

A Diversity Comparison Study of Plankton and Benthos Related to the Pollution Level In Reservoir Mulur, Central Java

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Abstract

Sunarto. 2013. As a freshwater formation, Reservoir Mulur is also a habitat for freshwater organisms. This includes a variety of plankton and benthos. The life of these organisms will be closely linked to environmental conditions, including water pollution levels. Sensitivity of aquatic organisms such as plankton and benthos make it as a good bio indicator for pollution. The purpose of this study was to determine the diversity level of plankton and benthos in Reservoir Mulur as well as to determine the pollution level of the waters of the reservoir. The analysis of pollution level is done by using the formula Shannon-Weiner diversity index. Water pollution level is determined by the amount of Shannon Weiner diversity index of plankton and benthos. The three sample locations of Reservoir Mulur generates Shannon Weiner ID values for plankton 2,219 (Station I), 2.427 (Station II) and 2.356 (Station III). As for the benthos Shannon Weiner ID values obtained 1,665 (Station I), 1.529 (Station II) and 0.975 (Station III). Based on the Shannon Weiner ID plankton, the entire site is being considered impure. This condition is different from the level of contamination based on Shannon Weiner ID benthos. The results based on a comparison of pollution levels in a row ID benthos were continuously polluted, moderate and severe.

Keywords: Reservoir elongation, pollution, plankton, benthos, Shannon Weiner

1 Introduction

Water becomes a vital resource and a fundamental requirement for life in this world. The role of water is very complex ranging from the individual to the communal needs. Water needs are increasing with the rapid growth of the human population on earth. The increasing demand for water is not in line with its limited availability. In fact, there is only 0.5% of the Earth's water resources left that can be immediately used. Even then, most of

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them now is in threat of the degradation of its quality and quantity (Odum, 1983; Widiarti and Ristianti, 2003; Hima, 2011). Reservoir Mulur is one multifunctional reservoir located in Sukoharjo, Central Java. The main function of this reservoir, among others, is as a means of water (irrigation), freshwater fisheries, recreation, and flood control reservoir. The dynamics use of this reservoir causes water quality degradation. Some of the negative impacts that may arise is the increased potential for water pollution and fertility. The main object of this research is the level of pollution in Reservoir Mulur. In this study the pollution level identified by comparative studies of Shannon Weiner diversity index value. The diversity observed in this study is the phytoplankton and benthos. The phytoplankton can be the indicator in surface waters, while the benthos can be the indicator of the waters in various roles as a filter feeder. This research is related to the water quality conditions concerning contamination levels and fertility. This research is expected to pave the way for subsequent research and insights as well as the policy maker parties. Through this research, the general public as well as the government will obtain significant information about the latest water quality in terms of the pollution level in Reservoir Mulur. The results of this research are two main data, namely: (1) the data of phytoplankton and benthos diversity and (2) the data rate of Reservoir Mulur contamination. The information from the output of the research will provide insight into related party as well as a reminder to pay attention to the condition. The role of Reservoir Mulur for the surrounding community is quite large. Acts of neglect of its management functions will potentially degrade even eliminate the existence of these reservoirs in the future.

Reservoir Mulur is located in Mulur village, District Bendosari, Sukoharjo, Central Java. This dam was built in 1926 and was subsequently expanded in 1940. Currently, the known Reservoir Mulur was built on state land area of 151 hectares with an area of 119.59 hectares and the area of inundation extents Watershed (DAS) by 7.82 km². The only water supply to this reservoir is River Jlantah through Dam Pepen (BPSDA, 2002). The utilization of Reservoir Mulur by a majority of the public is about freshwater fishing with floating net-cages. In some areas, people use the land around as the rice fields. Fishing area is located near the embankment on the west. Meanwhile, the majority of the rice fields area is in the south to the east. In the rice fields is often found diverse water bird activity (BPSDA, 2002). Reservoir Mulur is often used as a local recreation. However, as the use of tourist facilities are not yet well organized. This reservoir tourism has not been promoted well so that its popularity has not been able to compete or support similar to the surrounding attractions such as Reservoir Gajah Mungkur. However, in time, the attention of the local government to develop this reservoir begins to appear. Reservoir Mulur indicated potential contamination originating from settlements and freshwater fisheries. In addition, the people's habit in using reservoir conditions also plays a role. Communities around the reservoir will typically utilize a dry land during the dry season as a temporary agricultural land. According to Barg (1992), agriculture and fisheries waste potentially cause hyper nitrification followed by the increased sedimentation, siltation, hypoxia, the changes in productivity and the benthic community structure.

1.1 Water Pollution

Law No. 32 of 2009 defines environmental pollution as the entry or the inclusion of living things, matter, energy, and / or other components into the environment by human activities that exceed the environmental quality standards that have been set. Water pollution specifically defined in Government Regulation No. 82 of 2001 as the introduction of living

things, matter, energy, and / or other components into the water by human activity causing water quality down to a certain level so that the water cannot function in accordance with their distribution.

According to Rapport (1989) and Norris and Thoms (1999) there are three approaches to differentiate waters "sick" and "healthy". All three indicators are: (1) the existence of a measurable stress or characteristics and indicators, (2) the ability of ecosystems to cope with the pressure or the bounce back (Holling, 1973), and (3) identification of risk factors such as the existence of industrial and sewage effluent (Barbosa, Callisto and Galdean, 2001).

Pollution in freshwater especially in lakes and reservoirs by various pollutants typically the subject of attention around the world as well as the subject matter area of major world's fresh water resources (Vorosmarty *et.al.*, 2010 in Thevenon and Pote, 2012). One of the freshwater pollutants now that need to be concerned on is the heavy metals. Heavy metals are natural components in the ground, with some of them as micronutrients needed by plants. The current pollution by heavy metals grown dramatically in the biosphere, including the waters by industrial activity and many of the toxic nature. (Benimeli *et.al.*, 2009).

The aquatic organisms become the sensitive area to water pollution. These organisms often act as bio-indicators for water. Bio-indicator is defined as an organism, or chemical markers of biological processes that are observable changes in its value as an indicator of changes in the environment and can also identify and quantify the impact of a pollutant in the environment. The use of bio-indicators of the water will act: identify the contamination, identification of toxic mechanisms, providing an early warning of environmental damage and provide an early indication of environmental remediation (Jain *et.al.*, 2010).

1.2 Plankton and Benthos Diversity

The diversity of living species in the waters is often indicates of the level of contamination. The existence of a species serves as markers of biological changes in water quality (Mills, 1989). Community is the most appropriate indicator to study the effects of environmental change. Natural communities are dynamic and always changing towards equilibrium (Botkin and Keller, 2000).

Methods of measuring water quality by physical and chemical indicators provide only limited data on the current state of the observations were made. This condition will give a serious problem when measurements carried out on water flow or to determine the condition in the long range. Judgment based only towards the condition of waters indication of physics and chemistry are not effective because the necessary observations periodically to provide better and continuous data (Lobo *et.al.*, 2004).

Biodiversity is able to represent not only the types of organisms that live in an area with ecological processes itself. Furthermore, biodiversity shows the interaction between the two components which can be translated to the ability of ecosystems to support life within (Barbosa *et.al.*, 1997, 1999; Galdean and Staicu, 1997 in Barbosa, Callisto and Galdean, 2001). This demonstrates the ability of biodiversity to describe the condition of the environment in the long span of time not only when the observations were made.

Plankton and benthos are two typical kinds of different aquatic organisms, especially when viewed by the depth of his habitat. Plankton is an organism that floats in the water and its movement depends on the flow of water motion. Benthos is an organism that creeps in the

bottom of the reservoir or most part of its body is in aquatic sediments. Benthos is distinguished by its way of eating a filter feeder and deposit feeder (Odum, 1983). Macro-benthos play a significance role to the aquatic community for its ability in mineralization, lifting and mixing of sediment, flow of oxygen into the sediment and organic material processing (Lind, 1979 in Khan *et.al.*, 2007).

2 Research Methods

2.1 Location and Time of Research

This study was located in the reservoir, located in Mulur village, District Bendosari, Sukoharjo regency, Central Java. The identification of types of plankton and benthos was conducted at the Laboratory Center and Laboratory Science Faculty University Sebelas Maret Technical Center Environmental Health and Communicable Disease Control. Sampling time was done in September 2012.

2.2 Procedure and Data Analysis

Samples for identification of plankton and benthos conducted in Reservoir Mulur at 3 different locations namely region sluice outlet (station I), Karamba region (station II) and the center of the reservoir (station III). Water samples taken for identification of plankton using plankton net and composites performed to homogenize the water on several layers of depth.

Benthos identification is done by taking sediment samples in the bottom of the reservoir waters at each station using Eckman Grab observation. Water and sediment sampling at each site performed repetitions for three (3) times. The procedure for identifying the type and amount of plankton carried out in accordance with the SNI 06-3963-1995 method. Meanwhile, for the type and amount of testing carried out in accordance with the method of Benthos SNI 03-3401-1994.

Determination of plankton and benthos diversity using Shannon Weiner Diversity Index with the following formula:

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

With:

H': Shannon Weiner Diversity Index

p_i: n_i / N, n_i is the number of species in the sample n and N is the total individual sample (Shannon-Weiner in Nolan and Callahan, 2005)

To compare the Shannon Weiner diversity index to the level of water pollution regulations used diversity index > 3.00 indicates the water is not polluted, index range of 1.00 to 3.00 indicates moderate blackened and diversity index < 1.00 showed blackened heavy (Wilhm and Dorris, 1967 in Khan *et.al.*, 2007).

Shannon Weiner diversity index of plankton and benthos in different test next 2 independent samples (T Test) to determine whether there is a difference in the two typical

diversity of the aquatic organisms. Diversity index and the calculation results with the provisions of its comparison in pollution levels based on Shannon Weiner diversity index were analyzed descriptively.

3 Main Result

Reservoir Mulur as an artificial lake is currently get less attention from both the public and relevant agencies. In fact, it was one of the reservoirs used by the people through a variety of functions given, among others, as a means of irrigation, freshwater fishery that sometimes tourist sites. Needs of the surrounding communities will be increased up to the amount of fishing pressure of the reservoir. Reservoir optimization will threaten the survival and function of the age of the reservoir in the future, especially if there is no management. Utilization will bring the potential risk of increased pollution and eutrophication.

Results of water sampling and soil from the 3 stations acquire data types and amount of plankton and benthos as follows:

Table 1: Results of water sampling and soil for plankton from the 3 stations

Organism	Name of the Species/Amount					
	Station I		Station II		Station III	
Plankton*	<i>Actinastrumsp</i>	6	<i>Anabaena sp</i>	84	<i>Closteriumsp</i>	6
	<i>Anabaena sp</i>	71	<i>Chlorella sp</i>	48	<i>Cyclotellasp</i>	81
	<i>Chlorella sp</i>	18	<i>Closteriumsp</i>	13	<i>Diatomasp</i>	18
	<i>Cyclotellasp</i>	18	<i>Cyclotellasp</i>	32	<i>Euglena sp</i>	26
	<i>Diatomasp</i>	21	<i>Diatomasp</i>	99	<i>Merismopediasp</i>	24
	<i>Euglena sp</i>	5	<i>Euglena sp</i>	10	<i>Naviculasp</i>	43
	<i>Merismopediasp</i>	25	<i>Flagilariasp</i>	5	<i>Nitschziasp</i>	24
	<i>Naviculasp</i>	11	<i>Lyngbyasp</i>	61	<i>Oscillatoriasp</i>	48
	<i>Pediastrumsp</i>	6	<i>Merismopediasp</i>	47	<i>Pediastrumsp</i>	3
	<i>Phytoconissp</i>	14	<i>Naviculasp</i>	5	<i>Phacussp</i>	22
	<i>Spyrogyrasp</i>	19	<i>Nitschziasp</i>	28	<i>Phytoconissp</i>	16
	<i>Surirellasp</i>	2	<i>Phacussp</i>	7	<i>Scenedesmussp</i>	3
	<i>Synedrasp</i>	1	<i>Phytoconissp</i>	42	<i>Spyrogyrasp</i>	5
	<i>Ulothrixsp</i>	9	<i>Scenedesmussp</i>	3	<i>Synedrasp</i>	24
	<i>Melosirasp</i>	1	<i>Spyrogyrasp</i>	20	<i>Anabaena sp</i>	42
	<i>Tabellariasp</i>	1	<i>Spirulinasp</i>	20	<i>Chlorella sp</i>	8
			<i>Staurastrumsp</i>	1	<i>Spirulinasp</i>	6
			<i>Ulothrixsp</i>	11	<i>Ulothrixsp</i>	21
			<i>Gyrosigmasp</i>	1		
			<i>Synedrasp</i>	2		

Table 2: Results of water sampling and soil for benthos from the 3 stations

Total Spesies Plankton	228	539	420
Benthos**			
<i>Pinnulariaviridis</i>	6	<i>Temoraturbinata</i> 1	<i>Synedracapitata</i> 3
<i>Temoraturbinata</i>	2	<i>Synedracapitata</i> 5	<i>Frustulia</i> 4
<i>Synedracapitata</i>	4	<i>Frustulia</i> 5	<i>vulgaris</i> 10
<i>Frustulia vulgaris</i>	15	<i>vulgaris</i> 11	<i>Alloheleasp</i> 23
<i>Skistidiaptomussp</i>	10	<i>Skistidiaptomussp</i> 3	<i>Balantidium coli</i> 106
<i>Tubifexsp</i>	3	<i>Alloheleasp</i> 8	<i>Pleurocerasp</i> 3
<i>Pleurocerasp</i>	5	<i>Pleurocerasp</i> 1	<i>Pilaampullacea</i> 2
<i>Pilaampullacea</i>	33	<i>Pilaampullacea</i>	<i>Skisdiaptomussp</i>
Total Spesies Benthos	78	34	151

The results types and amount of plankton and benthos in Table 1 shows the highest number of total organisms (plankton and benthos) at station III and the fewest at station I. For the highest species diversity in station II (20 species of plankton and benthos 7 species) and the lowest at station I (16 species of plankton and benthos 8 species). Differences between the species making up the community stations are not too flashy when it is compared to the number of individuals between stations.

In detail, the amounts of plankton were observed at station II (539) and fewest first stations (228). Meanwhile, for the most benthos at station III (151) and fewest station II (34). For the plankton, the number of individuals is in line with the number of species making up the community at an observation location. Yet it was not happened to benthos. The identification result of the type and amount of plankton and benthos then applied to the formula of Shannon Weiner Diversity Index compared to Wilhm pollution standards and Dorris, 1967 obtained the following results:

Table 3: The identification result of the type and amount of plankton and benthos then applied to the formula of Shannon Weiner Diversity Index compared to Wilhm pollution standards and Dorris, 1967

Typical Organism	Station I	Status pollution	Station II	Status pollution	Station III	Status Pollution
Plankton*	2,219	Polluted being	2,427	Polluted being	2,356	Polluted being
Benthos**	1,665	Polluted being	1,529	Polluted being	0,975	Polluted heavy

Different character in each station will affect the different levels of pollution as well as the condition of organisms in it. Shannon Weiner diversity index calculations result showed plankton diversity is highest on Station II (2,427). Plankton diversity is a value serially II Station > Station III > I. Stations Based on the status of blackened; the three stations were classified as polluted.

Station II is located in the area of fisheries dominated the many floating net (FloatingNet Cages). Indeed Station II is located a little over the edge with some eating houses located at its edge. However, the depth of water at this station with a 310 cm is deep enough. Contamination at this station indicated derived from fisheries, tourism (restaurant), agricultural and domestic waste.

Based on the diversity index value, the diversity of plankton in the observation stations do

not differ much, so did its pollution status. This condition is made possible by limited input into the Reservoir Mulur. The reservoir water is supplied only by a river (Jlantah) and the condition subsided due to the influence of dry season. The reduced rate of water supply entry will indirectly reduce pollutant loads as well as reduce the ability of reservoir waters dissolve contaminants.

Benthos indeed has a range of values wider than plankton. Highest index value was found at station I (1,665) and the lowest at station III (0,975). Span a wide diversity index value causes the difference in status blackened waters at Station III is heavily polluted.

Station III is located in the middle of the reservoir. Although located in the middle, fairly shallow depth of 130 cm. The cause is partly due to the sedimentation. Diversity index value <1.00 defined by Restu (2002) in Fitriana (2006) as an indication of low diversity, poor, very low productivity as an indication of severe stress and unstable ecosystems in the waters.

Benthos naturally feels a greater burden of pollution than plankton. This situation is as the impact of his life on the bottom habitat. The entire pollution and contaminants will settle on the bottom, some will also drift with sediment and accumulate in certain parts of the reservoir waters, as happened in Station III. Benthos utilizes water and takes food of the parts that have been polluted environment on the basis of suitable character as a filter feeder.

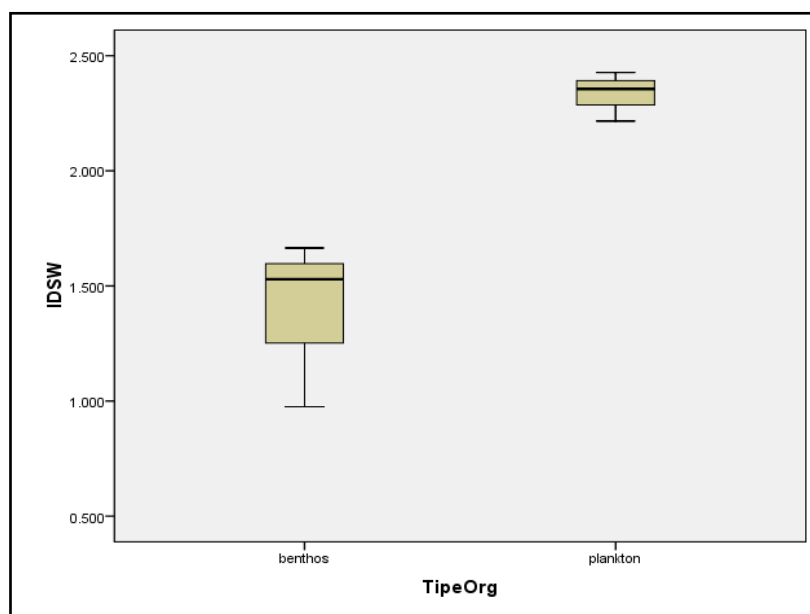


Figure 1: the difference between the Shannon Weiner Diversity Index (IDSW) on plankton (right) and benthos (left)

Boxplot in Figure 1 above shows the difference between the Shannon Weiner Diversity Index (IDSW) on plankton (right) and benthos (left). However, based on both T test (normally distributed data) the fact that there is no significant difference between IDSW plankton and benthos ($\text{sig} > 0,05$). Although it was mentioned statistically to be not significantly different, but different values factually demonstrate the potential for increased pollution in the Reservoir Mulur.

A greater level of pollution on the bottom shows the pollution that has lasted a long time.

Because based IDSW count value is not too far away, meaning it has not been too severe pollution. Naturally, because of human activities on the Reservoir Mulur has not been too much and relatively far away from the industrial area. Dominant activity around the Reservoir Mulur area is still a domestic activities, agriculture and freshwater fisheries are not too developed.

The emergence of severe indications blackened on one observation station can be early warnings for reservoir management in the future. It is a marker that among the various activities that take place in or around it, there is potential for contamination to watch out or controlled. The kind of freshwater fisheries activities will contribute the rest of aquaculture feed and fish waste that can be toxic to aquatic organisms. Similar conditions apply to agricultural activities accounted for the rest of the potential use of fertilizers to the soil with a content processing pollutants and eutrophication potential triggers.

4 Conclusion

Based on the research that has been conducted at the site of Reservoir Mulur, Sukoharjo known Shannon Weiner Diversity Index for plankton worth 2,219 at Station I, II Station III valued worth 2,247 and 2,356 stations. IDSW mean plankton from the third observation station was 2,274. For the calculation of successive IDSW benthos obtained 1,665 results (Station I), 1.529 (Station II) and 0.975 (Station III). Benthos of the average IDSW third observation station was 1,389.

Comparison with the pollution level provides the results for the overall status of plankton IDSW being blackened. This condition is different from the comparison IDSW benthos which successively obtained pollution levels are being blackened, blackened medium and heavy pollutants. However, if the average is taken IDSW for plankton and benthos, it can be said the whole location status were blackened. It means that although there is a specific difference between the value of plankton and benthos IDSW but not too significant.

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