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Phytoplankton diversity as a bioindicator environmental changes in coal mine area

Muhammad Zaini[1*], Hepy Zahra Saputri[1], Danang Biyatmoko[2]

[1] *Biologi Study Program – Education Faculty (FKIP), Lambung Mangkurat University, Hasan Basry Kayu Tangi Banjarmasin, South Kalimantan, Indonesia*

[2] *Program Study of Animal Production, Faculty of Agriculture, Lambung Mangkurat University, A.Yani Km 36 Banjarbaru 70714 South Kalimantan, Indonesia*

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Key words: Binuang Dam, Biological indicator, Chemical, Physics, Waters Quality.

Abstract

The aim of this research was to determined phytoplankton variety and quality of Binuang Dam chemical-physics waters. Methodology this research is descriptive and observation is arranged to direct observation at the site, water and phytoplankton sampling was done on 4 different observing stations. The observation was repeated three times on three nearby places. Phytoplankton sampling did by using net plankton no 25 on depth 10-50 cm. The counting of indicator was using Shannon's-Wienner variety index. The result of this research is based on the occurrence of phytoplankton that can be made as the bioindicator of the change waters environment at Binuang Dam in particular for BOD'S rate, COD, iron rate, manganese, zinc, aluminium, and sulphate, are *Selenastrumgracile, Pediastrum simplex, Meugeotia* sp, *Staurastrum chaetoceros*, *Cocconeis placentula*, *Closterium sp, Draparnaldia plumosa*, *Gomphonema geminatum,* and *Fragillaria crotonensis*. Phytoplankton which can be used as the indicator of environmental change based on the abundance at observational area are *Microcystis ae ruginosa* and *Spirogyra prolifica*. Based on the classification of Diversity Index (Fahrul, 2007), Binuang Dam's phytoplankton diversity is around 1,566 and categorized as medium. Binuang Dam is categorized medium polluted, based on the average of variety index point is around 1,566.

***Corresponding Author:** Muhammad Zaini ✉ danang_biyat@yahoo.com

Introduction

Coal mining in Kalimantan is now alarming. Not only production forests are depleted worked blindly, but also protected are as and agricultural land without the slightest heed community environment (Nurlela and Koestoer, 2012). Changes in human activity in influencing ecosystem often run regardless of the threshold of the ecosystem, which is a carrying capacity and the capacity of the environment in which the change occurred. Changes in the ecosystem often exceed the carrying capacity and the capacity and the ability of ecosystems to be able to rehabilitate himself naturally, arise as a result of natural disasters such as tsunamis, landslides, floods, etc.

Binuang Dam is one of the important water source for the people living in the District Binuang. Dam that stretches from the north east to the south is the source of water for the needs of the community. Condition of the water that comes from the Highlands Tarungin the rainy season becomes cloudy, though having a depth of 3 meters or more. In contrast, when the dry season, the water depth is only 0.5-1 m.

During the dry season, water turbidity increases, this means the water quality is also getting bad. Though the raw water to be obtained from the dam Binuang taps which have existed decades ago. According to the Head of Sub-district taps Binuang (Press. .com), Local governments are trying to find other water sources so that people served with clean water. Changes to water quality is closely related to water potential factor in terms of physics, chemistry, and biology.

Changes caused by biological factors related to the abundance and composition of phytoplankton. The presence of phytoplankton in a body of water can provide information about the condition of the waters, it is closely related to the role of phytoplankton as an indicator of the quality and fertility of a body of water.

The existence of water bodies Binuang Dam increasingly threatened. This is due to a lot of open coal mining company in the upstream. When it rains, particulates and liquid waste from the company enters water body the dam. Accumulation of waste material adds to the pressure on the water body.

Pressure on water body causes decreased function dam, ecologically, socially, and aesthetics. Based on this phenomenon, the proposed research question of how the diversity of phytoplankton as bioindicators of environmental change in the area of coal mine. The aim of this research was to determined phytoplankton variety and quality of Binuang Dam chemical-physics waters.

Materials and methods

Material

The study was conducted in October-November 2013. The study on population was all phytoplankton species found in the region Binuang Dam, Tapin district. Phytoplankton samples were netted using a plankton net no 25. Sampling was done by systematic sampling as many as 12 points out of a total area of 584 m2, shown in Figure 1.

Methods

Index measurement and identification diversity of phytoplankton

The implementation stage of the research consists of a) Take a sample of phytoplankton species in four observation stations, b) Filter out 30 liters of water samples taken in the vertical depth of 10-50 cm, c) Filter the water using a plankton net no.25, until the remaining 50 ml, d) Accommodating screening results into a collection bottle, and given Lugol 8 drops, e) Conducting observations of phytoplankton in the laboratory, f) Identify phytoplankton observed using a variety of sources (Edmonson, 1989; Bold & Wayne, 1985; Prescott & Mahendra, 1984; Chairuddin & Mashuri, 1982; John *et al.*, 2002),

Measurement of physical and chemical quality of water

Measure the environmental parameters include water clarity, water temperature, current velocity, light intensity, TDS, TSS, pH, BOD, COD, DO, various minerals (ions of phosphate, nitrate, arsenic, cadmium, copper, iron, lead, manganese, zinc, nitrite, aluminum, calcium, sodium, and sulfate), and h) Calculate the abundance of phytoplankton using a formula APHA (1998), The Importance by Odum (1998), and the Diversity Index (H') using Shannon-Wienner formula (Odum, 1996). Classification according Diversity Index (Fahrul, 2007) use to analysis of water conditions using water pollution criteria, as shown in Table 1.

Data Analysis

Fieldwork was carried out to take samples of phytoplankton, and the measurement of environmental factors waters. Rainfall measurement using secondary data from the Central Statistics Agency Tapin District at 2013. Laboratory studies to determine the value of density, abundance and diversity index of phytoplankton conducted at the Faculty of Fisheries Unlam Banjarbaru. Analysis of water samples in the Central Health Banjarmasin, South Kalimantan.

Analysis of water using a chemical physic water quality of the river (South Kalimantan Governor Regulation no. 5 of 2007, dated January 29, 2007), shown in Table 2.

Results and discussion

Results

Phytoplankton Diversity

Phytoplankton species identified from each station as shown in Table 3. This table shows the 30 species of phytoplankton found in the station I (control), located in the north east, this area has not been affected by coal mining activity. Station II, III, and IV are waters that intersect with mining activities, both affecting surface run off, or through water catchment. Three species simultaneously is not found in these stations namely 1) *Selenastrum gracile*, 2) *Pediastrum simplex*, 3) *Meugeotia sp*., shown in Table 3.

Table 1. The classification of Diversity Index.

Diversity Index (H ')	Indicators		
	Category	Species distribution	Community stability
< 1,0	Low	Low	Low
1,0–3	Middle	Middle	Middle
>3	High	High	High

4) *Staurastrum chaetoceros*. Lowest number of species found at station II (53%), compared with stations III and IV on average (67%). This decrease is related to the distance to the waters of mining sites. The greater the percentage decline in phytoplankton closer to the mine site. Phytoplankton species were obtained and the data supporting kuantiatif used for calculating the density, abundance and diversity index of phytoplankton as presented in Table 4.

Table 2. Criteria for Water Pollution.

Diversity Index (H ')	Status of Water
> 2	Unpolluted
1,6 – 2,0	Contaminated Lightweight
1,0 – 1,5	Polluted Medium
< 1	Tainted Weight

Third highest species density sampling area is *Spirogyra prolifica* of 1,170 ind./L. found in station II. Te low density species *Stephanodiscus sp.* is also in station II, Eunotia sp at station II and III, *Gyrosigma kutzingii* and *Surirella striatula* at station III with each density of 0.28 ind./L. The highest average abundance of *Microcystis aeruginosa* is a species of 44.98 followed by 44.73 *Spirogyra prolifica*. Both phytoplankton species dominate the waters Binuang Dam. Lowest abundance Diatoma anceps species found in station IV.

Lowest diversity index found in station II at 1.235, 1.546 at station III, and IV of the highest at 1,918 stations. Diversity Index the third station is smaller than the control at 3.652. Concluded Diversity Index Binuang Dam waters were moderate (Fahrul, 2007), Where the criteria associated with water pollution, the waters being polluted Binuang Dam (Lee, *et al.*, 1975 in Halang, 2011).

Physical and chemical quality of water

Physical and chemical state of the waters Binuang Dam when implemented research are presented in Table 5.

Table 3. Phytoplankton Species Found in Water Binuang Dam.

No.	The Name of Species	Occurances			
		Station I	Station II	Station III	Station IV
1.	*Coelosphaerium kuetzingianum*	√	√	√	√
2.	*Oscillatoria limosa*	√	-	√	√
3.	*Microcystis aeruginosa*	√	√	√	√
4.	*Merismopedia* sp	√	-	√	√
5.	*Closterium* sp	√	-	√	-
6.	*Draparnaldia plumosa*	√	-	√	-
7.	*Selenastrum gracile*	√	-	-	-
8.	*Pediastrum simplex*	√	-	-	-
9.	*Meugeotia* sp	√	-	-	-
10.	*Gonatozygon kinahani*	√	√	√	√
11.	*Spirogyra prolifica*	√	√	√	√
12.	*Mesotaenium aplanosporum*	√	√	√	√
13.	*Staurastrum chaetoceros*	√	-	-	-
14.	*Ankistrodesmus falcatus*	√	-	√	√
15.	*Sphaeroplea annulina*	√	√	-	√
16.	*Amphora ovalis*	√	√	√	√
17.	*Cymbella cistula*	√	-	√	√
18.	*Cocconeis placentula*	√	√	-	-
19.	*Stephanodiscus* sp	√	√	-	√
20.	*Diatoma anceps*	√	√	√	√
21.	*Stauroneis phoenicentron*	√	√	-	√
22.	*Eunotia* sp	√	√	√	-
23.	*Gomphonema geminatum*	√	-	-	√
24.	*Gyrosigma kutzingii*	√	-	√	-
25.	*Fragillaria crotonensis*	√	-	-	√
26.	*Navicula platystoma*	√	√	√	-
27.	*Nitszchia sigmoidea*	√	√	√	√
28.	*Synedra ulna*	√	√	√	√
29.	*Tabellaria sp*	√	√	√	-
30.	*Surirella striatula*	√	-	√	√
	Total	30	16	20	19

TDS physical parameters are below the maximum limits.TSS values ranged from 2.00 to 59 mg/L, the maximum limit is exceeded at station IV at 59 mg/L. PH of the water within the parameters that can be tolerated by the phytoplankton. BOD values ranged from 5.45 to 10.35 mg/L, all stations above the maximum threshold. COD values ranged from 13.67 to 25.98 mg / L above the threshold at stations I and II. DO values ranged from 6.58 to 6.82 mg/L, all stations are above the threshold. Based on the values of BOD, COD, and DO show Binuang Dam waters have changed.

Ions dissolved total phosphate-P, nitrate, As, Cd, Cu, Pb, SO4, Zn, and Nitrite are all under the maximum threshold, except for Zn ions, in particular stations I and III. Although these ions are below the threshold, but when positioned together in the water, the toxic effect increases . Humidity at the time of the study from 54 to 97.8%, with an average humidity of 75.9%. 21,4-34,2°C air temperature, with an average daily temperature 29,1°C. The total intensity of solar radiation 1826.5%, with an average of 58.9% daily irradiation. Rainfall in October in District Binuang is 0, meaning no rain during October (dry season). Source: Central Bureau of Statistics Tapin District, 2013.

Table 4. Value Density, Abundance and Diversity Index Phytoplankton.

No.	The Name of Species	Number of individuals /L				Critical value				Diversity Index			
		Sta.1	Sta.2	Sta. 3	Sta.4	Sta.1	Sta.2	Sta.3	Sta.4	Sta.1	Sta.2	Sta.3	Sta.4
1.	*Coelosphaerium kuetzingianum*	15,28	2,22	0,83	2,50	12,46	4,33	3,65	7,34	0,302	0,006	0,029	0,068
2.	*Oscillatoria limosa*	8,33	-	2,50	83,33	7,38	-	7,91	51,64	0,161	-	0,068	0,354
3.	*Microcystis aeruginosa*	12,50	83,89	98,61	55,56	9,46	18,59	78,96	37,38	0,212	0,345	0,205	0,440
4.	*Merismopedia* sp	37,22	-	0,83	9,17	23,40	-	6,68	10,74	0,425	-	0,101	0,178
5.	*Closterium* sp	2,78	-	0,56	-	6,22	-	3,44	-	0,102	-	0,021	-
6.	*Draparnaldia plumosa*	2,50	-	0,83	-	6,09	-	6,68	-	0,089	-	0,030	-
7.	*Selenastrum gracile*	2,78	-	-	-	4,61	-	-	-	0,082	-	-	-
8.	*Pediastrum simplex*	23,61	-	-	-	15,00	-	-	-	0,277	-	-	-
9.	*Meugeotia* sp	5,56	-	-	-	6,00	-	-	-	0,164	-	-	-
10.	*Gonatozygon kinahani*	2,78	3,06	1,39	1,67	4,61	8,56	4,06	6,91	0,079	0,023	0,043	0,058
11.	*Spirogyra prolifica*	24,17	1.170	7,78	31,11	15,28	97,45	11,81	24,98	0,264	0,354	0,161	0,424
12.	*Mesotaenium aplanosporum*	3,89	3,06	3,33	0,83	6,78	4,39	5,49	3,46	0,132	0,008	0,118	0,028
13.	*Staurastrum chaetoceros*	0,83	-	-	-	3,64	-	-	-	0,042	-	-	-
14.	*Ankistrodesmus falcatus*	1,39	-	0,83	0,83	3,92	-	3,65	6,49	0,063	-	0,025	0,032
15.	*Sphaeroplea annulina*	3,06	2,50	-	4,72	4,75	4,35	-	5,44	0,083	0,006	-	0,079
16.	*Amphora ovalis*	0,83	0,56	1,39	0,83	3,64	4,21	4,06	6,49	0,034	0,012	0,037	0,034
17.	*Cymbella cistula*	1,39	-	1,11	1,11	2,31	-	6,88	6,63	0,026	-	0,039	0,044
18.	*Cocconeis placentula*	2,50	0,56	-	-	4,47	4,21	-	-	0,098	0,012	-	-
19.	*Stephanodiscus* sp	0,56	0,28	-	0,83	1,89	4,19	-	6,49	0,027	0,006	-	0,028
20.	*Diatoma anceps*	5,83	0,56	3,33	0,28	7,75	4,21	11,55	3,17	0,130	0,011	0,197	0,013
21.	*Stauroneis phoenicentron*	0,56	0,56	-	0,56	1,89	4,21	-	3,31	0,012	0,011	-	0,023
22.	*Eunotia* sp	0,83	0,28	0,28	-	3,64	4,19	3,24	-	0,042	0,007	0,012	-
23.	*Gomphonema geminatum*	0,83	-	-	0,56	3,64	-	-	3,31	0,034	-	-	0,020
24.	*Gyrosigma kutzingii*	4,72	-	0,28	-	5,58	-	3,24	-	0,098	-	0,010	-
25.	*Fragillaria crotonensis*	1,39	-	-	0,56	2,31	-	-	3,31	0,026	-	-	0,023
26.	*Navicula platystoma*	3,61	0,56	0,56	-	6,64	4,21	6,47	-	0,126	0,011	0,090	-
27.	*Nitszchia sigmoidea*	23,89	1,67	4,44	0,56	16,75	8,45	12,38	3,31	0,337	0,015	0,184	0,020
28.	*Synedra ulna*	1,11	0,56	4,17	0,56	2,17	4,21	9,14	3,31	0,045	0,012	0,103	0,023
29.	*Tabellaria* sp	4,44	106,9	1,94	-	5,44	20,27	7,50	-	0,112	0,393	0,061	-
30.	*Surirella striatula*	1,39	-	0,28	0,83	2,31	-	3,24	6,49	0,026	-	0,010	0,028
	Total	200,6	1.377	135,3	196,4	200	200	200	200	3,652	1,235	1,546	1,918

Discussion

The composition and abundance of phytoplankton in a certain very waters act as a natural food in the tropical upper level, and provider of oxygen in water (Jinan *et al.*, 2012; Abida, 2010). The presence of input of organic materials can cause turbidity levels that occur in waters Binuang Dam. This led to the availability of nutrients that are unevenly distributed and the penetration of light that enters the waters will be reduced, thus affecting the activity of phytoplankton in photosynthesis, the same results as reported by James and Bruce (1985).

Table 5. Physical and Chemical State of Water Binuang Dam, Tapin District.

No	Parameters & The unit	Unit	Measurement results at Station				Max. Limit	Range
			I	II	III	IV		
	A. Physics							
1.	TDS	mg/L	143,70	954,00	267,00	249,00	1.000	249-954
2.	TSS	mg/L	3,00	2,00	36,00	59,00	50	2,00-59
3.	Current velocity	cm/s	0,14	0,30	0,23	0,24		0,23-0,30
4.	Colour		bright-greenish	murky brownish	murky brownish	murky brownish		
5.	Brightness	cm	97,33	32,00	37,00	41,33		32,0 - 41,33
6.	Intensity	Lux	9.800	7.500	8.100,00	8.500,00		7500-8.500
7.	Temperature	oC	28,00	31,00	32,00	31,00		31-32
	B. Chemical							
8.	pH	mg/L	7,56	7,54	7,98	7,99	6- 9	7,54-7,99
9.	BOD	mg/L	10,61	10,35	5,45	6,31	3	5,45-10,35
10.	COD	mg/L	26,63	25,98	13,67	15,83	25	13,67-25,98
11.	DO	mg/L	6,61	6,58	6,82	6,79	4	6,58-6,82
12.	Phosphate	mg/L	0,015	0,015	0,043	0,056	0,2	0,015-0,056
13.	Nitrate	mg/L	0,0863	0,063	0,2208	0,1881	10	0,063-,2208
14.	Arsenic	mg/L	0,002	0,002	0,002	0,002	1	0,002
15.	Cadmium	mg/L	0,0043	0,0043	0,0104	0,0043	0,1	0,0043-0,0104
16.	Copper	mg/L	0,0093	0,0093	0,0093	0,0105	0,02	0,0093-0,0105
17.	Iron	mg/L	0,0833	0,1167	0,4144	0,8132		0,116-,8132
18.	Lead	mg/L	0,0095	0,0095	0,0095	0,0095	0,3	0,0095
19.	Manganese	mg/L	0,019	1,154	0,4698	0,2337		0,2337-1,154
20.	Zinc	mg/L	0,0942	0, 0485	0,516	0, 0485	0,05	0, 0485-0,516
21.	Nitrite	mg/L	0,0020	0,0020	0,0020	0,0020	0,06	0,0020
22.	Aluminium	mg/L	0,0390	0,0390	0,1229	0,2644		0,0390-0,2644
23.	Calsium	mg/L	29,5	133,4	21,31	22,55		21,3 -133,4
24.	Sodium	mg/L	3,951	3,165	3,592	3,617		3,165-3,617
25.	Sulfate	mg/L	2,5687	17,956	15,6	17,333	400	15,6-17,956

Dam waters BOD value has exceeded the Binuang, the high value of BOD indicates polluted waters organic matter, particularly at station II. This phenomenon is consistent with the low value of DO at station II compared to other stations. Waters have BOD values of more than 10 mg/L is considered polluted (Effendi, 2003). Phytoplankton species are adaptive in this condition is Cocconeis placentula. This is evidenced by the discovery of this species only at station II.

Chemical Oxygen Demand (COD) at station II (25.98 mg/L), well above the limits of the standard. The high BOD and COD values illustrate that these waters have been polluted by organic waste and negative impact on the lives of aquatic animals. The presence of sulfate in these waters deserves attention, given these waters close to the coal mining area, the elements Fe reaction with SO_4 to form a compound $FeSO_4$. high concentrations of these compounds may endanger the survival of aquatic organisms. Changes to water quality can be evaluated from the abundance and composition of phytoplankton (Wijaya and Hariyati, 2009). This is because phytoplankton plays an important role in a body of water. Phytoplankton serve as primary producers in the food chain and have the ability to respond to a change to the environment (Baxter, 1977).

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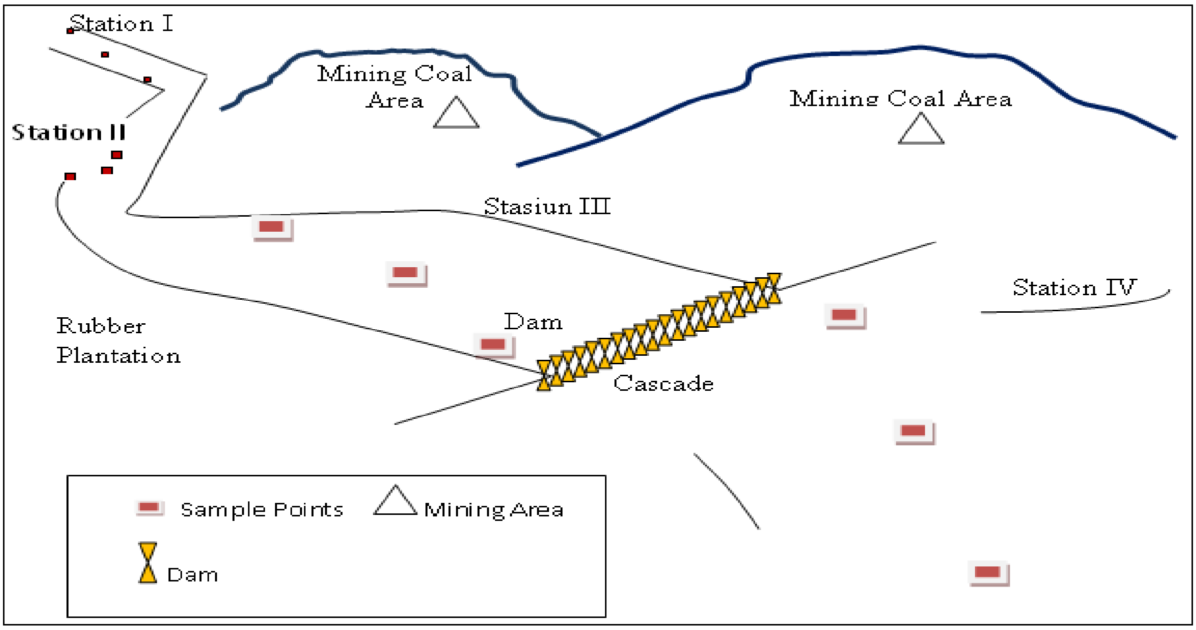

Fig. 1. Location Map and Point Sampling at Binuang Dam.

The density of the species and the value of the highest importance is *Spirogyra prolifica*, and *Microcystis aeruginosa*. The density of the species and the importance of the two species is related to the ability of the class Chlorophyceae in phytoplankton photosynthesis, and the two species have a range of high tolerance to environmental factors. This is supported by the open water conditions, so there is no barrier for the sunlight to enter the waters (Emma *et al.*, 2011). Bold and Wynne (1978) stated that the phytoplankton of the class Chlorophyceae and the most widespread species endemic area. Both of these species are able to take advantage of sunlight even in the minimal (Kasim *et al*, 1999; Peterson *et al*, 1989).

The dominance of the phytoplankton community by *Microcystis aeruginosa* and *Spirogyra prolifica* need to watch out, because the population explosion (blooming) both species of algae can be harmful to other organisms and disrupt the stability of aquatic ecosystems. Domination by certain species indicates that the aquatic ecosystem is no longer stable. This indicates that the water quality is already affecting the phytoplankton community structure (Francesca *et al.*, 2004).

Phytoplankton species that has the lowest density is *Diatoma anceps* at station IV, *Eunotia sp* at stations II and III, and *Gyrosigma kutzingii* at station III, with each only density of 0.28 ind. / L. Lowest abundance *Diatoma anceps* is a species found in station IV. Phytoplankton species are from the phylum Chrysophyceae. The difference in the value of the abundance of phytoplankton can be caused by several factors including: the availability of nutrients, the presence of water and the rate in column light grazing by other organisms (Konge *et al.*, 2012). The small numbers on the density and abundance of phytoplankton species is suspected because of the ability to adapt to environmental conditions less water (Abida, 2010).

Factors such as zooplankton predators, and the influence of physico-chemical factors waters unsuitable especially BOD and COD levels are high, the presence of some dissolved heavy metals such as iron and including mineral phospor (Healey and Hendzel, 2011), manganese, aluminum, and sulfate which is a limiting factor and may inhibit growth. Heavy metal naturally found in all of nature, but in very low levels. Originally the entry of heavy metals into waters naturally divided into three a) comes from the coast, including rivers and the results of erosion by waves and weathering rock, b) is derived from the oceans as a result of volcanic activity that is in the sea, c) is derived from the atmosphere in the form of particles or dust that fell into the sea (Bryan in Supriharyono, 2000). Onyema *et al.* (2008) and also Alfiandri and Harahap (2012) stated that heavy metal contaminants in the water can be influenced by oceanographic parameters include temperature, salinity, pH, flow velocity, and wave turbelensi. Increased content of heavy metals in seawater besides allegedly by increased activity of nearby waters, can also suspected by low pH and salinity (Courtney *et al.*, 2009), high temperature (Fortune *et al.*, 2009) and nutrient influx from river mouth into the sea (Hans *et al*, 2007). In this study, total dissolved ions Phosphate-P, Nitrate, As, Cd, Cu, Pb, SO_4, Zn, and Nitrite are all under the maximum threshold, except for Zn ions, in particular stations I and III.

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