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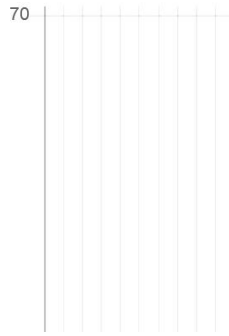

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Water quality and fish diversity in the Brantas River, East Java, Indonesia

Alfiah Hayati*, Nureka Tiantono, Muhamad Fadhil Mirza, Iman Dary Supriyadi Putra, Muhamad Maulana Abdizen, Antien Rekyan Seta, Binti Mar`atus Solikha, Muhamad Hilman Fu'adil, Trisnadi Widyaleksono Catur Putranto, Mochamad Affandi, Rosmanida

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Abstract

This research aimed to determine the water quality and fish diversity in Brantas river. Three station for sampling locations were in the upstream (one station on Karangkates reservoir) and downstream (two stations on the Surabaya and Jagir river). Water quality parameters were BOD, COD, DO, pH, temperature, and the levels of heavy metals (Pb, Cr, Cu, and Cd). Fish specimens was identified using fish identification book. The results of this research indicated that there was a difference in the water quality of upstream and downstream of the Brantas river. On the upstream, the source of pollution was mostly from fish catching, agriculture, and industrial activities. While on the downstream of the river it mostly dominated by industrial waste and domestic waste. The water quality in both stations had far exceeded the quality standards that was included in the polluted category. The concluded that Brantas river has been contaminated by waste (heavy metals), exceeded the water quality standard. The diversity of fish in the down-stream (Surabaya river) has the highest diversity values, followed Jagir river and in the upstream (Karangkates reservoir) has the lowest value of diversity. Brantas river water was included in the category of moderate diversity.

Keywords: Brantas river, water quality, heavy metal, fish

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Introduction

Brantas river is the second longest river in Java island after Bengawan Solo (Usman,-). The downstream of Brantas river branches off to become Surabaya river and Porong river. Surabaya river branched into Kali Mas and Jagir river, then it flows into the Java Sea. Brantas river has very important role for east Java's rice cultivation, it provides water for irrigation and also domestic water supply for the cities along the stream. Located on the upstream side of Brantas river is Karangkates reservoir. The ecosystem on the upstream and downstream of Brantas river is highly effected by anthropogenic pressure. This anthropogenic pressure comes from the number of residential buildings, agriculture, and industries which build along downstream Brantas river Surabaya river (Begum et el., 2008; Nugrahadi et al., 2011).

The number of residential buildings along the river has increased the pollution load of Brantas river, there are also many industrial activities contribute in increasing the pollution by disposing the waste directly into the river. The Brantas river watershed which flows in Surabaya has many uses, both directly and indirectly. The direct uses of the river are as clean water source for domestic uses, provides water for local water company, and support livelihood of local fisherman. The indirect use is as the habitat of aquatic biotas that serves as food source for the people in Surabaya city and as bio-indicator of the ecosystem such as fish. River pollution is generally caused due to high levels of heavy metals. Heavy metals contained in the river was toxic and disrupt aquatic ecology. These pollutants have a negative impact on water quality and biota of water as a source of animal protein (Akobundu, 2012).

Fish is one of aquatic biotas that plays important role in the stabilization of water ecosystem and also for the people along the stream (Pracheil, 2010). High levels of fish diversity indicates high quality of waters ecosystem, so that the level of fish diversity can be used as indicator to estimate water quality and level of pollution presents in the waters (Ngodhe et al., 2013).

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Method

The materials used in the measure-ment of water quality were samples of water which directly taken from Brantas River, titration solution, digital camera (Canon EOS 550 D and Sony), Fish Identification Guidebook (Kottelat et al, 1993).

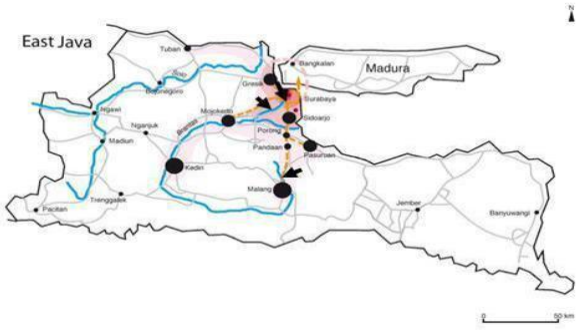

Figure 1. Sampling station was in the upstream and the downstream of Brantas river (arrow)

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Sampling (water and fish) were three stations: one station on the upstream of the Brantas river (Karangkates reservoir) and two stations in the downstream of the Brantas river (Surabaya and Jagir river). Sampling were done in March, June and September 2016. Sampling was repeated twice on each station.

Measurement of Water Quality

Samples of water were taken using Water Sampler, then the physical and chemical parameters were measured in the field. The quantity of dissolved oxygen (DO) was determined by electrochemical method using DO meter. The water temperature was measured using Mercury Thermometer. The water acidity was estimated using pH meter and Litmus paper.

Measurement of Water Transparency

The water transparency was measured using Secchi Disk. To accurately estimate the water transparency, ensured that the Secchi Disk was installed properly in the rope. After that, the Secchi Disk was slowly lowered into the water until the white disk is no longer visible. The length of the rope was measured using measure tape or ruler to obtain the first depth. Then, the Secchi Disk was pulled slowly until the white disk was visible, and the second depth was measured. The value of water transparency was the average of the two depth [Water transparency (cm): (1^{st} depth + 2^{nd} depth)/2].

Measurement of Biochemical Oxygen Demand (BOD)

BOD measurement was done in several stages. The first stage was made of the reference solution, namely by entering the diluent solution which has been made into two clean bottles to the brim and then sealed. The first bottle directly titrated to determine DO in zero day (DO_0) and a second bottle was stored in an incubator 20 ° C during the five days (DO_5 blank), then prepare 12 bottles BOD for dilution, the next stage of dilution of samples, water samples obtained included in 12 BOD bottles for 6 types of dilution, then enter the dilution water. The first-sixth bottles were evaluated the specified DO in zero day (DO_0). In the seventh - twelfth bottles were incubated at 20 ° C for five days (DO_5). Furthermore, namely stage BOD value calculation, the formula used to calculate the BOD value is as follows: BOD_5 (20 ° C 5 days) = (DO_0 - DO_5 sample) x dilution.

Measurement of COD

To measure the COD beforehand the water samples were taken using water sampler, then placed in sampling bottle and kept in ice box. After that, 5 ml of sample was pipetted into 250 ml Erlenmeyer tube. Then added 1 gr of Hg_2SO_4, 1 mL $K_2Cr_2O_7$ (0,25 N), 3 mL reagent that contains Ag_2SO_4 and H_2SO_4, placed the screw-cap and the Erlenmeyer was shook until homogenous. Then, the COD tube was placed inside the COD incubator under the temperature of 148^0C for two hours. After incubated for two hours, the sample was then heated and the COD incubator was turned off. The solution inside the COD tube was then poured onto new Erlenmeyer tube and the COD tube was washed with distilled water. Ferroin indicator was added into the solution and the titration was done by adding Ferro Ammonium Sulphate (FAS) 0.1 N. The calculation of COD levels was conducted to both blank and samples.

Measurement of heavy metals levels

Heavy metals (Pb, Cr, Cu, and Cd) in water sample were detected by AAS. Water samples were collected from three different sampling station, one station in the upstream (Karangkates reservoir) and two station in the downstream (Surabaya and Jagir river) of Brantas river. Samples were collected in good quality screw-capped high density pre sterilized polypropylene bottles, 1 L each bottles. Then the bottles were labelled properly and analysed in laboratory to detect the levels of metals by Atomic Absorption Spectrometer (AAS). High pure (Anal R grade) chemicals and double distilled water were used for preparing solutions for analysis. Preservation and analysis of water samples were based on Standard Methods proposed by American Public Health Association (APHA). The selected metals used in this study were Pb, Cd, Cr, and Cu.

Fishes Identification

Sampling fish in every station done by catching on the small boat for 2 hours. Mesh sizes for one mess then identified using Fish Identification Book. The book used in identifying the fish species is the Identification Book by Kottelat et al (1993).

Measurement of Diversity Index

The fish diversity was estimated through evaluating the fish species diversity or heterogeneity index. The species diversity was evaluated using formula of Shanon-Wiener's diversity index (1949):

$$H' = -\sum_{i=1}^{n} \left[\frac{n_i}{N} \ln \frac{n_i}{N} \right]$$

H' = Shannon-Wiener Diversity Index
ni = Number of individual types of all n
N = Total number of individuals

Data Analysis

The data obtained from the observation and measurement of the water quality was analyzed using descriptive statistic.

Results

The result showed that the water quality in Brantas River is varies in each sampling location. It relates to the physical-chemical factors of waters in Brantas River. During the research, the average amount of rainfall in Surabaya, according to the Indonesian agency of Meteorology, Climatology and Geophysics (BMKG) is presented in Figure 2.

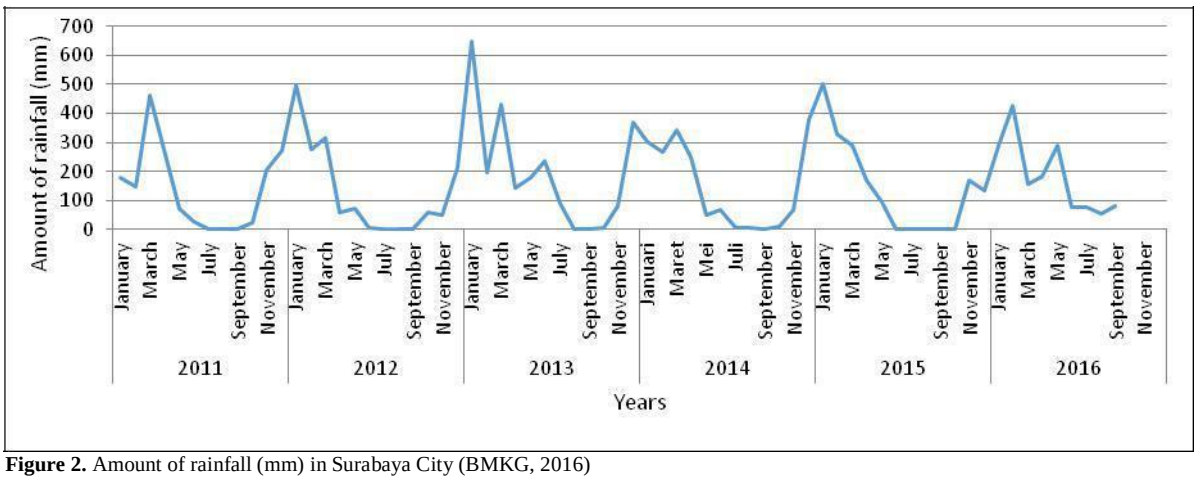

Figure 2. Amount of rainfall (mm) in Surabaya City (BMKG, 2016)

The rainy season is characterized by the amount of rainfall over 50 mm, meanwhile the dry season occurs when the rainfall is less than 50 mm.

Based on these dates, the result obtained from the sampling during March to September 2016 in three stations (one station of the upstream (Karangkates reservoir) and two stations at downstream (Surabaya and Jagir river) showed that the water quality in this location is very low and exceeded the water quality standard (Figure 3). Water quality standards (East Java Governor Regulation No. 61 Year 2010) is 3 ppm for BOD, 25 ppm COD, 4 ppm DO, while a pH of 6-9, and a temperature deviation of 3°C.

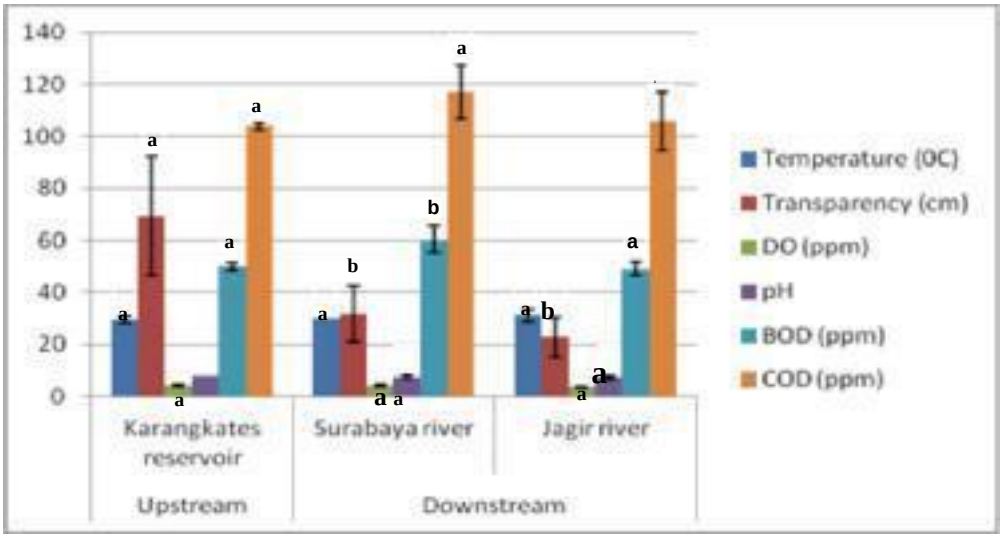

Figure 3. The water quality of the upstream and downstream of Brantas river in 2016

Statistical analysis (ANOVA) showed no significant (P>0.05) difference between the quality of the water (temperature, DO, pH, and COD) with a third variation of the sampling station (upstream and downstream), except transparency and BOD. Transparency in the upstream (Karangkates reservoir) is higher than the downstream (Surabaya and Jagir river) and BOD in the lower upstream than downstream.

The data variations and levels of heavy metals in the water of the Brantas river is presented in Figure 4. The results showed concentrations of heavy metals (Pb, Cr, Cu, and Cd) downstream Brantas higher than upstream. Based on data from heavy metals (Figure 4) shows the concentration of heavy metals in the Brantas river has exceeded the quality standards. The quality standard Pb (0.03 ppm), Cr (0.05 ppm), Cu (0.02 ppm), and Cd (0.01 ppm).

Results of statistical tests (ANOVA) showed no significant (P>0.05) difference between the concentrations of all heavy metals (Pb, Cu, and Cd) with a variety of sampling stations (upstream and downstream), except Cr. Cr concentration in higher downstream than upstream.

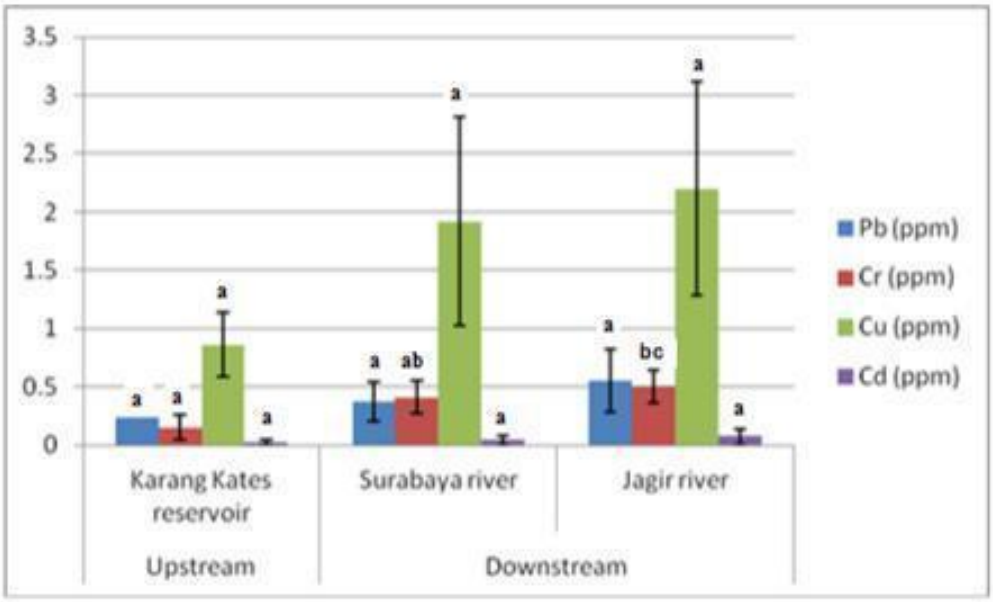

Figure 4. The levels of heavy metals on the upstream (Karangkates reservoir) and the downstream (Surabaya River and Jagir River) of Brantas River in 2016.

Results of sampling fish in the river Brantas (Karangkates reservoir, Surabaya and Jagir river) found various kinds of fish. The diversity of fish in the river Brantas shown in Figure 5.

The results of the fish sampling upstream and downstream of the river Brantas shows the average fish most commonly found in the downstream (Jagir river of 108.67 individu), then followed up the Brantas river (Karangkates reservoir of 98.67 individu), whereas in other Brantas River downstream (Surabaya river just 95.67 individu). The number of fish species diversity of 25 species, with 13 species of details in the upstream and downstream (Surabaya river river Jagir 19 species and 17 species) (Figure 5). In Karangkates reservoir fish species most commonly found are *Amphilopus labiatus* (55 animals), Surabaya river that *Barbonymus gonionotus* (35.33 individu), and Jagir River species most commonly found was *Hemibragus nemurus* (Table 1).

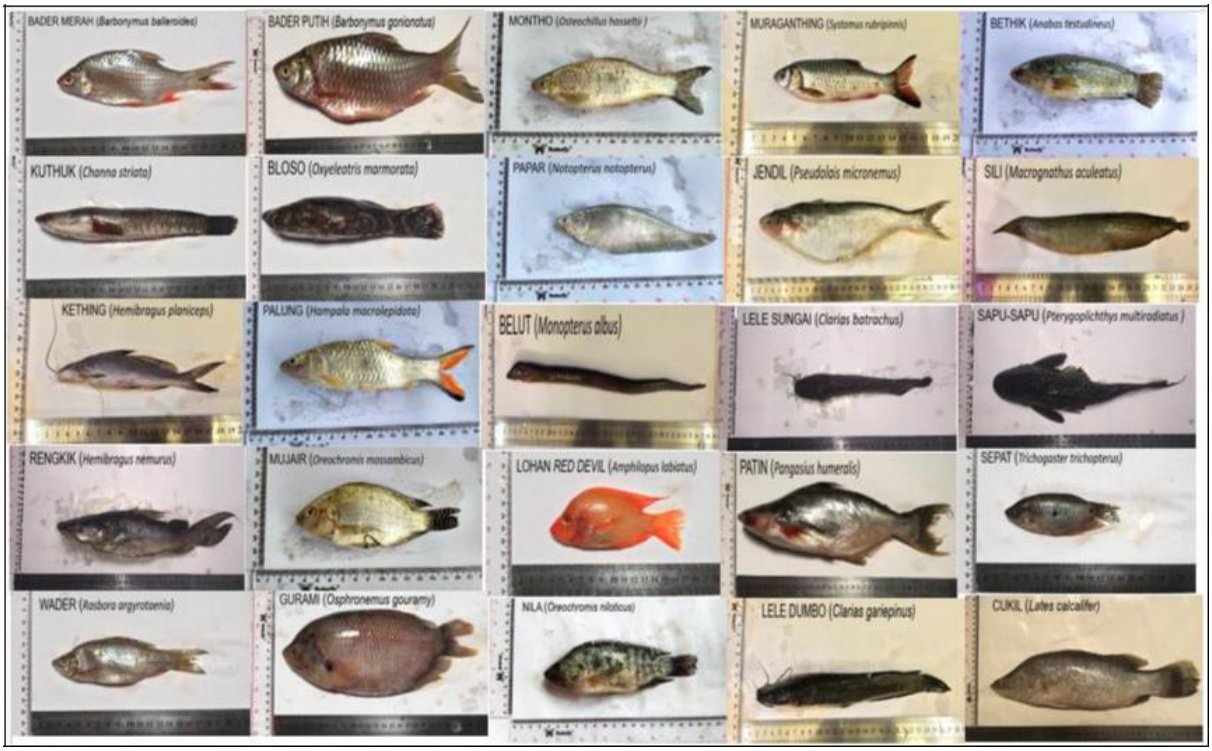

Figure 5. Fish diversity in Brantas River

Table 1. The average number of fish species found in the upstream and downstream Brantas river

No	Species	Local names	Upstream	Downstream	
			Karangkates reservoir	Surabaya river	Jagir river
1	*Barbonymus balleroides*	Bader Merah	3.83	25.67	7.00
2	*Barbonymus gonionotus*	Bader Putih	4.83	35.33	8.67
3	*Osteochillus hasseltii*	Montho	2.17	6.33	0.67
4	*Systomus rubripinnis*	Muraganthing	0.00	1.33	0.67
5	*Anabas testudineus*	Bethik	0.00	2.50	0.67
6	*Channa striata*	Kuthuk	1.50	3.17	1.00
7	*Oxyeleotris marmorata*	Bloso	1.33	2.17	1.33
8	*Notopterus notopterus*	Papar	0.00	1.50	0.00
9	*Pseudolais micronemus*	Jendil	0.00	1.00	10.67
10	*Macrognathus aculeatus*	Sili	0.00	2.50	0.00
11	*Hemibragus planiceps*	Keting	0.50	2.83	39.00
12	*Hampala macrolepidota*	Palung	0.00	1.17	3.33
13	*Monopterus albus*	Belut	0.00	0.17	0.33
14	*Clarias batrachus*	Lele Sungai	0.00	0.50	2.33
15	*Liposarcus pardalis*	Sapu-sapu	0.67	0.67	1.67
16	*Hemibragus nemurus*	Rengkik	0.00	0.67	26.67
17	*Oreochromis mossambicus*	Mujair	20.50	4.50	0.00
18	*Amphilopus labiatus*	Lohan *red devil*	55.00	0.00	0.00
19	*Pangasius humeralis*	Patin	1.17	0.00	0.00
20	*Trichogaster trichopterus*	Sepat	1.17	1.50	0.33
21	*Rasbora argyrotaenia*	Wader	4.67	0.00	0.00
22	*Osphronemus gouramy*	Gurami	1.33	0.00	0.00
23	*Oreochromis niloticus*	Nila	0.00	2.17	0.00
24	*Clarias gariepinus*	Lele Dumbo	0.00	0.00	3.00
25	*Lates calcalifer*	Cukil	0.00	0.00	1.33
The average number of fish			**98.67**	**95.67**	**108.67**

The calculation result of diversity index of Shannon-Wienner showed that the value of fish diversity index highest in the downstream (Surabaya river at 1.8030), followed Jagir river (1.6294) and the upstream (Karangkates lowest reservoir 1.3913). The one of the species that dominate upstream ie *Amphilopus labiatus* invasive species. The existence of this fish makes the loss of other fish species. This makes the species found in the upstream fewer than downstream (Figure 6). Species are few and difference between the abundance of species from each other will make the value of diversity to be low.

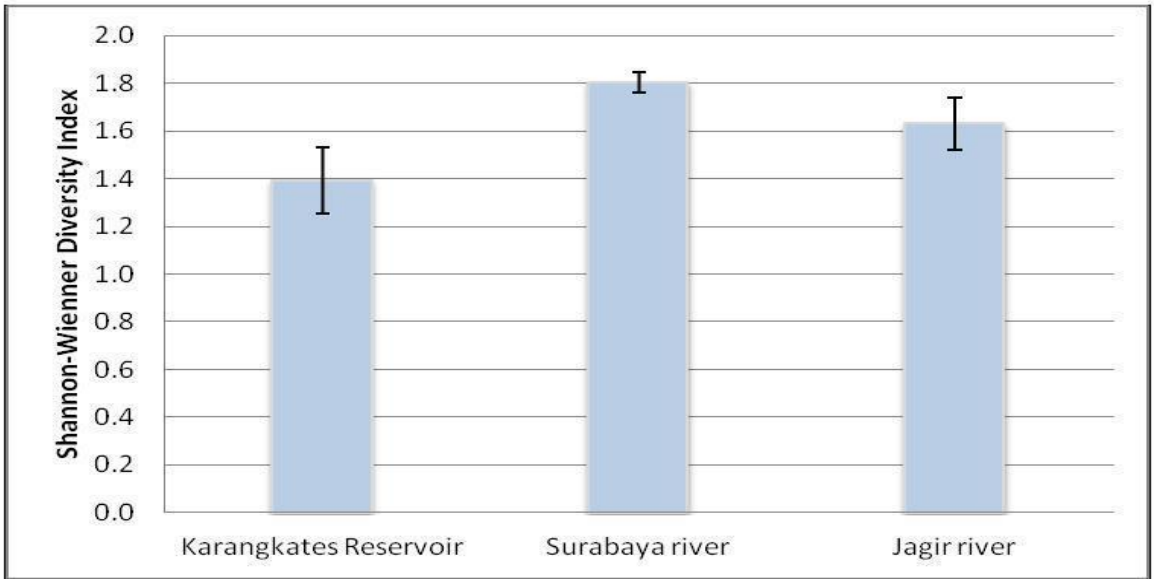

Figure 6. The values of fish diversity index in Brantas River based on Shannon-Wienner's index (1949).

Discussions

The dry season was happened from June to October (Figure 2) that in the years 2011-2015, while the rainy season was happened in the rest of the months. But, this pattern is different from 2016 where it rain almost throughout the year. This happened because Indonesia, specifically Surabaya, is located in very strategic area, where it located in tropic region between two continents (Asia and Australia) and two oceans (Pacific and Indian Ocean), so that the region is very vulnerable to climate or weather change. The weather anomalies that happened in 2016/2017 was caused by natural phenomena, namely the El Nino and La Nina and also the changes in sea surface temperatures.

Based on this data can be seen that in the upstream and downstream of the Brantas river has been polluted organic waste (Alaerts and Santika, 1984), where most of the pollution comes from household and industrial waste. Based on the water quality parameters, it can be seen that the downstream part of the Brantas river has contamination levels higher than the upstream part, this is because many domestic and industrial waste that enters the waters of the downstream of Brantas river, besides the pressure of pollution from the upstream also increases the pollution load on the lower reaches of the Brantas river.

In the Brantas river upstream fish is dominated by family groups Cichillidae one of which is *Amphilopus labiatus* a fish species that are invasive alien who came from Nicaragua, Latin America (Loiselle, 1998), thus reducing the presence of other species. Additionally circumstances Karangkates Reservoir waters which are tapering also supports the development of this *Amphilopus labiatus*. According Baensch & Fischer (2007), the most suitable habitat for fish Amphilopus is the stagnant waters of the lake. The fish most commonly found in the section essentially rocky and not commonly found in the section where the water tends to flow. In the downstream of the Brantas River precisely in Surabaya River, the species most commonly found are *Barbonymus gonionotus*, this is because the nature of the waters of Surabaya River is lotik and fish *Barbonymus gonionotus* fish families Cyprinidae According to Cummins and Wilzbach (2008), fish Cyprinidae have high adaptability the most important environmental factors in rivers, namely the strong current. Adaptation to the strong currents which have the ability to swim fast. This fast swimming abilities possessed by the species of the family Cyprinidae so as to fight the current strong enough to pass through the fish ladder. Fish Cyprinidae have an aerodynamic body shape to be able to move to maintain its position in the strong current to get food in the form of invertebrates that float along the water (Cummins and Wilzbach, 2008). In Jagir River fish species most commonly found are *Hemibragus nemurus* this is because the fish species is a group Siluriformes fish or catfish. According Vannote et al., (1980) on the river width or downstream (Order > 6) is dominated by invertebrates collector types and usually in dominance by fish groups and groups of fish species of catfishes planktivorous (plankton). This is the reason fish group Siluriformes one *Hemibragus nemurus* found many in Jagir river.

Based on the results of the diversity according of Odum (1971) included into the range of categories between 1 <H '<3 where the range of those categories waters Brantas river can be inferred to have diversity being, productivity is quite balanced, pressure ecological being, and stability being.

Acknowledgement

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