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Water pollution level of the Upstream Citarum river based on macrozoobenthic family biotic index

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Abstract

Citarum River was known as the dirtiest river in the world in 2009, it was caused by the increase in population growth around the Citarum River, which damaging the river and the surrounding environment. This research was conducted at 4 stations, namely 1.Situ Cisanti; 2.Wangisagara; 3.Majalaya; and 4.Sapan, by using purposive sampling method and descriptive quantitative analysis method to determine the level of water pollution in the Upstream Citarum River based on the family biotic index of macrozoobenthos. The results showed that the level of water pollution in the Upstream Citarum River was light to severe. The FBI value of the Upstream Citarum River ranges from 3,95-5,85. Station 1 and station 2 have slightly bad water criteria with each FBI value is 5,85 and 5,77, station 3 has an FBI value of 3,95 with very good water criteria, and station 4 has an FBI value of 5,63 with sufficient water criteria.

Keywords: water pollution level, the Upstream Citarum river, macrozoobenthos, family biotic index (FBI)

1. Introduction

Citarum River is a river that flows along 297 km through 13 districts/cities ^[1]. Population growth around the Citarum River continues to increase, causing the increase in the need for land and damaging the river, also the surrounding environment ^[2]. In 2009, the Citarum River was known as the dirtiest river in the world, and Fulazzaki research ^[3] shows that in 2009 the water quality of the Citarum River is very bad. Based on the final report of water quality in Citarum River : planning interventions to improve water quality in upper Citarum River (2012) ^[4], the Citarum River is polluted by domestic waste, industrial waste, agricultural waste, and municipal solid waste. van Ginkel research ^[5] shows that the largest polluter of the Citarum River is the industry.

The level of water pollution in the Citarum River can be determined by looking at the physical, chemical, and biological parameters of the river. One of the biological parameters is macrozoobenthos. Macrozoobenthos is an invertebrate organism that lives on and in the seabed ^[6]. Macrozoobenthos can be found all over the river. According to Kawuri ^[7] macrozoobenthos are an organism that is sensitive to the changes of water quality in their habitat, which can affect their composition and abundance. This is related to their tolerance to environmental changes, so these organisms are often used as an indicator of the water pollution level ^[8].

Family Biotic Index (FBI) is an index that is used to analyze water quality by taking into the tolerance value of an organism based on its family. The macrozoobenthic tolerance value describes whether the macrozoobenthos is intolerant or tolerant, the tolerance value for macrozoobenthos to environmental changes ranges from 0-10 ^[9]. FBI values can be used to support and explain the physical and chemical parameter data of waters ^[10].

2. Materials and Methods

This research was conducted using field observation and purposive sampling methods. Sampling was done by 4 repetitions every 2 weeks at 4 different stations, that are: Station 1 (Situ Cisanti - 7°12'29" S 107°39'33" E); Station 2 (Wangisagara - 7°4'54" S 107°44'20" E); Station 3 (Majalaya - 7°3'4" S 107°45'24" E); and Station 4 (Sapan - 7°0'8" S 107°43'12" E).

The tools used in the macrozoobenthic sampling were surber nets (40 x 25 cm) and ekman grab (20 x 20 cm). Macrozoobenthic sampling using surber nets was carried out at stations that had shallow depths, and macrozoobenthic sampling using ekman grab was carried out at a deep enough station and it was not possible to use surber nets.

The family biotic index value can be calculated by the following formula ^[11]:

$$FBI = \frac{\sum xi \times ti}{N}$$

Description :

FBI = Family biotic index value

xi = Number of specimens in taxa i

ti = Tolerance value of taxa i

N = Total number of specimens in the sample

Water pollution criteria based on the FBI value :

Table 1: The level of water pollution based on the FBI

No.	FBI Value	Water Quality	Water Pollution Level
1.	0,00 – 3,75	Well	Not polluted by organic matter
2.	3,76 – 4,25	Very good	Slightly polluted by organic matter
3.	4,26 – 5,00	Good	Polluted by some organic matter
4.	5,01 – 5,75	Enough	polluted a little bit of organic matter
5.	5,76 – 6,50	A little bad	Polluted a lot by organic matter
6.	6,51 – 7,25	Bad	Very much polluted by organic matter
7.	7,26 – 10,00	Poor	Heavily polluted by organic matter

Source: Hilsenhoff ^[11]

The data were analyzed by quantitative descriptive method, and the results were explained by relating the FBI values to physical, chemical, and water substrate parameters.

3. Results and Discussion

The Citarum River has 19 Watersheds with the Citarum Watershed as its main river. Observations were made at 4 stations, namely station 1 (Situ Cisanti) which has a calm water flow and has a greenish-brown color of the water. Station 2 (Wangisagara) has a heavy water flow with light

brown color. Station 3 (Majalaya) has a brown and heavy water flow. In Station 3, a lot of garbage was found. Furthermore, station 4 (Sapan) has a calm water flow and a black color of the water.

3.1 Physical and Chemical Parameters of Upstream Citarum River Water

Physical and chemical parameters data of Upstream Citarum River water are shown in Table 2, as follows:

Table 2: Data of physical and chemical parameters of Upstream Citarum River water

No.	Parameter	Unit	Stasiun			
			1	2	3	4
1.	Temperatur	°C	24,35 ± 3,29	24,85 ± 2,80	24,98 ± 1,88	24,20 ± 1,10
2.	Depth	Cm	60,25 ± 4,99	66,50 ± 4,36	26,50 ± 11,85	31,25 ± 12,92
3.	Light-Transparency	Cm	48,1 ± 8,2	41,1 ± 23,4	25,3 ± 10,9	23,2 ± 9,9
4.	Flow	M/s	0,04 ± 0,01	0,24 ± 0,12	0,20 ± 0,17	0,34 ± 0,10
5.	pH	-	6,50 ± 0,22	6,45 ± 0,31	6,33 ± 0,22	6,54 ± 0,26
6.	DO	Mg/l	7,55 ± 0,28	7,28 ± 1,06	6,80 ± 0,21	6,68 ± 0,49
7.	BOD	Mg/l	2,45 ± 0,12	2,77 ± 0,95	3,13 ± 0,37	4,24 ± 1,01

(Table description: 1. Situ Cisanti, 2. Wangisagara, 3. Majalaya, 4. Sapan)

The station with the highest temperature is station 3 with an average temperature value of 24,98 °C ± 1,88. And the station with the lowest average temperature is station 4 which has an average water temperature of 24,20 °C ± 1,10. This temperature difference is caused by the differences in water depth that affect the penetration of solar heat ^[12]. In the upstream, water temperature is also affected by air temperature and water level, whereas in the downstream area, the temperature is affected by wastewater temperature and the upstream temperature ^[13].

Station 2 is the deepest station with an average depth of 66,50 cm ± 4,36, and station 3 is the shallowest station with an average depth of 26,50 cm ± 11,85. According to Kurniawan *et al.* ^[14] the depth of the river is affected by the sedimentation/deposition process, if the sedimentation is high, the river will become increasingly shallow. Station 3 has the shallowest depth due to high sedimentation processes because station 3 is surrounded by cliffs of land that are prone to landslides which then enter into the river body and cause sedimentation. This data is supported by Kurniawan *et al.*

research ^[14] which shows that station 3 has an increased quantity of sediment in 2018, the sediment comes from land erosion in the watershed and sediment carried from the upstream.

The highest average light transparency is at station 1, which is 48,1 cm ± 8,2, and the lowest average light transparency is at station 4, which is 23,2 cm ± 9,9. According to Dahlgre *et al.* ^[15] water transparency can be affected by turbidity, in low turbidity conditions, light can penetrate to the streambed.

Station 1 has the slowest average current speed of 0,04 m/s ± 0,01. Station 4 has the fastest current speed with an average current speed of 0,34 m/s ± 0,10. The current at station 1 belongs to the very slow flow type. Meanwhile, currents at stations 2, 3, and 4 are included in the medium current type. The different current speeds at each station are influenced by friction with land, wind, river contours, river locations, and disturbances such as garbage and algae ^[16].

The average pH value of station 3 is 6,33 ± 0,22, station 3 has the lowest average pH value. The station with the highest average pH value is station 4, which is 6,54 ± 0,20, and is the

station with the highest average pH value. pH value in the river is influenced by the decomposition process, industrial pollutants, and acidic runoff water [17]. The addition of CO₂ into the water could increase H₂CO₃, then decreases the pH value of the water [18]. Station 3 has the lowest pH value, this is due to the high amount of industrial waste disposal in station 3. Station 3 is an area with a large number of industrial factories. Based on a report written by Birry *et al.* [19], there were 800 textile industries around station 3 in 2012. The high activity of these industries caused the high amount of carbon dioxide (CO₂) in this station [19], which then caused the pH value of this station is quite low.

Station 1 has the highest average of dissolved oxygen concentration compared to other stations, which is 7,73 mg/l \pm 0,28, and station 4 is the station with the lowest average dissolved oxygen concentration of 6,73 mg/l \pm 0,49. Dissolved oxygen in the riverine environment is affected by the photosynthesis process, flow, light, and nutrients on the biomass of periphyton and macrophytes [20]. It is also affected by water temperature, respiration, and contaminants [21]. Besides, according to Happy *et al.* [22] dissolved oxygen in the water is also affected by the BOD value. Station 4 has the lowest dissolved oxygen concentration because station 4 has a

fairly high BOD value compared to the other 3 stations, which is 4,24 mg/l \pm 1,01. The Upstream Citarum River has dissolved oxygen concentrations ranges from 6,68 to 7,55 mg/l. The concentration of dissolved oxygen in the Upstream Citarum River increases, compared to Happy *et al.* research [22], that shows the dissolved oxygen concentration of the Upstream Citarum River in 2012 ranged from 0,38-4,6 mg / l. Station 1 has the lowest average BOD value, which is 2,45 mg/l \pm 0,12, and station 4 has the highest average BOD value 4,24 mg/l \pm 1,01. According to Salmin [23], the BOD value of water is influenced by the population and temperature of the water. High BOD values are also influenced by water pollutants such as industrial wastewater [24]. The BOD value of the Upstream Citarum River which ranges from 2,45-4,24 mg/l is considered quite low, compared to the data of Nufutomo and Muntalif research [25] that shows the BOD value of the Upstream Citarum River in 2017 is higher, it is ranged from 2,65-6,24 mg/l.

3.2 Physical and chemical parameters of the substrate

Observation data of the Upstream Citarum River substrate is shown in Table 3, as follows:

Table 3: Observation data of the Upstream Citarum River substrate

No.	Parameters	Unit	Station			
			1	2	3	4
1.	Texture	-	Dusty clay	Clay	Clay sandy	Loamy clay dusty
No.	Parameters	Unit	Station			
			1	2	3	4
2.	pH	-	7,24	7,06	7,44	7,36
3.	C-Organik	%	5,26	3,98	1,22	4,19
4.	N-total	%	0,50	0,42	0,18	0,22
5.	C/N ratio	-	10	9	7	19

(Table description: 1. Situ Cisanti, 2. Wangisagara, 3. Majalaya, 4 Sapan)

Station 1 has a dusty clay substrate, station 2 has a clay substrate, station 3 has a sandy clay sub, strate and station 4 has a dusty clay substrate. The Upstream Citarum River has various types of substrates, this can affect the distribution of macrozoobenthos that live in it. According to Palealu *et al.* [26] the presence of macrozoobenthos can be seen from the substrate type. This is supported by the results of research by Fadly *et al.* [27] which showed that the type of substrate affected the abundance of macrozoobenthos in waters as much as 41,1%.

The pH of the Upstream Citarum River substrate ranges from 7,06 to 7,44. According to Azmi *et al.* [28] normal pH values in waters range from 6,5-7,5. The substrate pH of the Upstream Citarum River is included in the safe limit criteria. However, for macrozoobenthos, the pH value is slightly too alkaline because according to Romimohtarto and Juwana [29] the best pH value that can support macrozoobenthic life ranges from 6-7.

The station that has the highest C-organic content is station 1 with 5,26% C-organic content, this is because station 1 has a calm water flow, and according to Barus *et al.* [30] calm waters allow siltation to be followed by the accumulation of organic matter to the bottom of the waters so that it has a high organic matter content. Then the lowest C-organic content is at station 3 with a C-organic content of 1,22. According to Barus *et al.* [30] low water C-organic can be caused by fine organic particles that do not settle on the substrate. This is because station 3 has a sandy substrate type.

The highest N-total is at station 1 with the N-total value of 0,50%. And the lowest N-total is at station 3 which is 0,18%. According to Barus *et al.* [30] the N-total value of water is influenced by the type of substrate, the smaller the substrate particle size, the greater the organic matter content in the waters.

The C/N ratio of the Upstream Citarum River ranges from 7-19. The highest C/N ratio is at station 4 and the lowest C/N ratio is at station 3. The C/N ratio value of water is influenced by the total N-total in these waters, because the higher the N-total value of water, the lower the C/N ratio [30]. According to Pratiwi *et al.* [31] a low C/N ratio indicates that the mineralization process of organic matter in waters is running well.

3.3 Family Biotic Index (FBI)

Data of macrozoobenthic FBI value in the Upstream Citarum River are shown in Table 4, as follows:

Table 4: Macrozoobenthic FBI Value in the Upstream Citarum River

Station	FBI	Criterion
1	5,85	Slightly Poor
2	5,77	Slight Poor
3	3,95	Very Good
4	5,63	Enough

(Table description: 1. Situ Cisanti, 2. Wangisagara, 3. Majalaya, 4. Sapan)

The FBI value can be used to support and explain the physical and chemical parameter data of waters ^[10]. The Upstream Citarum River has an FBI value that ranges from 3,95-5,85. The station with the highest FBI value is station 1, which is 5,85, and has water criteria that are a little bad and polluted with a lot of organic matter. This is consistent with the results of the C-organic substrate observations, which show that the station 1 substrate contains very high C-organic (Table 3). Station 2 has an FBI value of 5,77 and is included in the slightly bad waters criteria and polluted with a lot of organic matter. Station 3 is the station with the lowest FBI value, which is 3,95, with the water criteria that are very good and polluted with a little organic matter. Following the results of the C-organic substrate observations (Table 3), which shows that station 3 has a low C-organic content. The FBI value of station 3 is quite low when compared with the research results of Zalthasmy *et al.* ^[32] which shows that in 2018 the FBI value of station 3 reached 9 with the very bad water criteria. Furthermore, station 4 has an FBI value of 5,63 and is included in the adequate water criteria, which less-more polluted with organic matter. The FBI value is related to the tolerance level of the macrozoobenthos at each station. The macrozoobenthic tolerance value describes whether the macrozoobenthos is intolerant or tolerant, the tolerance value for macrozoobenthos to environmental changes ranges from 0-10 ^[9]. In all stations found *Lymnaea rubiginosa* from the Lymnaeidae family in a high abundance, *Lymnaea rubiginosa* has a tolerance value of 6. However, at station 3 other species are also commonly found, namely *Chironomus* sp. from the Chironomidae family which has a low tolerance value, which is 2, and *Placobdella parasitica* from the Glossiphoniidae family which has a tolerance value of 1.

4. Conclusion

The level of water pollution in the Upstream Citarum River based on the FBI value of macrozoobenthos is light to heavy polluted, this is shown by the FBI values that range from 3,95 to 5,85. The FBI value of station 1 is 5,85 with slightly bad water criteria, FBI value of station 2 is 5,77 with slightly bad water criteria, FBI value of station 3 is 3,95 with very good water criteria, and FBI value of station 4 is 5,63 with sufficient water criteria. The water quality of the Upstream Citarum River has developed as indicated by an increase in dissolved oxygen concentration, a decrease in BOD value, and an increase in water quality based on the decreasing FBI value.

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