by aquatic organisms such as phytoplankton so that the low nitrate and phosphate content in water can affect the abundance of phytoplankton [17].

Phytoplankton diversity index in the cikeruh river ranged from 0.65-0.84, while for zooplankton diversity index ranged from 0.17-0.32 with an average value of phytoplankton dominance index ranging from 0.16-0.35 while the average value average zooplankton dominance index ranges from 0.68-0.83 (Fig. 4). This shows if the distribution of phytoplankton at each station is evenly distributed there is no species that dominates, and the stability of the aquatic ecosystem is said to be good, while the zooplankton has a low diversity index with a high dominance index so there are species that dominate. The imbalance of the ratio of N and P in waters will affect the biological condition of the ecosystem such as phytoplankton biomass,

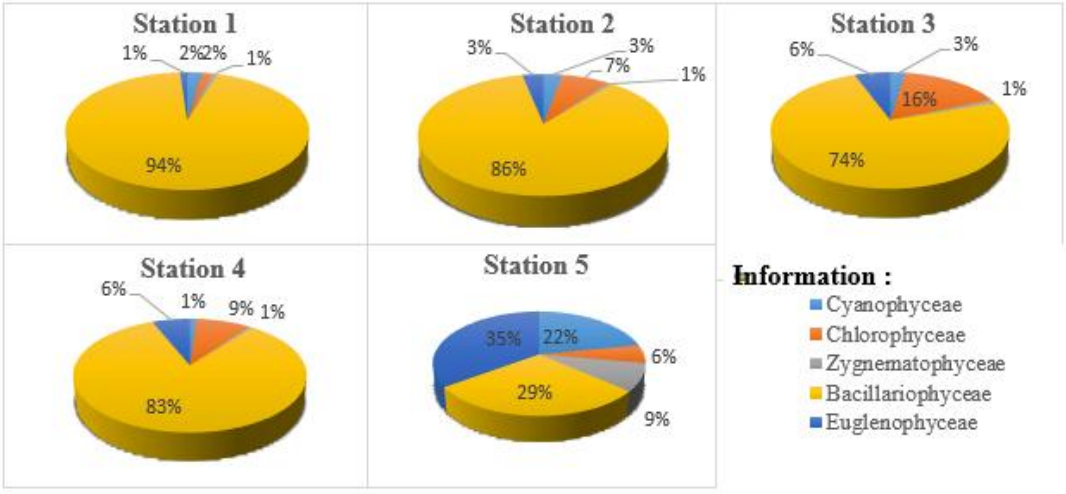

Fig. 2. Phytoplankton composition based on class

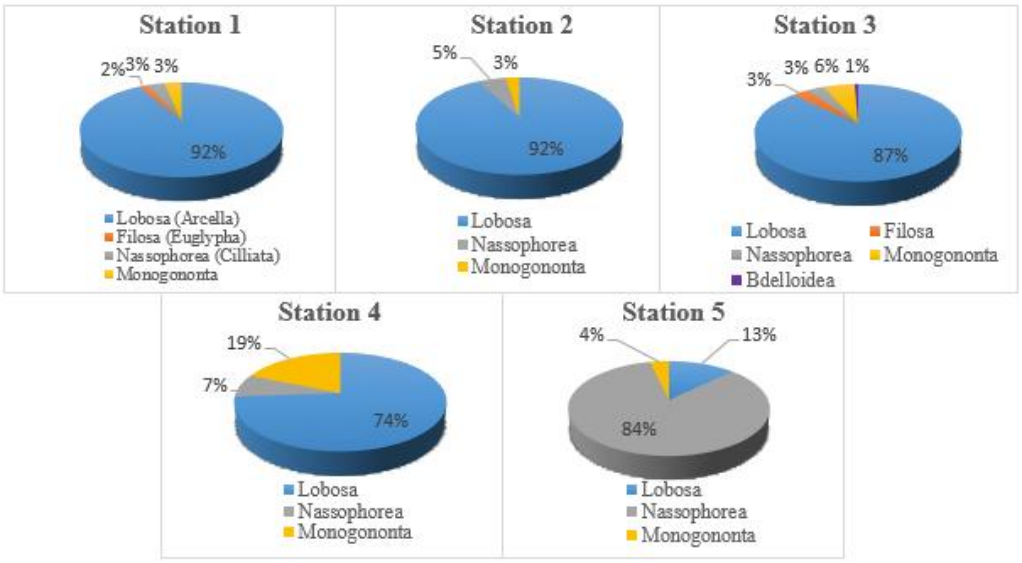

Fig. 3. Zooplankton composition based on class

species composition is likely to occur dominance species certain types and also on the dynamics of food [9].

The comparative value of the percentage of station 1 and station 3 has the greatest of genera found in almost every observation (Table 3), this is presumably caused by station 3 receiving input from the tofu industry. The waste from the tofu industry contains organic compounds that are used by plankton as a food source [18]. The impact of the current of tofu waste carried by the flow can be seen at station 4 and station 5 which have decreased the number of plankton genera. The reduced genera at station 4 and station 5 due to unfavorable marine environmental conditions can be seen from the low do values, and high BOD_5 values (Table 1). Excessive loads of decomposed organic matter usually cause damage to the aquatic environment, as indicated by the incomplete genera found.

Phytoplankton Morisita index at all research stations ranges from 1.37 to 2.17 zooplankton ranging from 1.03 to 2.31, which indicates that phytoplankton and zooplankton in cikeruh river

Table 2. Plankton average abundance (ind / L)

Class	Station				
	1	2	3	4	5
Phytoplankton					
Cyanophyceae	29	95	68	63	833
Chlorophyceae	19	243	437	526	244
Zygnematophyceae	10	23	29	33	388
Bacillariophyceae	1157	2842	2010	4873	1153
Euglenophyceae	14	108	156	366	1398
Subtotal	1665	3310	2699	5860	4066
Zooplankton					
Lobosa	140	120	113	83	38
Filosa	3	-	4	-	-
Nassophorea	5	7	4	8	253
Monogononta	5	3	8	21	11
Bdelloidea	5	-	5	-	-
Subtotal	158	130	134	112	302
Total	1823	3440	2833	5972	4367

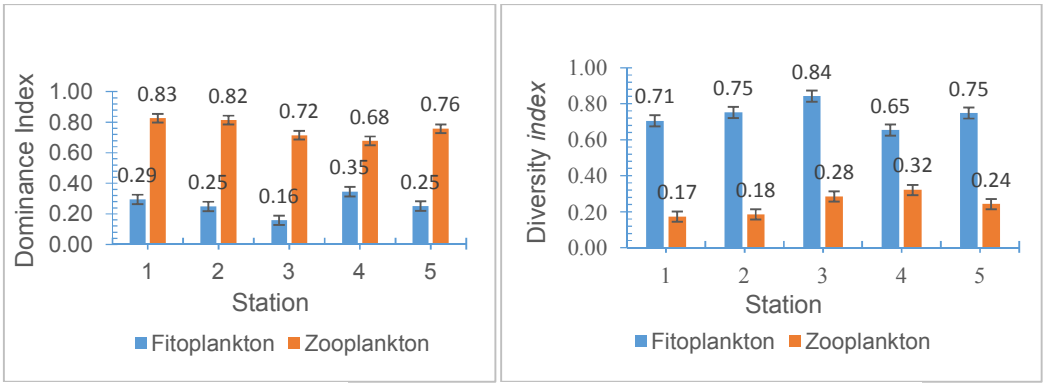

Fig. 4. Plankton diversity and dominance index

Tabel 3. Plankton deficit species

Station	Sampling						Average
	1	2	3	4	5	6	
1 and 2	-21%	-45%	-29%	-60%	-85%	-21%	-44%
1 and 3	-29%	-118%	-86%	-120%	-69%	-42%	-77%
1 and 4	7%	-27%	-43%	-120%	-38%	-32%	-42%
1 and 5	-7%	18%	-7%	-40%	-62%	-16%	-19%

Note: Value (-) the number of genera downstream is more than upstream,
Value (+) the Number of genera downstream is less than upstream

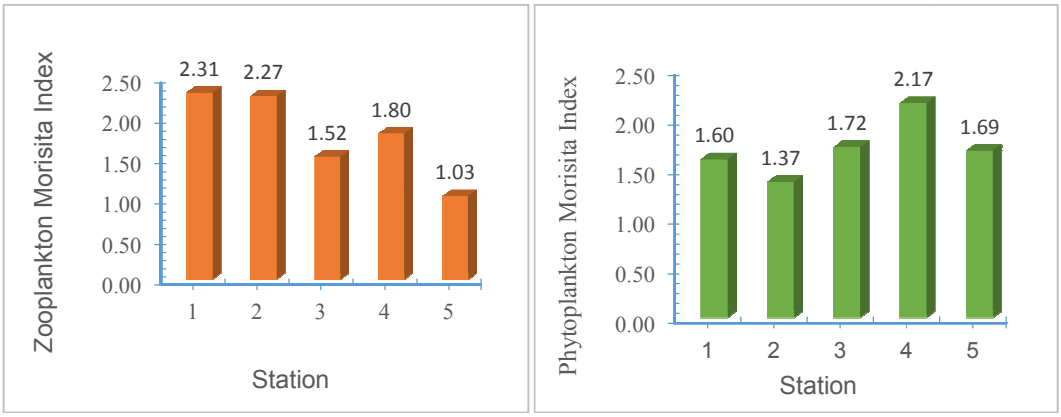

Fig. 5. Phytoplankton and zooplankton morisita index

has a group distribution pattern. The pattern of group distribution is determined by the response and adaptation patterns of organisms to changes in environmental quality, eating habits and ways of reproducing. Also besides, the way of life of groups of biota shows a strong tendency to compete with other biotas, especially in terms of food.

4. CONCLUSION

The physical and chemical parameters qualify for Indonesian Government Regulation No. 82 of 2001 class II and III. The results showed that plankton was identified as many as 33 phytoplankton genera and six zooplankton genera, the spatial distribution of plankton in the Cikeruh River was different at each station, at station 1 consisted of 14 phytoplankton genera, station 2 27 phytoplankton genera, station 3 24 phytoplankton genera, station 4 25 phytoplankton genera, and at station 5 was found 22 phytoplankton genera. Plankton distribution patterns in the Cikeruh River based on the morisita index are in groups, with high diversity in phytoplankton (D value 0.68-0.84) while

zooplankton has low diversity (D value 0.17-0.32). There was no domination of certain species at each station for phytoplankton (C value 0.16-0.35), however, zooplankton domination of the genera Arcella occurred at each station for zooplankton (0.68-0.83).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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