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PLANKTON DIVERSITY IN CIMANUK RIVER, WEST JAVA

(Keanekaragaman Plankton di Sungai Cimanuk, Jawa Barat)

Setyo Budi Susilo[2], Djadja S. Sjafei[3] and M. F. Rahardjo[3]

ABSTRACT

A study on plankton abundance and diversity was conducted in Cimanuk river in 1999/2000 from the headstream (Garut area) down to the estuary (Indramayu area). The objectives of this study were to identify some plankton community parameters and assess fertility or tropic status and pollution level of the river water based on its plankton community condition. Twelve sampling stations were chosen along the river. At each station, the water was sampled three times; which were in August, October, and January, to represent three different seasons of the year. The results of this study indicate that, in total, the number of phytoplankton genera found in Cimanuk river was 63. In addition, there are 23 genera of zooplankton constituting six classes. In term of phytoplankton composition, Cimanuk river can be assumed to not having significant pollution pressure yet. Spatially, plankton abundance in Cimanuk river follows a pattern of "low - high - low" from upstream to downstream. Seasonal difference could only be seen significantly in lower part of the river (Indramayu area). In each segment of the river, there was no obvious difference among stations. Refer to the plankton abundance, Cimanuk river can be categorized as oligotropic to mesotropic water. Analyses of diversity, similarity, and dominance indices of phytoplankton also showed that Cimanuk river has not been polluted significantly yet.

Keywords: plankton, abundance, diversity, Cimanuk river, fertility, pollution, seasonal.

ABSTRAK

Suatu studi tentang kelimpahan dan keanekaragaman plankton telah dilaksanakan di Sungai Cimanuk pada tahun 1999/2000 mulai dari hulu sungai (daerah Garut) hingga estuari (daerah Indramayu). Tujuan penelitian ini adalah untuk menilai tingkat kesuburan dan pencemaran sungai tersebut berdasarkan kondisi komunitas plankton. Dua belas stasiun pengambilan contoh dipilih di sepanjang sungai ini. Pada setiap stasiun, air sungai diambil contohnya tiga kali yaitu pada bulan Agustus, Oktober, dan Januari, untuk dapat mewakili tiga musim yang berbeda pada tahun tersebut. Hasil penelitian ini menunjukkan bahwa secara total jumlah genera fitoplankton yang ditemukan di sungai ini adalah 63 genera. Sementara itu terdapat pula 23 genera zooplankton yang termasuk dalam 6 kelas. Dilihat dari aspek komposisi fitoplankton, Sungai Cimanuk dapat dikatakan belum mendapatkan tekanan pencemaran secara nyata. Secara spasial, kelimpahan plankton di Sungai Cimanuk mengikuti pola "rendah-tinggi-rendah" dari hulu ke hilir. Perbedaan musim hanya terlihat secara nyata di bagian hilir sungai. Pada setiap bagian memanjang sungai, tidak terdapat perbedaan kelimpahan antar stasiun. Dari aspek kelimpahan plankton, Sungai Cimanuk dapat dikatogorikan sebagai perairan oligotrofik hingga mesotofik. Analisis terhadap indeks-indeks keanekaragaman, similaritas, dan dominansi fitoplankton juga menunjukkan bahwa Sungai Cimanuk belum tercemar secara nyata.

Kata kunci: plankton, kelimpahan, keanekaragaman, Sungai Cimanuk, kesuburan, pencemaran, musiman.

INTRODUCTION

Plankton is motionless tinny organism living in the water column. Plankton cannot swim or has limited ability to swim so that its movement depends on the water current. Plankton is divided into two major groups namely phytoplankton (plant) and zooplankton (animal). Plankton is the lowest organism in the tropic chain structure of aquatic environment. Phytoplankton is a primary producer in various aquatic environments due to its quantity. Therefore, plankton or phytoplankton in particular is very important organism in waters including river. The positive relationship between fish production and phytoplankton abundance has been studied intensively (Boyd, 1979).

Based on its size, plankton can be categorized into ultraplankton (diameter less than 5 μm), nanoplankton (5-60 μm), netplankton (more than 60 μm) (Reynolds, 1990). Nybakken (1992)

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classified plankton in the same base into 5 groups, which are megaplankton (more than 2 *mm*), macroplankton (0.2-2.0 *mm*), microplankton (20 *μm* - 0.2 *mm*), nanoplankton (2-20 *μm*), and ultraplankton (less than 2 *μm*) (see also Michael, 1994). Nybakken (1992) also categorized plankton into two groups based on the water current where it lives, which are limnoplankton, plankton living in stagnant water; and rheoplankton, plankton living in the flowing water. The same categorization can be found in Davis (1955). Another plankton grouping based on the environment are limnoplankton (in stagnant water), meroplankton (in flowing water), haliplankton (marine plankton), and hypalmyroplankton (plankton in brackish water).

Generally, phytoplankton is as a single cell, colony, or filamentous. Fresh water plankton generally consists of filamentous (flagellated) plankton and colonized plankton (Ruttner 1973). Fish usually does not like the filamentous plankton and therefore dominance of this type of plankton does not mean much to the fisheries (Basmi, 1987).

Plankton community determines the health of river ecosystem. Fertility or tropic status, pollution level, and stability of aquatic environment may be reflected on plankton community condition (Naulita *et al.*, 1993; Parsons *et al.*, 1984; Lewis, 1974). This study is about to show the condition of plankton community in Cimanuk river as measured in three different seasons. The objevtives of this study are to identify some plankton community parameters and assess fertility or tropic status and pollution level of the river water based on its plankton community condition.

Cimanuk is one of the six major rivers in West Java, (the others are Citarum, Ciliwung, Cisadane, Cimandiri, and Citandui), flowing from hilly area of Garut, the Cikurai mountain, passing through Sumedang and Majalengka areas, and ended in the coastal area of Indramayu (the Java Sea). The length of this river is approximately 175 km with the width varies from about 6 *m* upstream to about 150 *m* downstream. Fisheries activities has been conducted in this river for a long time. The river has given much benefit for nearby people. However, research on its plankton community and its tropic status and pollution level was still rare. This was the reason why this study was conducted.

Plankton community condition reflects the water quality condition and knowing the plankton community condition may assume the condition of water quality. This paper basically is about to infer general condition of water quality of the river based on the fact of plankton community condition. It is intended to see from the plankton community condition as a biological indicator of aquatic environmental condition. Detail relationship between plankton community and water quality parameters will not be discussed in this paper and outside the scope of this paper. Water quality condition in Cimanuk river has been reported and discussed by Susilo and Syafei (2006).

MATERIALS AND METHODS

The study was conducted from June 1999 to January 2000 in Cimanuk river, including its major tributary, Cipeles river or "Sungai Cipeles". In this study, the river basin was divided into three segments (areas) from upstream toward downstream, which were Garut area, Sumedang area, and Indramayu area. In each area, four sampling stations were chosen. The stations were named referring to the initial area names, which were G1, G2, G3, G4, S1, S2, S3, S4, I1, I2, I3, and I4. Station S2 was in the tributary and the I' stations located downstream of Rentang weir. Consequently, plankton community of the I' stations may not relate directly with that of upper stations. Figure 1 shows the locations of the stations along the river.

Some important plankton community parameters were analyzed to reflect the temporal and spatial differences. Samplings were done in August 1999 to reflect the condition of dry season, in October 1999 as a representation of transition season (early wet season), and in January 2000 as a representation of wet or rainy season. About 100 lt. water was sampled and filtered from the river using plankton net No. 25. The samples were then preserved with lugol solution for further analyses at the Laboratory of Hydrobiology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University. Plankton identification was based on Edmondson (1959) and Needham and Needham (1963).

Plankton abundance or density was calculated using the following formula:

$$N = \left(\frac{V_s}{V_a}\right)\left(\frac{O_c}{O_p}\right)\left(\frac{1}{E}\right)\left(\frac{n}{F}\right)$$

N = abundance (plankters/lt), n = calculated num-ber of plankton of all objective fields observed, V_s = volume of sample water (ml), V_a = volume of original water filtered (lt), O_c = area of cover glass (mm^2), O_p = area of objective field of microscope, E = volume of one drop of water (ml), F = number of objective fields observed.

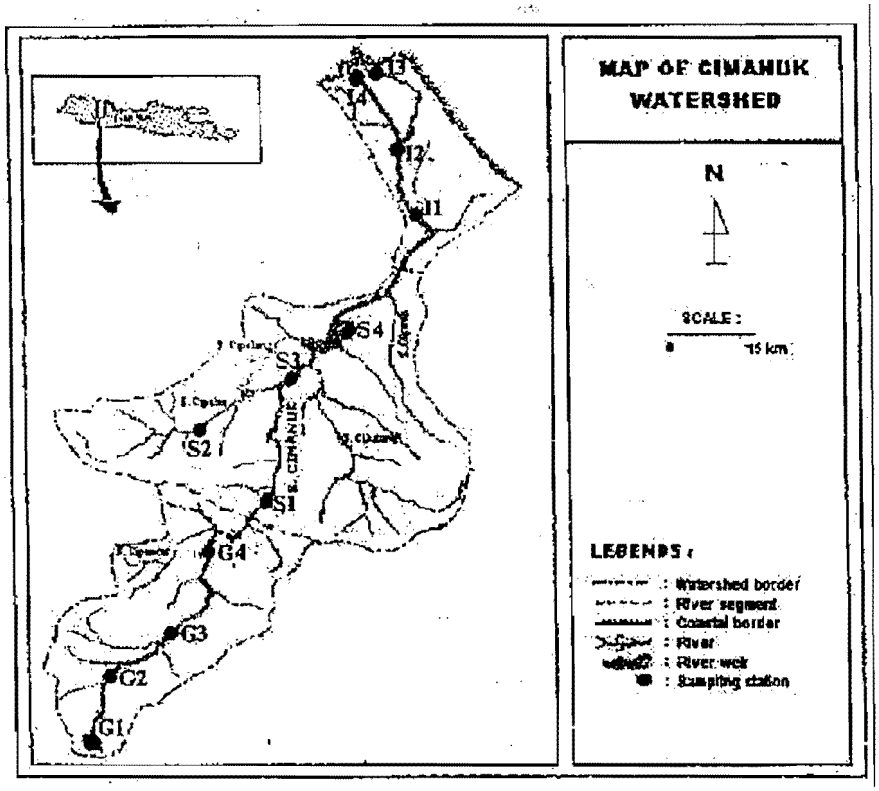

Figure 1. Cimanuk River Basin and Sampling Stations.

Diversity and similarity or evenness indices were based on Shannon-Wiener formula:

$$H' = -\sum_{i=1}^{k} p_i \ln p_i$$

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

H = diversity index, S = similarity or evenness index, p_i = proportion of species i-th to the total plankters of all species (n_i/N), H_{max} = maximum diversity = ln k.

Dominance index was calculated using the following formula:

$$D = \sum_{i=1}^{k} \frac{n_i}{N}$$

D = dominance index, n_i = number of plankters of species i-th, N = total number of plankters of all species.

RESULTS AND DISCUSSION

Species richness

The study shows that species richness of phytoplankton increases downstream. It is found 24 genera of phytoplankton in the upper stream of Cimanuk river (Garut area), 36 genera in the middle stream (Sumedang area), and 55 genera in lower stream (Indramayu area). The same pattern is found on zooplankton genera. Plankton genera in Cimanuk river can be seen on Table 1 and Table 2.

The number of phytoplankton genera found in this study is higher than that found by authors of PUSDI-PSL-IPB (1979). They found only 18 genera in the upper area, 16 genera in the middle, and 6 genera in the lower area. Thus, the spatial distribution pattern of phytoplankton species composition found by authors

of PUSDI-PSL-IPB (1979) is different from what it is found in this study. They found that the number of species decreases downstream while this study's finding shows on the contrary. It seems that it probably has been an environmental change in the source or origin of plankton during the two periods of sampling. As already known, plankton in river generally comes from ponds, lakes, reservoirs, or other inundated area.

Table 1. Phytoplankton genera in Cimanuk river

Area (segment) of the river							
Garut		**Sumedang**		**Indramayu**			
Bacillariophyceae		**Bacillariophyceae**		**Bacillariophyceae**		**Cyanophyceae**	
1	*Asterionella*	1	*Campylodiscus*	1	*Asterionella*	1	*Anabaena*
2	*Cocconeis*	2	*Cocconeis*	2	*Cocconeis*	2	*Aphanocapsa*
3	*Cyclotella*	3	*Cyclotella*	3	*Coscinodiscus*	3	*Coelosphaerium*
4	*Diatoma*	4	*Diatoma*	4	*Cyclotella*	4	*Microcystis*
5	*Melosira*	5	*Eunotia*	5	*Diatoma*	5	*Oscillatoria*
6	*Navicula*	6	*Gomphonema*	6	*Fragillaria*	6	*Phormidium*
7	*Nitzschia*	7	*Melosira*	7	*Golenkia*	7	*Polycystis*
8	*Stauroneis*	8	*Navicula*	8	*Gyrosigma*	8	*Rivularia*
9	*Synedra*	9	*Nitzschia*	9	*Melosira*	9	*Tetrapedia*
10	*Tabellaria*	10	*Stephanodiscus*	10	*Navicula*	**Xanthophyceae**	
Chlorophyceae		11	*Surirella*	11	*Nitzschia*	1	*Ophiochytium*
1	*Ankistrodesmus*	12	*Synedra*	12	*Stauroneis*	2	*Tribonema*
2	*Chaetopora*	13	*Tabellaria*	13	*Stephanodiscus*	**Chrysophyceae**	
3	*Closterium*	**Chlorophyceae**		14	*Surirella*	1	*Synura*
4	*Gonatozygon*	1	*Cladophora*	15	*Synedra*	**Dinophyceae**	
5	*Microspora*	2	*Closterium*	16	*Tabellaria*	1	*Ceratium*
6	*Pediastrum*	3	*Coelastrum*	**Chlorophyceae**		**Myxophyceae**	
7	*Scenedesmus*	4	*Cosmarium*	1	*Ankistrodesmus*	1	*Stigonema*
8	*Spirotaenia*	5	*Docidium*	2	*Chaetophora*		
9	*Zygnema*	6	*Euastrum*	3	*Cladophora*		
Cyanophyceae		7	*Gonatozygon*	4	*Closterium*		
1	*Aphanocapsa*	8	*Microspora*	5	*Coleochaeta*		
2	*Oscillatoria*	9	*Mougeotia*	6	*Crucigenia*		
3	*Phormidium*	10	*Netrium*	7	*Docidium*		
4	*Polycystis*	11	*Oedogonium*	8	*Enteromorpha*		
Xanthophyceae		12	*Pediastrum*	9	*Eudorina*		
1	*Botryococcus*	13	*Penium*	10	*Genicularia*		
		14	*Pleurotaenium*	11	*Gonatozygon*		
		15	*Protococcus*	12	*Microspora*		
		16	*Richterella*	13	*Mougeotia*		
		17	*Scenedesmus*	14	*Netrium*		
		18	*Spirogyra*	15	*Oedogonium*		
		19	*Staurastrum*	16	*Pediastrum*		
		20	*Tetnemorus*	17	*Pleurotaenium*		
		Cyanophyceae		18	*Richterella*		
		1	*Aphanocapsa*	19	*Scenedesmus*		
		2	*Polycystis*	20	*Spirogyra*		
		3	*Tetrapedia*	21	*Spirotaenia*		
				22	*Staurastrum*		
				23	*Tetraspora*		
				24	*Ulotrix*		
				25	*Zygnema*		

In total, the number of phytoplankton genera found in Cimanuk river in this study is 63. Some of the genera, which are *Cocconeis, Cyclotella, Diatoma, Melosira, Navicula, Nitzs-*

chia, *Synedra*, *Tabellaria*, *Closterium*, *Gonatozygon*, *Microspora*, *Pediastrum*, *Scenedesmus*, *Aphanocapsa*, and *Polycystis*, can be found in the whole river from upper part to lower part. Some other can be found only in two parts or even in one part of the river (see Table 1).

Table 2. Zooplankton Genera in Cimanuk River

Genus	Area (segment)		
	Garut	Sumedang	Indramayu
Rhizopoda			
Acanthocystis			v
Ciliophora			
Astasia		v	v
Blepharisma			v
Coleps		v	
Frontonia		v	
Loxodes		v	
Monas			v
Paramaecium		v	
Tentor		v	
Volvox		v	
Vorticella		v	
Rotifera			
Brachionus			v
Filinia			v
Ploesoma			v
Polyathra			v
Cladocera			
Polyphemus			v
Daphnia		v	v
Nauplius			v
Copepoda			
Canthocamptus			v
Diaptomus		v	v
Limnocalanus			v
Macrotrix			v
Diptera			
Phalacrocera		v	

In the upper part (Garut), there are four classes of phytoplankton namely Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Xanthophyceae. In the middle part (Sumedang), there are only the first three of above mentioned. In the lower part (Indramayu), there are seven classes, which are the four above plus classes of Chrysophyceae, Dinophyceae, and Myxophyceae. Generally, the major genera in Cimanuk river belong to the classes of Bacillariophyceae and Chlorophyceae.

This study finds 23 genera of zooplankton constituting in six classes. This number is much higher than that found by PUSDI-PSL-IPB (1979), which were 14 genera. This study is unable to find any zooplankton in Garut area (upper stream) while the earlier authors found *Centropyxis* in that area. It seems that this part of the river has very few species of zooplankton. It should be noted that in this part of river the water current is still quite strong so that the chance to capture a single species of zooplankton becomes very small.

The number of zooplankton genera found in the middle stream of the river (Sumedang area) is 12 genera from the classes of Ciliophora, Cladocera, Copepoda, and Diptera. Meanwhile, there are 15 zooplankton genera in the lower stream (Indramayu area) from the classes of Rhizopoda, Ciliophora, Rotifera, Cladocera, and Copepoda. Ciliophora is most common class of zooplankton found in Cimanuk river.

Distribution and abundance

Plankton abundance is indeed one of indicators to see the goodness of water quality, especially for fisheries. However, it should be realized that the number of plankton caught by the net is only a part of the available plankton in the water. Ruttner (1973) said that plankton caught by the plankton net represents only 1-10 % of the entire plankton living in the water. Plankton smaller than the netplankton does not retain in the plankton net. In term of plankton abundance (captured), Purnamawati (1992), referring to Landner (1976), said that the water is categorized into oligotropic (nutrient poor) if the plankton abundance is 0-2,000 plankter/lt, mesotropic (medium rich of nutrient) if the plankton abundance is 2,000-15,000 plankter/lt, and eutropic (nutrient rich) if the plankton abundance is more than 15,000 plankter/lt.

The existence of certain species of phytoplankton can also be used as an indicator whether the corresponding water is polluted or not (Wetzel, 1975). *Melosira*, *Dinobryon*, and *Cyclotella*, for instance, can be used as a clue that the water has not been polluted yet. On the contrary, *Nitzschia*, *Aphanizomenon*, and *Microcystis* indicate that water is already polluted.

In Garut area, phytoplankton that always found at all stations and every sampling are *Synedra* and *Gonatozygon*, while *Microspora* and *Nitzschia* are almost always found. The existence of *Nitzschia* indicates that the water is already polluted although it is not all the time. *Microcystis* that also an indicator of water pollution is not found in this area. Therefore, it can be inferred from the existence of phyto-

plankton genera that the pollution level in this environment probably is still light. Moreover, *Cyclotella* and *Melosira*, which are indicators of the healthy quality of water, are still found in this area. Phytoplankton abundance in Garut area can be seen on Table 3.

Table 3. Phytoplankton Abundance in Garut Area (Plankter/lt)

No	Genus	August			October				January			
		G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4
1	*Synedra*	123	14	91	27	434	32	50	41	41	41	23
2	*Diatoma*	14	9	105	0	0	0	0	0	0	9	0
3	*Nitzschia*	165	91	41	9	165	0	0	9	45	183	69
4	*Navicula*	41	0	55	0	27	0	0	4	0	0	0
5	*Closterium*	91	91	27	0	0	32	73	41	9	0	9
6	*Tabellaria*	50	5	0	14	9	5	0	4	9	9	0
7	*Gonatozygon*	132	11	77	23	73	128	82	146	77	19	23
8	*Cocconeis*	0	19	0	0	0	0	0	0	0	0	0
9	*Melosira*	0	14	60	0	0	46	0	0	0	9	0
10	*Scenedesmus*	0	19	0	27	0	0	0	18	0	14	9
11	*Pediastrum*	0	0	0	123	0	0	41	0	0	19	27
12	*Cyclotella*	14	36	0	0	0	23	0	0	0	27	0
13	*Asterionella*	19	36	0	14	14	0	0	0	0	0	0
14	*Microspora*	50	14	19	1024	27	36	41	0	64	27	41
15	*Zygnema*	23	14	32	0	0	19	0	9	0	0	0
16	*Aphanocapsa*	0	5	0	0	0	0	0	0	0	0	0
17	*Ankistrodesmus*	0	23	36	0	0	23	0	0	0	0	19
18	*Stauroneis*	0	19	0	0	0	0	0	0	0	19	9
19	*Oscillatoria*	0	0	0	9	0	0	46	0	0	0	0
20	*Polycystis*	9	0	0	0	0	0	64	41	0	0	0
21	*Phormidium*	178	9	36	18	82	0	0	0	0	14	14
22	*Spirotaenia*	14	0	0	0	0	0	0	9	0	0	0
23	*Botryococcus*	0	0	23	27	5	0	60	0	0	0	0
24	*Chaetopora*	0	9	0	0	0	0	0	0	0	0	0

Meanwhile, Table 4 shows the phytoplankton abundance in Sumedang area. Table 4 also shows that *Synedra*, *Gonatozygon*, and *Diatoma* are the genera that always found at all stations in every sampling. Although *Nitzschia* is often found, *Melosira* is often found too. In general, therefore, this area still has a good water quality, or may be a light pollution. The frequency of finding *Cyclotella* indeed is lower than that in Garut area.

Phytoplankton abundance in Indramayu area is presented on Table 5. In this area, there are also three genera of phytoplankton that always found at all stations in every sampling. The three are *Synedra*, *Gonatozygon*, and *Closterium*. *Microcystis* is seldom found but *Nitzschia* is still often found. Meanwhile, *Cyclotella* and *Melosira* have been seldom found. Observing the phytoplankton data on Table 5, it can be considered that the pollution level in this lowest part of the river is slightly higher than that in upper parts of the river.

After looking over Table 3, 4, and 5, it can be concluded that *Synedra* and *Gonatozygon* are two important phytoplankton genera in Cimanuk river. They are always found along the river all the time. This finding is slightly different from what PUSDI-PSL-IPB (1979) found where in the upper stream was dominated by *Navicula* and then by *Synedra*, *Spirogyra*, and *Oscillatoria*. In the middle stream the primary genus was *Synedra* followed by *Navicula*. In the lower part of the river the important genus of phytoplankton was *Navicula*. In this current study, *Navicula* is infrequent in the whole river. This indicates that the quality of aquatic environment has been changed since 1977/1978 causing the change of phytoplankton composition in Cimanuk river. In 1977/1978, PUSDI-PSL-IPB (1979) did not find any *Gonatozygon*.

The plenty of *Gonatozygon*, which is the "desmid" group, may also indicate that the water is oligotropic with slightly acid (Evison, 1975). However, Chlorophyceae and Cyano-

phyceae are more abundant than the other classes. Based on that, this water can also be categorized as eutropic (Wetzel, 1975). Therefore, it might be wise if we appraise the Cimanuk river as oligotropic to eutropic.

Table 4. Phytoplankton Abundance in Sumedang Area (plankter/lt)

No	Genus	August				October				January			
		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
1	*Synedra*	1325	960	1143	501	823	1120	1143	869	526	526	640	206
2	*Diatoma*	2697	2928	1646	2283	274	206	663	1531	526	800	1189	503
3	*Nitzschia*	1554	617	365	0	480	571	869	754	297	480	297	183
4	*Navicula*	0	0	160	0	23	0	0	46	0	0	0	0
5	*Closterium*	23	21	46	117	0	0	21	23	0	0	0	0
6	*Tabellaria*	69	0	183	89	0	160	0	0	0	0	0	0
7	*Gonatozygon*	320	501	137	343	252	160	228	183	1463	1668	823	1257
8	*Cocconeis*	0	0	183	21	0	91	114	0	0	0	0	0
9	*Melosira*	365	0	297	871	503	274	457	365	252	114	686	46
10	*Scenedesmus*	0	0	0	21	46	23	0	0	0	0	0	0
11	*Pediastrum*	0	0	0	89	91	0	0	23	0	23	731	0
12	*Cyclotella*	0	0	0	0	0	160	0	0	0	0	0	0
13	*Spirogyra*	0	0	46	0	0	0	46	23	21	0	0	0
14	*Microspora*	0	48	0	0	0	0	0	0	0	0	0	0
15	*Aphanocapsa*	0	0	0	0	0	0	0	0	0	0	0	46
16	*Mougeotia*	320	254	434	185	0	1943	1074	1463	1897	1006	1531	1189
17	*Oedogonium*	0	21	0	0	0	0	69	137	0	206	69	69
18	*Surirella*	0	0	0	0	46	46	0	274	0	0	0	0
19	*Richterella*	0	0	0	0	0	0	0	46	0	0	0	0
20	*Docidium*	0	0	0	0	0	69	21	0	0	0	0	0
21	*Netrium*	46	0	0	0	0	0	0	23	0	0	0	0
22	*Protococcus*	3771	1440	1143	1646	2880	0	0	137	114	0	0	23
23	*Tetrapedia*	46	48	343	0	0	23	0	0	0	0	0	0
24	*Campylodiscus*	0	0	0	0	0	23	0	0	0	23	23	0
25	*Polycystis*	0	0	0	0	0	46	69	46	0	0	0	0
26	*Staurastrum*	0	0	23	0	0	0	0	0	0	0	0	0
27	*Penium*	0	21	0	0	0	0	0	0	0	0	0	0
28	*Stephanodiscus*	0	0	0	0	0	0	0	0	114	23	0	46
29	*Gomphonema*	0	48	0	0	0	0	0	0	0	0	0	0
30	*Coelastrum*	0	0	0	274	0	0	0	0	0	0	0	0
31	*Cosmarium*	0	21	46	0	0	0	0	0	0	0	0	0
32	*Cladophora*	0	0	23	21	320	183	69	114	0	23	0	0
33	*Tetmemorus*	0	0	0	21	0	0	0	0	0	0	0	0
34	*Pleurotaenium*	46	0	23	0	0	0	0	0	0	0	23	0
35	*Euastrum*	0	0	0	0	0	0	0	0	0	23	0	0
36	*Eunotia*	0	0	0	0	0	0	0	0	0	0	0	23

Plankton abundance may also be used as an indicator of fertility of aquatic environment. An oligotropic water has the abundance of 0-2,000 plankter/lt, a mesotropic has the abundance of 2,000-15,000 plankter/lt, and a eutropik has abundance of more than 15,000 plankter/lt (Basmi, 1987). Table 6 shows the plankton abundance in Cimanuk river in this study.

It can be seen from Table 6 that there is an abundance difference both spatially and temporally. Garut area, in general, has the least (less than 1,000 plankter/lt). There is no significant difference among stations and sampling time here although in wet season (January) the abundance decreases a bit. With this fact, the upper part of Cimanuk river (Garut) may be categorized as an oligotropic.

The highest plankton abundance is found in Sumedang area although it is still less than 15,000 plankter/lt. The plankton abundance in this area has the same pattern as that in Garut

area, where spatial and temporal differences are not clear enough although in rainy season (January) the abundance is slightly lower. Since the plankton abundance in this area is in the range of 2,000-15,000 plankter/lt, the Cimanuk river in this part may be categorized as mesotropic.

Table 5. Phytoplankton Abundance in Indramayu Area (plankter/lt)

No	Genus	August				October				January			
		I1	I2	I3	I4	I1	I2	I3	I4	I1	I2	I3	I4
1	*Synedra*	503	407	41	5	169	311	146	370	41	64	87	82
2	*Diatoma*	46	0	0	0	5	0	0	46	0	0	5	5
3	*Nitzschia*	69	471	37	32	32	37	18	37	9	0	14	9
4	*Navicula*	0	0	0	0	0	0	357	32	0	0	9	5
5	*Closterium*	23	3945	599	937	96	229	82	517	18	5	146	32
6	*Tabellaria*	0	0	0	27	9	0	0	0	0	0	0	0
7	*Gonatozygon*	457	421	32	5	283	526	219	1440	14	5	14	32
8	*Cocconeis*	0	0	0	0	78	0	0	0	0	0	0	0
9	*Melosira*	0	0	0	0	9	5	0	87	0	0	0	0
10	*Scenedesmus*	0	5	0	0	9	5	0	9	5	23	0	0
11	*Pediastrum*	23	672	146	55	201	215	110	599	0	0	23	5
12	*Cyclotella*	0	0	5	0	0	32	0	9	0	0	0	0
13	*Spirogyra*	0	9	0	0	9	9	5	9	0	0	0	0
14	*Microspora*	0	0	197	0	14	0	0	0	0	0	18	78
15	*Aphanocapsa*	0	0	0	0	0	0	41	0	0	0	0	0
16	*Mougeotia*	91	0	5	0	0	27	0	0	0	0	0	0
17	*Oedogonium*	69	0	9	0	9	0	5	5	0	0	0	0
18	*Surirella*	0	0	0	0	0	0	0	100	9	18	9	18
19	*Richterella*	0	0	0	0	0	0	0	5	0	0	0	0
20	*Docidium*	23	5	0	0	0	0	0	0	0	0	0	5
21	*Netrium*	0	0	0	0	0	0	0	0	18	0	0	0
22	*Asterionella*	0	0	0	23	0	0	0	9	0	0	0	0
23	*Tetrapedia*	0	0	0	0	0	0	0	0	0	0	0	9
24	*Zygnema*	0	0	0	0	5	0	0	0	0	0	0	0
25	*Polycystis*	23	0	0	0	5	137	73	110	14	0	0	0
26	*Staurastrum*	69	0	0	0	0	0	0	5	0	0	0	0
27	*Ankistrodesmus*	845	0	215	0	0	0	5	0	5	9	0	0
28	*Stephanodiscus*	0	0	0	0	0	0	0	5	0	0	0	0
29	*Phormidium*	23	0	0	0	0	0	0	0	0	0	0	0
30	*Tribonema*	0	0	0	0	0	0	0	14	5	0	0	0
31	*Microcystis*	0	0	0	0	9	9	0	0	0	0	0	0
32	*Cladophora*	0	0	0	0	0	0	0	0	0	0	5	0
33	*Coscinodiscus*	595	37	32	114	0	0	0	0	0	0	0	0
34	*Tetraspora*	46	5	0	0	0	5	0	0	0	110	41	23
35	*Synura*	115	41	0	0	0	0	0	0	0	0	0	0
36	*Rivularia*	206	0	0	0	0	0	0	0	0	0	0	0
37	*Anabaena*	389	18	18	0	23	5	5	0	0	0	5	0
38	*Eudorina*	983	0	5	0	0	0	0	0	0	0	0	0
39	*Pleurotaenium*	0	0	0	0	9	0	0	0	0	0	0	9
40	*Golenkia*	0	0	0	0	5	0	0	0	0	0	0	0
41	*Crucigenia*	0	0	0	0	0	9	5	0	0	0	0	0
42	*Gemcularia*	0	0	0	0	0	5	0	0	0	0	0	0
43	*Ulotrix*	0	0	0	0	0	0	0	5	0	0	0	0
44	*Fragillaria*	0	0	110	5	0	96	86	50	0	0	0	50
45	*Enteromorpha*	69	0	0	0	0	0	0	0	0	0	0	0
46	*Spirotaenia*	0	0	0	0	0	0	0	0	18	0	0	0
47	*Coelosphernum*	0	0	0	0	0	0	0	0	0	0	0	9
48	*Chaetophora*	0	0	0	0	0	0	0	0	0	0	0	5
49	*Stigonema*	0	0	0	0	9	0	0	0	0	0	0	0
50	*Gyrosigma*	0	0	0	0	0	14	0	5	9	0	0	0
51	*Oscillatoria*	69	37	0	0	5	101	55	0	0	0	0	0
52	*Ophiochytium*	23	0	0	0	0	5	0	5	0	0	0	0
53	*Stauroneis*	0	0	5	0	0	0	0	0	0	0	0	0
54	*Coleochaeta*	0	0	9	0	0	0	0	0	0	0	0	0
55	*Ceratium*	0	0	0	274	0	0	0	0	0	0	0	0

The effect of season on the plankton abundance is obvious in Indramayu area. The rainy season corresponding to high level of turbidity significantly diminishes plankton abundance at every station. It is indeed easy to understand since the lower stream is the place of sediment accumulation and the current is slower so that the environment resembles a lake Tem-

poral variability of phytoplankton in tropical lakes has been studied comprehensively by Melack (1979). The plankton abundance in this area is lower than that in Sumedang area so that the water may be categorized as oligotropic to mesotropic.

Table 6. Total Plankton Abundance in Cimanuk River (plankter/lt.)

No	Area	August				October				January			
		1	2	3	4	1	2	3	4	1	2	3	4
1	Garut	-	923	438	602	1 315	936	344	457	322	245	390	243
2	Sumedang	10 583	6 925	6 422	6 638	6 857	5 412	4 794	6 102	5 230	4 982	6 033	3 953
3	Indramayu	5 378	6 348	1 465	1 824	1 025	1 869	1 271	3 528	152	234	390	376

Diversity and biological indicators

As mentioned above, total abundance of plankton as well as the existence of certain species of phytoplankton may be used as biological indicators of the quality condition of aquatic environment. In term of the two indicators, Cimanuk river is categorized as oligotropic to mesotropic as discussed above. Based on APHA (1976) plankton genera commonly living in clear water are *Rhizoclonium, Pinnularia, Cladophora, Surirela, Cyclotella, Rhodomonas, Ankistrodesmus, Chrysococcus, Agmenellum, Coccochloris, Navicula, Ulothrix, Micrasterias, Calothrix, Meridion, Entophysalis, Chromulina, Hildenbrandia, Phacotus, Staurastrum, Microcoleus*, and *Cocconeis*. On the other hand, there are some species that usually live in polluted water such as *Phormidium, Agmenellum, Carteria, Pyrobotrys, Nitzschia, Lepocinclis, Anabaena, Euglena, Tetraedron, Oscillatoria, Chlorococcum, Spirogyra, Phacus, Chlorogonium, Chlorella, Gomphonema, Stigeoclonium, Anacystis, Arthrospira, Chlamydomonas*, and *Lyngbya*. This study finds both groups of plankton in Cimanuk river so that the river may not very clean but also not very polluted.

Genera's diversity of phytoplankton can also be used as an indicator the goodness of aquatic environment. This indicator usually is presented as a diversity index. This index may be calculated using some different methods (the use of different logarithm bases), and therefore, comparing the indices should be very cautious and make sure that all indices being compared are computed with the same method. Higher value of the index reflects better condition of the environment and vise versa. With the basis of natural logarithm, the index is considered high if it is more than 3 and is said to be low if it is less than 1 (Omori and Ikeda, 1984).

The higher phytoplankton diversity reflects that the aquatic environment is more stable because there is more choice of food in the environment to support various higher level organisms. In general, the phytoplankton diversity indices in Cimanuk river are in the range of 1-3. Consequently, it can be assumed that the river has moderate phytoplankton diversity. The phytoplankton diversity indices are presented on Table 7.

Table 7. Phytoplankton Riversity Indices in Cimanuk River.

No	Area	August				October				January			
		1	2	3	4	1	2	3	4	1	2	3	4
1	Garut	-	2.29	2.44	2.35	0.83	1.47	1.89	2.28	1.73	1.57	1.89	2.08
2	Sumedang	1.66	1.66	2.28	1.69	1.97	2.08	1.95	2.11	1.70	1.86	2.05	1.81
3	Indramayu	2.54	1.27	1.93	1.30	2.30	2.90	1.86	1.89	1.25	1.45	2.03	2.33

The existence of misgiving to the aquatic environment by pollutant can also be testified from the phytoplankton similarity index (Daget, 1976). When the index closer to unity, the abundance of every species is almost uniform and is not dominated by one or two species. It means that the aquatic environment has not been received a significant stress. On the other hand

when the environment has been suffering from a heavy pressure the similarity index will be close to zero. The moderate value of the index is among 0.5 to 0.75. Phytoplankton similarity indices in Cimanuk river are presented on Table 8.

Tabel 8. Phytoplankton Similarity Indices in Cimanuk River

No	Area	August				October				January			
		1	2	3	4	1	2	3	4	1	2	3	4
1	Garut	-	0.87	0.84	0.95	0.35	0.67	0.86	0.90	0.77	0.88	0.76	0.90
2	Sumedang	0.67	0.65	0.74	0.61	0.71	0.72	0.76	0.72	0.74	0.69	0.86	0.67
3	Indramayu	0.80	0.45	0.23	0.52	0.70	0.90	0.64	0.60	0.50	0.70	0.70	0.80

The similarity index is the opposite of the dominance index. The higher dominance index means that there is one or two species dominating the environment so that the abundance of phytoplankton is not uniform. Higher value of dominance index is corresponding to lower value of similarity index. The moderate value of the index is in the range of 0.6-0.8 (Odum, 1971). Phytoplankton dominance indices in Cimanuk river may be seen on Table 9.

Table 9. Phytoplankton Dominance Indices in Cimanuk River

No	Area	August				October				January			
		1	2	3	4	1	2	3	4	1	2	3	4
1	Garut	-	0.12	0.12	0.12	0.67	0.31	0.20	0.13	0.42	0.24	0.26	0.18
2	Sumedang	0.41	0.26	0.58	0.21	0.22	0.19	0.17	0.17	0.24	0.20	0.16	0.22
3	Indramayu	0.12	0.40	0.23	0.42	0.20	0.17	0.15	0.23	0.50	0.31	0.20	0.13

The values of similarity and dominance indices on Table 8 and Table 9 indicate that the water of Cimanuk river has not been signifycantly pressured by pollution. The similarity indices, in general, are more than 0.5 while the dominance indices are less than 0.5. Evaluation on those indices comes up with the conclusion that diversity findings also in line with the findings of various biological indicators mentioned earlier. Those indices reflect that the pollution pressure to the Cimanuk river is still light. In this study, zooplankton is excluded from indices calculations because of its low abundances.

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