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Study on Correlation of Macrozoobenthos Profusion and Pollution Level In Cinde River Batu City, Indonesia

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Abstract

Cinde river is one of the river name at the Bumiaji's region in Batu. The human's activities that influence Cinde River are the residence, cow farming, farming and sand mining. Those activities will influence either the abiotic or biotic factors in Cinde River. The aim of this paper are therefore to know the characteristics of macrozoobenthos in the waters of Cinde river that possible can serve as bioindicators of water quality. The research was conducted in April – June 2013. Determination of water sampling point and macrozoobenthos using purposive sampling method, while the method of the water sampling and macrozoobenthos in the river collected by grab samples. Sampling macrozoobenthos collected by kicking method. Analysis of the relationship between water quality parameters in the presence of macrozoobenthos performed using (Principal Component Analysis) PCA. The result of the water level of this research: site one (station 2, 3, 4, 5, 9, and 10) were middle polluted and site two (station 1, 6, 7, and 8) were moderate polluted.

Keyword: Macrozoobenthos, water quality, Cinde river

1. Introduction

Surface waters is classified into main two groups: standing water and flowing water (Anggraini, 2007; Jeffries & Mills, 1996; Nontji, 1986). Flowing water can be seen through the continuous stream with various speed so that water time movement happen continuously, such as: river, ditch, and canal (Ewusie, 1990; Odum,1971; Armitage *et al*., 1983). River is a kind of waters with open system and it depends on environment condition (Nontji, 1986; Norris & Thoms, 1999; Vannote *et al*., 1980).

Physical chemistry characteristic of waters is very important in ecology. Biogeographically distribution of macrozoobenthos is determined by such environment factors as temperature, pH, hardness, BOD, stream speed, substratum depth, oxygen and other factors (*Untung et al*., 1996; Hawkes, 1979). The addition of organic and inorganic materials in the form of waste into the waters will change the chemical order of water as well as influence biological characteristics of water (Trisna, 2001; Riska, 2006). The damage of such waters ecosystem will give impact to water biota life like the changing of macrozoobenthos community structure in which the distribution and macrozoobenthos variety can show the quality of river waters (APHA, 1992; Ravera, 1979).

Macrozoobenthos is the type of animals which live in the basic elements of waters. They are macroscopic in size and invertebrate, in which this group is a kind of organism that feel directly the influence of environment change since generally macrozoobenthos do not move so that this particular animal is able to respond the condition of water quality continuously (Dennis & Patil, 1977; Lenat & Barbour, 1994; Reynoldson & Metcalfe-Smith, 1992; Smith *et al*., 2007; Haase *et al*., 2004; Cummis, 1975). Based on such explanation, this research aims at measuring the status of Cinde River waters quality in Batu City based on the distribution and variety of macrozoobenthos type.

2. Material and Methods

2.1 Study Area

Cinde river is the one largest river in Batu, extends over an area of 6,235 km^2 and lies between 7° 44' 55,11" to 8° 26' 35,45" North latitude and 122° 17' 10,90" to 122° 57' 00,00" East longitude (Figure 1). This research was conducted on April until June 2013. During the study, ten sampling stations were chosen for sampling (Figure 1).

2.2 Collection, Preservation and Identification

Taking sample of macrozoobenthos in the basic layer of waters by using kicking method and purposive random sampling toward ten stations based on the consideration of land use system and use of river around the main body of Cinde River and each of them has two repetitions. Sieving was done using 0.5 micron mesh size sieve. Brush and forceps were used for cleaning and picking of organisms. Macrozoobenthos organisms were collected and preserved in screw caped broad mouth plastic bottles followed by 70% alcohol and transferred to the laboratory safely. Identification of macrozoobenthos type was conducted in Waters Science Laboratory of Fishery and

Marine Science Faculty on State University of Brawijaya by using identification books: Freshwater Biology (Edmonson, 1962), An Introduction to Aquatic Insects of North America (Merritt and Cummins, 1996), A Guide to Study Freshwaters Biology (Needham &Needham, 1978), and Freshwater Invertebrates of the United States (Pennak, 1978). Sample of river water was taken by taking grab sample (Effendi, 2003).

2.3 Data Analysis

Data analysis involves parameter of community structure (density), while community function was analyzed through composition and type role in the habitat. Macrozoobenthos species density is defined as the number of individual of certain species in every station. It can be formulated as follow (Odum, 1993; Brower, 1990):

$$K = \frac{10000 \times a}{b}$$

Keterangan:

K = Density of macrozoobenthos (ind/m^2)

a = Amount of macrozoobenthos (ind)

b = Wide of seine macrozoobenthos (cm^2) (10.000 conversion from cm^2 to m^2)

Relation between macrozoobenthos community with eternal factors is analyzed with Principal Componen Analysis (PCA) through Statistics 6.0 program software. PCA is a multifarious analysis that is conducted by selecting variable based on the consideration of data completeness and variable ability in explaining the variety of area characteristics (Biggs, 2000).

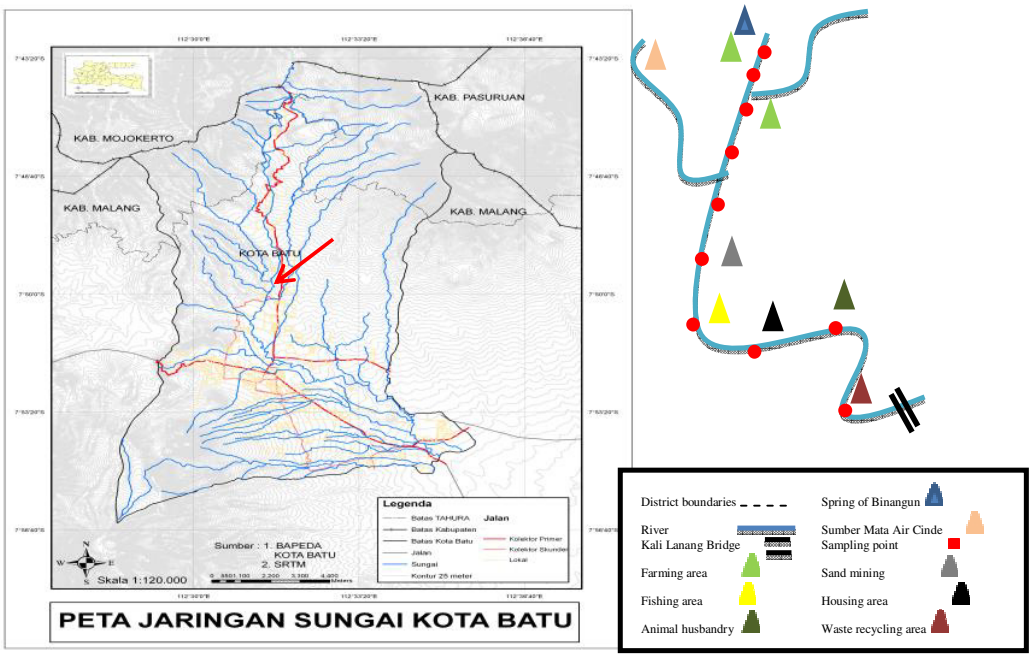


Figure 1. River Water Sampling Locations and macrozoobenthos in Cinde River (Source: Goverment of Batu City, 2013)

3.Result And Discussion

Based on the result of identification, composition of macrozoobenthos community consists of five main classes: Gastropoda, Crustacea, Hirudinea, Oligocaeta, and Insecta. Insecta has the highest density (91.2 ind/5m^2), Gastropoda (20.2 ind/5m^2), Crustacea (6.6 ind/5m^2), Oligocaeta (4.6 ind/5m^2) and Hirudinea has the lowest density (0.8 ind/5m^2) (Figure 2).

Insecta is highly spread out since it can be seen in every station. Insecta that was successfully found consists of ten equivocal: Baetidae, Hydropsycidae, Tipulidae, Chironominae, Chironomidae (P), Tanipodinae, Orthocladinae, Ecnomidae, Coenagriidae, and Cainidae. Baetidae found in almost every station except station 9 with a total density 28.2 ind/5m^2, Coenagriidae 18.2 ind/5m^2, Tanipodinae 15.8 ind/5m^2, Orthocladinae 9.6 ind/5m^2, Chironomidae (P) 7 ind/5m^2, Caenidae 6.8 ind/5m^2, Hydropsycidae 6.2 ind/5m^2, Tipulidae 1.8 ind/5m^2, Chironominae 1 ind/ 5m^2, and Ecnomidae 0.4 ind/5m^2.

Baetidae can be found in every station since its substratums are highly available in hard rock as the habitat of Batidae. According to Hawking and Smith (1997), Baetidae lives in hard rock and water vegatation. Baetidae also

lives in calm stream-waters. According Quigley (1977), Baetidae has gill as respiratory aid so that it is able to adapt. It also can be found in every station.

Hirudinea has the lowest total density and consists of one equivocal: Richardsosianidae. Richardsosianidae found in station 9 and 10 have total density (0.8 ind/5m^2). The use system of land in station 9 and 10 are the areas of animal husbandry and waste recycling. Station 9 and 10 are located in Village, Bumiaji. Areas around river in these stations are animal husbandry and waste recycling areas which cause the organic material contaminating the river as the result of animal husbandry and waste recycling wastes so high. This is shown by the high total of N compared to previous sampling that was around 1.6 – 1.72 mg $^{L-1}$ and the total of P which was approximately 0.53 – 0.71 mg $^{L-1}$. Quigley (1977), says that Hirudinea is a kind of parasite animal that eats blood and liquid of other aquatic animals. Hirudinea is different from Annelida since it has sucker and it is usually sticky to hard rock or other objects in the waters.

The lowest number of equivocal in this research is in the station 2. There are four equivocal such as Gammaridae, Baetidae, Caenidae and Lumbriculidae. The land in station 2 is a farming area (Figure 3).

The highest number of equivocal in this research is in the station 5, there are 12 equivocals such as Palnorbidae, Thiaridae, Baetidae, Tipulidae, Lumbriculidae, Caenidae, Lymnaeidae, Hydrobsicidae, Orthocladinae, Gammaridae, Chironomidae (P) and Tanypodinae. The land in station 5 is an area after the meet of Binangun water source with Cinde water source (Figure 3).

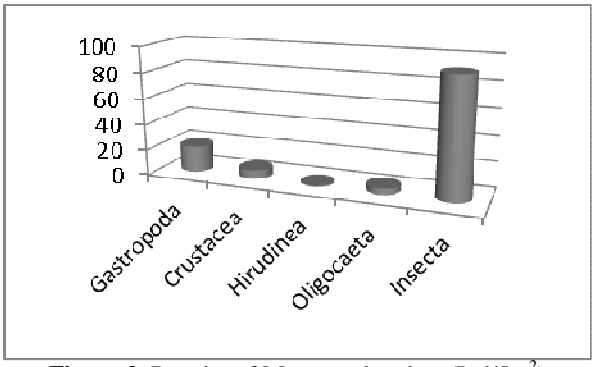


Figure 2. Density of Macrozoobenthos (Ind/5m^2)

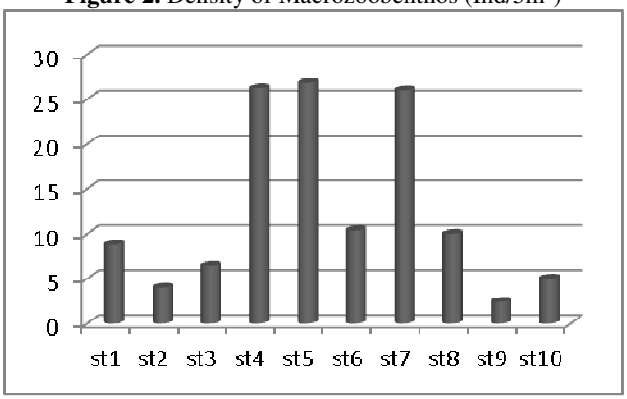


Figure 3. Total Density of Macrozoobenthos in Every Station (ind/5m^2)

Water temperature ranges between 21 ^{0}C – 24 ^{0}C. Temperature rise in the range of 0 – 25 ^{0}C did not significantly affect the total number of species and the composition of the emergence period Trichoptera, Ephemeroptera, Megaloptera and Gammarus but if > 25 ^{0}C, Oligochaeta, Chironomus, Chaoborus and Pisidium began to increase (Wright, 1995).

Based on the result of field observation, it is found in pH 6,6 – 7.58, the lowest pH is found in station 1, that is 6.6 while the highest pH is found in station 10, that is 7.58. According to Barus (2002) and Effendi (2003), most of aquatic biota are sensitive to the change of pH and the value of pH is around 7 – 8.5.

Based on the result of measuring activity in the field, the stream speed in Cinde River area is around 20.5 – 60 cm/sec. According to Pertiwi *et al*., (2003); Dean (2001), the samples of macrozoobenthos which live in slow stream (10-25 cm/sec) are Tubificidae, Dysticidae and Richardsosianidae, while those which live in swift stream (50 – 100 cm/sec) are Blepharoceridae, Perlodidae and Hydrobsycidae.

Based on the research result, the value of hardness is around 25 – 85 ppm. If it is related to the finding of macrozoobenthos, the value of hardness in observation station is relatively relevant to macrozoobenthos life. It is in line with Fore *et al*., (1993) who says that the grouping of macrozoobenthos is based on the value of hardness: hardness(48 – 72 mg L^{-1}) is for species: Baetidae, Chironomidae, Simuliidae, Tipulidae, Nemouridae, Hydrobsicidae, Amphlipterygidae, Ceoridae, Culicidae, Gammaridae, Geriidae, Hydrophylidae, Hydrometridae, Mesovelidae, Noctuidae, Olighochaeta, Tubificidae, Perlidae and Bhythiniidae. Hardness (52 – 88 mg $^{L-1}$) is for species: Baetidae, Chironomidae, Simuliidae, Tipulidae, Lepidostomatidae, Tricladida, Muscidae, Pyralidae, Richardsosianidae and Hydrobsicidae. Hardness (56.05 – 108.1 mg $^{L-1}$) is for species: Baetidae, Chironomidae, Muscidae, Simuliidae, Hydrobsycidae and Tipulidae.

The value of DO is around 6.14 – 7.04 mg $^{L-1}$. Macrozoobenthos has tolerance toward oxygen 3 mg $^{L-1}$; it is for Trichoptera, Ephemeroptera, Mollusca and it is dominantly for Insecta; while macrozoobenthos which have tolerance toward oxygen 3 mg $^{L-1}$ in waters are Odonata, Lepidoptera, Mollusca, Chironomus tummi, and Tubificidae (Sudaryanti dan Marsoedi, 1995; Watson and Abbey, 1980).

From the research result, the value of BOD is around 2.13 – 4.29 mg $^{L-1}$. According to Quinn *et al*., (1992), the grouping of macrozoobenthos is based on organic materials (0.13 – 1.2 mg $^{L-1}$) such as Baetidae, Chironomidae, Simuliidae, Tipulidae, Hydrobsicidae, Helodidae, Agriidae, Amphlipterygidae, Ceoridae, Culicidae, Gammaridae, Geriidae, Lepidostomatidae, Tricladida, Hydrophylidae, Hydrometridae, Mesovelidae, Noctuidae, Olighochaeta, Tubificidae, Perlidae and Bhythiniidae.

Based on the result of measuring the suspended density total, the value is around 110 – 800 mg $^{L-1}$. The value is relative high, yet it is still under the limit that supports the waters organism life. Based on the Life Environment Ministry decision Num 51/MNLH/2004, this value is relevant to the standard of water quality for biota under 2000 mg $^{L-1}$ that can support the water biota life (MNLH, 2004).

Based on the result of measuring the total of N and P, the total of N is around 1,34 – 1,84 mg $^{L-1}$ while the total of P is around 0,08 – 0,71 mg $^{L-1}$. Low profusion of benthos is around 12 – 134 ind/m^2 that is supported by low phosphate (PO_4) and it can be associated with less fertile waters (Sagala, 2012). Parameter of NH_4 is a little bit higher than its maximum, that is 1,06 mg $^{L-1}$, and it might be from decomposition of domestic waste done by aquatic microbe, especially those which appear with low water face in dry season. However, this does not influence benthos community life since it does not cause toxic. Parameter of PO_4 which is 0,08 mg $^{L-1}$ shows that the waters is less fertile and it is relevant to the water source, especially in mountain range and long stream waters areas (Sagala, 2012; Humphrey and Dostine, 1994).

PCA is a type of ordinance technique that is used to show the position of points in multifarious room and lack of dimension (Sheaves, 2003). PCA will group sites into two or three dimensions based on the similarity in taxonomy composition (Biggs, 2000). The result of station grouping can be seen in Figure 4.

From station grouping, there are two groups: group I and group II. Station grouping results two groups divided into two quadrants because the use system of the land is not so far different between group I and group II. Group I consists of stations: 2, 3, 4, 5, 9 and station 10. Group II consists of stations 1, 6, 7 and station 8.

Macrozoobenthos which form group I are Baetidae (b), Cainidae (ca), Chironomidae (chp), Chironominae (ch), Gammaridae (g), Hydropsycidae (h), Lumbriculidae (lu), Lymnaedae (ly), Orthocladinae (o), Palnorbidae (p), Richardsosianidae (r), and Tanipodinae (t) (Figure 5). Group I consists of six stations: stations 2, 3, 4, 5 located in Cinde River, Bumiaji Village as well as stations 9 and 10 located in Pandan Village, Bumiaji subdistrict.

Baetidae is the species of macrozoobenthos which greatly found in group I (23,17%). Baetidae in group I can be found in every station since group I has much substratum in big hard rock and it becomes Baetidae habitat. According to Hawking and Smith (1997), Baetidae usually lives around hard rock and water vegetation. Baetidae lives in calm stream waters as well. According to Quigley (1977), Baetidae has gill as respiratory aid so that it can adapt and it can be found in every station.

Richardsosianidae is less found in group I since its habitat is less appropriate. Quigley (1977), says that Hirudinea is a kind of parasite animal that like to eat other aquatic animals' blood and liquid. They are differemt from Annelida since they have sucker that is usually sticky to hard rock or other objects in the waters. According to Pertiwi *et al*., (2003); Shine (1986), the samples of macrozoobentos which live in slow stream (10 – 25 cm/sec) are Tubificidae, Dysticidae, and Richardsosianidae.

The temperature of group I is around 21 – 23 ^{0}C, and it is categorized as normal. The stream speed is around 23 – 45 cm/sec in it is categorized as fast stream speed since it is more than 10 cm/sec. Its pH is around 6,6 – 7,55 and it is categorized as normal. Its DO is around 6,86 – 7,02 mg $^{L-1}$ and it is categorized as very good. Its BOD_5 is around 2,76 – 3,09 mg $^{L-1}$ and it is categorized as good since it is unavailable in observation station which has BOD_5 more than 10 mg $^{L-1}$ that is actually the limit of waters pollution. Its hardness is around 25 – 53 mg $^{L-1}$ and it is categorized as soft. According to Fore *et al*., (1993), macrozoobenthos group that can be found at hardness 48,05 – 72,07 mg $^{L-1}$ are Baetidae, Chironomidae, Simuliidae, Tipulidae, Nemouridae, Hydrobsicidae, Helodidae, Elmidae, Agriidae, Amphlipterygidae, Ceratopogonidae, Ceoridae, Culicidae, Gammaridae, Geriidae, Grepsidae,

Lepidostomatidae, Tricladida, Hydrophylidae, Hydrometridae, Mesovelidae, Notonectidae, Noctuidae, Olighochaeta, Tubificidae, Perlidae and Bhythiniidae.

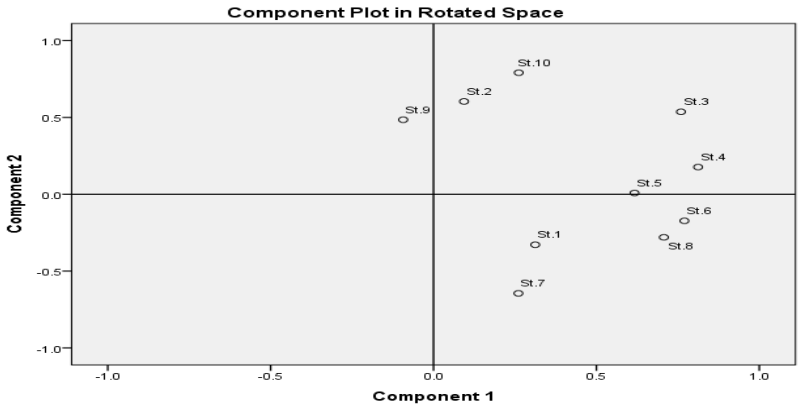
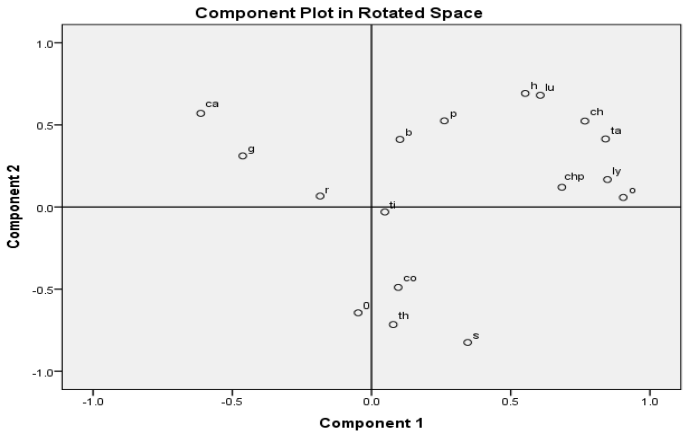


Figure 4. Grouping station



Picture index:

B :Baetidae	g:Gammaridae	r:Richardsosianidae	ca:Cainidae
h:Hydropsycidae	s:Sundathelphusidae	chp: Chironomidae (P)	lu:Lumbriculidae
ta: Tanipodinae	ch:Chironominae	ly: Lymnaedae	th: Thiaridae
co: Coenagriidae	o: Orthocladinae	ti: Tipulidae	0: Ecnomidae
p: Palnorbidae			

Figure 5. Grouping macrozoobenthos

Group II consists of four observation stations, they are: stations 1, 6, 7, and 8 located in Cinde River. Macrozoobenthos that form group II are Coenagriidae (co), Ecnomidae (0), Sundathelphusidae (s), Thiaridae (th), and Tipulidae (ti) (Figure 5).

Coenagriidae is species of macrozoobenthos that are mostly found in group II (14.44%) at station 7. Thiaridae is also around 14. 14% at station 7. Substratums in station 7 are gravel and mud that are available in big hard rock area. Hynes (1977), says that the samples of macrozoobenthos that live in rock substratum are Ephemeroptera, Gastropoda, and Planaria. According to Suwondo *et al*., (2005), Gastropoda which live together among their species is because they usually live assembly and they are sticky to certain place all the time.

The temperature of group II is around 21 – 24 ^{0}C and it is categorized normal. Its stream speed is around 20,5 – 60 cm/sec and it is categorized as fast stream since it is more than 10 cm/sec. Its pH is around 7,04 – 7,58 and it is categorized normal. Its DO is around 6,14 – 7,04 mg $^{L-1}$ and it is categorized very good. Its BOD_5 is around 2,13 – 4,29 mg $^{L-1}$ and it is categorized moderate. The hardness is around 28 – 85 mg $^{L-1}$ and it is categorized low up to moderate. According to Fore *et al*., (1993), the groups of macrozoobenthos that is available at hardness 52,05 – 88,08 mg $^{L-1}$ are Baetidae, Chironomidae, Simuliidae, Tipulidae, Nemouridae, Elmidae, Lepidostomatidae, Tricladida, Muscidae, Pyralidae, Richardsosianidae and Hydrobsycidae.

Based on the table of macrozoobenthos: Indicator Used to Measure Water Quality, according to Untung *et al*., (1996); Suter (1993), macrozoobenthos species that are highly found in group I is from class 2 like Baetidae, Hydropsycidae and Cainidae. There are also some species from class 5 like Tanypodinae and Orthocladinae. In this group, macrozoobenthos class 3 and 4 are found as well. Macrozoobenthos from class 3 are Gammaridae and Lymnaeidae while from class 4 is Richarsosianidae. The data show that group I is a type of waters class 2, it is a river that is slightly polluted since the macrozoobenthos species from class 2, 3, 4 mingle within it. According to Untung *et al*., (1996), waters can be said polluted if there are macroinvertebrate from ordo Plecoptera (Perlidae, Perlodidae), Odonata (Platycnemididae), Coleoptera (Elminthidae) and waters is categorized polluted if some of species from class 2, 3, 5 and 6 mingle within it.

Based on table of Macrozoobenthos: Indicator Used to Measure Water Quality, according to Untung *et al*., (1996), macrozoobenthos species that are highly found in group II are those from class 2 like Tipulidae. From class 3, there are Coenagriidae, Thiaridae, dan Ecnomidae. The data show that group II is a type of waters class 3; it is a river which is moderately polluted since macrozoobenthos species from class 2 and 3 mingle. This is in line with Untung *et al*., (1996); Wells (1991), who say that the sample of macrozoobenthos that are moderately polluted are Plecoptera, Ephemeroptera, non-cased Trichoptera, Odonata and Coleoptera.

4.Conclusion

Composition of macrozoobenthos consists of 5 classes: Gastropoda, Crustacea, Hirudinea, Oligochaeta and Insecta. Baetidae type has the highest total density of all study sites (28.2 ind/5m^2). Results of PCA analysis showed the presence of two group areas: site one (station 2, 3, 4, 5, 9, and 10) were middle polluted and site two(station 1, 6, 7, and 8) were moderate polluted.

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Tabel 1. Density of Macrozoobenthos (ind/5m^2) in study area

No	Taxa	Station									
		1	2	3	4	5	6	7	8	9	10
	Insecta										
1	Baetidae	6	4	18	69	21	9	6	8	-	5
2	Hydropsycidae	-	-	6	4	12	-	-	1	4	4
3	Tipulidae	-	-	-	4	-	-	-	5	-	-
4	Chironominae	-	-	-	-	5	-	-	-	-	-
5	Chironomidae (P)	3	-	-	3	10	5	-	11	3	-
6	Tanipodinae	4	-	-	10	45	6	7	7	-	-
7	Orthocladinae	-	-	6	3	16	13	6	4	-	-
8	Ecnomidae	2	-	-	-	-	-	-	-	-	-
9	Coenagriidae	-	-	-	33	-	2	51	5	-	-
10	Cainidae	6	7	4	6	3	-	2	-	3	3
	Gastropoda										
11	Thiaridae	20	-	-	3	2	4	47	3	-	-
12	Lymnaeidae	-	-	-	-	7	4	2	-	-	3
13	Palnorbidae	-	-	-	4	2	-	-	-	-	-
	Crustacea										
14	Sundathelphusidae	-	-	-	-	-	7	6	6	1	3
15	Gammaridae	3	6	-	-	1	-	-	-	-	-
	Oligocaeta										
16	Lumbriculidae	-	3	2	2	10	2	-	-	-	4
	Hirudinea										
17	Richardsosianidae	-	-	-	-	-	-	-	-	1	3
	Total taxa	7	4	5	11	12	9	8	9	5	7
	Total species	44	20	32	131	134	52	130	50	12	25

Tabel 2. Result of water quality

St.	Parameter (mg $^{L-1}$)						pH	Stream speed (cm/sec)	Temperature (^{0}C)
	Total of N	Total of P	Hardness	TSS	DO	BOD			
1	1,34	0,14	25	220	6,80	3,01	6,6	45	22
2	1,73	0,11	28	140	6,54	3,48	7,34	33	23
3	1,84	0,08	30	260	7,04	2,13	7,35	28	23
4	1,52	0,12	35	110	6,14	4,29	7,04	30	24
5	1,58	0,15	40	350	7,02	3,28	7,15	60	22
6	1,66	0,13	40	270	7,02	2,76	7,48	24	21
7	1,49	0,16	34	800	6,86	3,09	7,55	24,5	21
8	1,67	0,46	53	340	6,95	2,95	7,48	38,5	23
9	1,64	0,53	85	500	6,14	3,4	7,44	20,5	24
10	1,72	0,71	66	190	6,67	3,5	7,58	21,5	21