

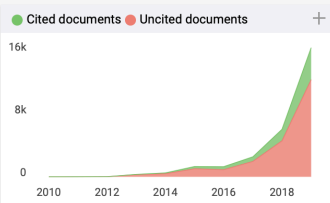
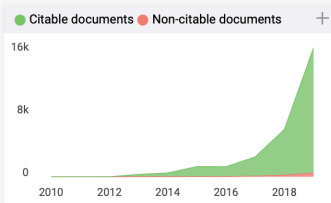
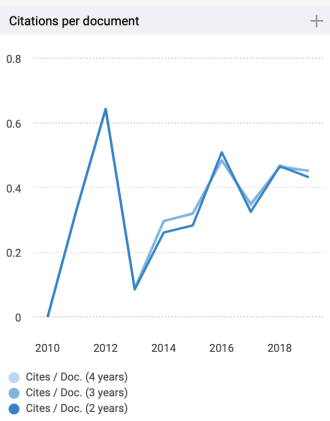
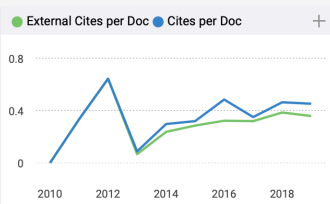
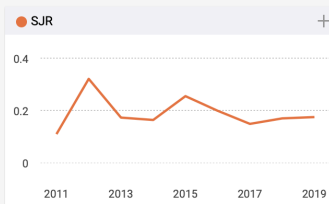


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Publisher	IOP Publishing Ltd.
Publication type	Conferences and Proceedings
ISSN	17551315, 17551307
Coverage	2010-2020
Scope	The open access IOP Conference Series: Earth and Environmental Science (EES) provides a fast, versatile and cost-effective proceedings publication service.
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Makrozoobentos as bioindicator water quality of Krukut River, Depok, West Java, Indonesia

A D Jayanti, M F Fachrul*, D Hendrawan

Environmental Engineering Department, Faculty of Landscape Architecture and Environmental Engineering, Universitas Trisakti, Jakarta, Indonesia

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River as one natural resource has a versatile function for human life. The function and usefulness of the river may be lost from a variety of anthropogenic activities into its capacity. Changes in agricultural land use patterns, moorings and settlements and increased industrial activity will have an impact on hydrological conditions within the watershed. Krukut River is one of the rivers that flow through in the middle development area of Depok City which has been defined as drinking water category B as drinking water intake.

Krukut river flows from Citayam to Glodok along ± 40 kilometers. Watershed Area of Krukut is Ciangke - Pesanggrahan Watershed located in District of Sawangan with a length of 12 kilometers. The river basin Krukut has an area of ± 84.9 km². The flow of Krukut River passes Depok City, Tangerang Regency, Parung district, Bogor district, Limo subdistrict, Pancoran Mas, Cipayung, and Bojongsari.

Increased population and rapid development in Depok City in 2 decades where the population in 2000 to 2016 increased from 1,160,791 to 2,106,100 inhabitants [1]. Krukut River currently only has a width of 1.5 meters. Changes in water quality and substrates where life greatly affects the composition and abundance of macrozoobenthic invertebrates can be used as a indicator of overall biodiversity in aquatic ecosystems. So, it needs to be done a study on the quality of waters in terms of composition and abundance of macrozoobentos waters of the middle segment of the Krukut River.



2. Research Method

The sampling of water in Krukut River conducted 4 times in May, June, March and April 2017. Taking macrozoobentos refers to SNI 06-3963-1995. Taking samples of macrozoobentos was done on 7 sampling points 2 times repetition. Taking a sample of macrozoobentos was done using Eckman Grab placed at the bottom of the water for about 5 minutes to capture the biota that drifted into the net and the substrate then filtered using a multilevel filter. Further identification by using stereomicroscope and macrozoobenthic identification books can use [11], [12], [13].

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3	06°23'05,82"LS 106°48'05,87"BT	Arsip Raya Street, Depok City, West Java.	1,5
4	06°22'58,59"LS 106°48'02,27"BT	Kp. Utan Jaya Street, Depok City, West Java.	2,3
5	06°22'19,79"LS 106°47'45,34"BT	Tanah Baru Beji Street, Depok City, West Java.	2,3
6	06°21'58,21"LS 106°47'40,03"BT	Jalan Curug Agung Tanah Baru, Beji Street, Depok City, West Java.	2,6
7	06°21'14,64"LS 106°47'37,93"BT	Grand Matoa Street, Krukut, Limo, Depok City, West Java.	1,2

2.1. Level of Pollution Based on Makrozoobentos Structure

2.1.1. Shannon Wiener's (H') Diversity Index

$$H' = -\sum p_i \log_2 p_i \quad (1)$$

Whereas : H' = Shannon Wiener's Diversity Index

n_i = Number of individuals in one species

N = Total number of individual species found

p_i = n_i/N

Tabel 2. Water quality criteria.

No.	Uniformity Index	Quality	Reference
I	> 3	Clean water	Wilha (1975)
	1 – 3	Medium Polluted	
	< 1	Heavily Polluted	
II	3.0 – 4.0	Very Lightly Polluted	Wilha (1975)
	2.0 – 3.0	Contaminated Lightly	
	1.0 – 2.0	Medium Polluted	
III	2.0	Not Polluted	Lee, dkk (1975)
	2.0 – 1.0	Contaminated Lightly	
	1.5 – 1.0	Medium Polluted	
	< 1.0	Heavily Polluted	

2.1.2. Uniformity Index (E)

$$E = \frac{H'}{H'_{max}} \quad (2)$$

E = Uniformity Indeks, H' = Diversity Indeks, H'max = Maximum Diversity Values (Log₂S), S = Number of species

Criteria : E ~ 0 = There is Dominance of Species

E ~ 1 = The number of Individuals of same species

Noted : The smaller the E value, the smaller the Similarity of the Species Population

2.1.3. Dominance Index (C)

$$C = \sum \left(\frac{n_i}{N} \right)^2 \quad (3)$$

C = Dominance Index, Ni = Number of Individuals of Each Type, N = Number of Individuals All Types.

Simpson Dominance Index value ranges from 0-1, if the Index value close to 1 means there is dominance of certain species in the waters.

3. Results and Discussion

3.1. The Shanon Wiener Diversity Index (H') in the Middle Segment Krukut River

This index provides information on regularity and irregularity in an index of diversity.

Table 3. Diversity Index (H') *Macrozoobentos* of middle segment.

Sampling Point	Diversity Index (H')	Average H'	Water Quality
1	March 2017	1.79	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
2	March 2017	1.33	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
3	March 2017	1.62	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
4	March 2017	1.60	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
5	March 2017	1.14	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
6	March 2017	1.32	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		

Sampling Point	Diversity Index (H')	Average H'	Water Quality	
7	March 2017	2.43	1.80	Moderate
	April 2017	2.95		Polluted
	May 2017	1.51		
	June 2017	0.31		

The index value of diversity in all sampling points ranging from 1.14 to 1.79 is the category of polluted waters being. The diversity index of sampling points 7 and 1 belongs to medium-polluted category (1.80 and 1.79), since pollutants entering the middle segment flow of Krukut River come from household waste around Krukut River which is a source of organic and inorganic waste, and B3.

3.2. Uniformity Index *Macrozoobentos* (E)

The middle segment of can be seen the uniformity index of type macrozoobentos (E) which describes the abundance of species. The uniformity index can be seen in Table 4.

Table 4. Uniformity Index *Macrozoobentos* (E) Krukut River.

Sampling Points	Uniformity Index (E)	Uniformity Average	
1	March 2017	0.72	0.63
	April 2017	0.92	
	May 2017	0.59	
	June 2017	0.28	
2	March 2017	0.64	0.78
	April 2017	0.89	
	May 2017	0.81	
	June 2017	0.78	
3	March 2017	0.83	1.07
	April 2017	0.89	
	May 2017	0.99	
	June 2017	1.56	
4	March 2017	0.83	0.74
	April 2017	0.69	
	May 2017	0.96	
	June 2017	0.48	
5	March 2017	0.68	0.58
	April 2017	0.36	
	May 2017	0.82	
	June 2017	0.48	
6	March 2017	0.91	0.68
	April 2017	0.53	
	May 2017	0.97	
	June 2017	0.31	
7	March 2017	0.68	0.67
	April 2017	0.93	
	May 2017	0.75	
	June 2017	0.31	

Marphisa sp is considered a widespread species in temperate and tropical regions [2]. *Viviparus* sp scattered in the waters allegedly because these locations contain small river estuaries [3]. Overall sampling points were dominated by *Viviparus* sp in May and June. That if a location is dominated by Bentos or *Viviparus* sp macroinvertebrate then the water quality in this location is good [4].

Almost all macrozoobenthic classes are always present in lotic habitats such as Gastropoda Class, Insekta, Pelecypoda and Oligochaeta which have a high attendance rate compared to other macrozoobentos classes [5]. Macrozoobentos *Melanoides* sp. is a species indicator of the presence of low dissolved oxygen (DO) and high suspended particles in river water ecosystems. There are macrozoobentos *Melanoides* sp. at sampling points 7 and 1 in March and April. Changing physical conditions - aquatic chemistry can lead to the disappearance of certain types of macrozoobentos and spur the growth of other species.

3.3. Macrozoobentos Dominance Index (C)

Dominance Index (C) is used to determine the quality of waters with large number of species or with a high diversity of species [6]. This situation is shown in the form of numbers that is the Dominance Index.

Table 5. Dominant Index (C) Central Segment Krukut River.

Sampling Point	Dominance Index (C)	Dominance Index (C) Average
1	March 2017	0.28
	April 2017	0.17
	May 2017	0.55
	June 2017	0.82
2	March 2017	0.38
	April 2017	0.41
	May 2017	0.63
	June 2017	0.33
3	March 2017	0.30
	April 2017	0.29
	May 2017	0.34
	June 2017	1.69
4	March 2017	0.32
	April 2017	0.46
	May 2017	0.28
	June 2017	0.61
5	March 2017	0.43
	April 2017	0.78
	May 2017	0.47
	June 2017	0.83
6	March 2017	0.22
	April 2017	0.62
	May 2017	0.35
	June 2017	0.89
7	March 2017	0.33
	April 2017	0.15
	May 2017	0.42
	June 2017	0.90

The Dominance Index value is inversely proportional to Diversity, if the Dominance Index is high then the Diversity Index is low and vice versa. The highest dominance index is owned by the sampling

point 5, with the average value of the Dominance Index being 0.63. At the sampling point 5 is dominated by macrozoobentos *Viviparus* sp.

3.4. Relation of Diversity Index (H'), Uniformity Index (E), and Dominance Index (C)

Table 6. Average Relationship Diversity (H'), Average Uniformity (E), and Average of Dominance Index (C).

Sampling Point	Average Diversity Index (H')	Average Uniformity Index (E)	Average of Dominance Index (C)
1	1.79	0.63	0.45
2	0.33	0.78	0.44
3	0.62	1.07	0.40
4	0.60	0.74	0.42
5	1.14	0.58	0.63
6	0.32	0.68	0.52
7	1.80	0.67	0.45

Within a community type diversity, uniformity and dominance can describe the disruption of aquatic ecosystems [7]. In a dominant community will control the community, so that if the dominant organism is lost it will cause important changes in the community, not only the biotic community but also in the physical environment. Dominance index is inversely related to diversity and uniformity whereas diversity and uniformity have a positive relationship [8]. The high diversity index shows the condition of the aquatic environment in the station is quite good and supports the life of biota in it. Crustacean group has a wide range of life from the muddy habitat to the clean waters and the Gastropoda group has a high adaptability to the environment and the type of feeder depositor on the mud surface [9]. Then from the group of Bivalves with *Corbicula javanica* type found with low abundance due to its nature cannot move actively and settled somewhere. Many studies which conclude that the Mollusca group can function as a bioindicator of freshwater pollution [10].

4. Conclusion

Macrozoobentos obtained as many as 23 species belonging to the 9 classes are 3 types of Bivalves, 7 types of Arthropoda, 2 types of Molusca, 4 types of Insects, 4 types of Oligochaeta, 2 types of Malacostraca, 1 Crustacea, 1 Diptera, and 1 Nematodes. The range of values of Diversity Index (H') 0.32-1.80, Uniformity Index (E) 0.58-1.07 and Dominant Index (C) 0.40-0.63. The results show the waters of the middle segment of Krukut River in medium contaminated state.

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by Perpustakaan Falitl

Submission date: 12-Apr-2023 10:42AM (UTC+0700)

Submission ID: 2062210876

File name: File_7.pdf (844.29K)

Word count: 2568

Character count: 12667

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2	06°23'26,02"LS 106°48'07,74"BT	Swadaya VIII Street, Depok City, West Java.	2,1
3	06°23'05,82"LS 106°48'05,87"BT	Arsip Raya Street, Depok City, West Java.	1,5
4	06°22'58,59"LS 106°48'02,27"BT	Kp. Utan Jaya Street, Depok City, West Java.	2,3
5	06°22'19,79"LS 106°47'45,34"BT	Tanah Baru Beji Street, Depok City, West Java.	2,3
6	06°21'58,21"LS 106°47'40,03"BT	Jalan Curug Agung Tanah Baru, Beji Street, Depok City, West Java.	2,6
7	06°21'14,64"LS 106°47'37,93"BT	Grand Matoa Street, Krukut, Limo , Depok City, West Java.	1,2

2.1. Level of Pollution Based on Makrozoobentos Structure

2.1.1. Shannon Wiener's (H') Diversity Index

$$H' = -\sum pi \text{Log}_2 pi \quad (1)$$

Whereas : H' = Shannon Wiener's Diversity Index
 n_i = Number of individuals in one species
 N = Total number of individual species found
 pi = n_i/N

Tabel 2. Water quality criteria.

No.	Uniformity Index	Quality	Reference
I	> 3	Clean water	Wilha (1975)
	1 – 3	Medium Polluted	
	< 1	Heavily Polluted	
II	3.0 – 4.0	Very Lightly Polluted	Wilha (1975)
	2.0 – 3.0	Contaminated Lightly	
	1.0 – 2.0	Medium Polluted	
III	2.0	Not Polluted	Lee, dkk (1975)
	2.0 – 1.0	Contaminated Lightly	
	1.5 – 1.0	Medium Polluted	
	< 1.0	Heavily Polluted	

2.1.2. Uniformity Index (E)

$$E = \frac{H'}{H'_{max}} \quad (2)$$

E = Uniformity Indeks, H' = Diversity Indeks, H' max = Maximum Diversity Values (Log₂S), S = Number of species

Criteria : E ~ 0 = There is Dominance of Species
 E ~ 1 = The number of Individuals of same species

Noted : The smaller the E value, the smaller the Similarity of the Species Population

2.1.3. Dominance Index (C)

$$C = \sum \left(\frac{n_i}{N}\right)^2 \quad (3)$$

C = Dominance Index, Ni = Number of Individuals of Each Type, N = Number of Individuals All Types.
 Simpson Dominance Index value ranges from 0-1, if the Index value close to 1 means there is dominance of certain species in the waters.

3. Results and Discussion

3.1. The Shanon Wiener Diversity Index (H') in the Middle Segment Krukut River

This index provides information on regularity and irregularity in an index of diversity.

Table 3. Diversity Index (H') Macrozoobentos of middle segment.

Sampling Point	Diversity Index (H')	Average H'	Water Quality
1	March 2017	1.79	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
2	March 2017	1.33	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
3	March 2017	1.62	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
4	March 2017	1.60	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
5	March 2017	1.14	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		
6	March 2017	1.32	Moderate Polluted
	April 2017		
	May 2017		
	June 2017		

Sampling Point	Diversity Index (H')	Average H'	Water Quality	
7	March 2017	2.43	1.80	Moderate
	April 2017	2.95		Polluted
	May 2017	1.51		
	June 2017	0.31		

The index value of diversity in all sampling points ranging from 1.14 to 1.79 is the category of polluted waters being. The diversity index of sampling points 7 and 1 belongs to medium-polluted category (1.80 and 1.79), since pollutants entering the middle segment flow of Krukut River come from household waste around Krukut River which is a source of organic and inorganic waste, and B3.

3.2. Uniformity Index *Macrozoobentos* (E)

The middle segment of can be seen the uniformity index of type macrozoobentos (E) which describes the abundance of species. The uniformity index can be seen in Table 4.

Table 4. Uniformity Index *Macrozoobentos* (E) Krukut River.

Sampling Points	Uniformity Index (E)	Uniformity Average	
1	March 2017	0.72	0.63
	April 2017	0.92	
	May 2017	0.59	
	June 2017	0.28	
2	March 2017	0.64	0.78
	April 2017	0.89	
	May 2017	0.81	
	June 2017	0.78	
3	March 2017	0.83	1.07
	April 2017	0.89	
	May 2017	0.99	
	June 2017	1.56	
4	March 2017	0.83	0.74
	April 2017	0.69	
	May 2017	0.96	
	June 2017	0.48	
5	March 2017	0.68	0.58
	April 2017	0.36	
	May 2017	0.82	
	June 2017	0.48	
6	March 2017	0.91	0.68
	April 2017	0.53	
	May 2017	0.97	
	June 2017	0.31	
7	March 2017	0.68	0.67
	April 2017	0.93	
	May 2017	0.75	
	June 2017	0.31	

Marphisa sp is considered a widespread species in temperate and tropical regions [2]. *Viviparus* sp scattered in the waters allegedly because these locations contain small river estuaries [3]. Overall sampling points were dominated by *Viviparus* sp in May and June. That if a location is dominated by Bentos or *Viviparus* sp macroinvertebrate then the water quality in this location is good [4].

Almost all macrozoobenthic classes are always present in lotic habitats such as Gastropoda Class, Insekta, Pelecypoda and Oligochaeta which have a high attendance rate compared to other macrozoobentos classes [5]. Macrozoobentos *Melanoides* sp. is a species indicator of the presence of low dissolved oxygen (DO) and high suspended particles in river water ecosystems. There are macrozoobentos *Melanoides* sp. at sampling points 7 and 1 in March and April. Changing physical conditions - aquatic chemistry can lead to the disappearance of certain types of macrozoobentos and spur the growth of other species.

3.3. Macrozoobentos Dominance Index (C)

Dominance Index (C) is used to determine the quality of waters with large number of species or with a high diversity of species [6]. This situation is shown in the form of numbers that is the Dominance Index.

Table 5. Dominant Index (C) Central Segment Krukut River.

Sampling Point		Dominance Index (C)	Dominance Index (C) Average
1	March 2017	0.28	0.45
	April 2017	0.17	
	May 2017	0.55	
	June 2017	0.82	
2	March 2017	0.38	0.44
	April 2017	0.41	
	May 2017	0.63	
	June 2017	0.33	
3	March 2017	0.30	0.40
	April 2017	0.29	
	May 2017	0.34	
	June 2017	1.69	
4	March 2017	0.32	0.42
	April 2017	0.46	
	May 2017	0.28	
	June 2017	0.61	
5	March 2017	0.43	0.63
	April 2017	0.78	
	May 2017	0.47	
	June 2017	0.83	
6	March 2017	0.22	0.52
	April 2017	0.62	
	May 2017	0.35	
	June 2017	0.89	
7	March 2017	0.33	0.45
	April 2017	0.15	
	May 2017	0.42	
	June 2017	0.90	

The Dominance Index value is inversely proportional to Diversity, if the Dominance Index is high then the Diversity Index is low and vice versa. The highest dominance index is owned by the sampling

point 5, with the average value of the Dominance Index being 0.63. At the sampling point 5 is dominated by macrozoobentos *Viviparus* sp.

3.4. Relation of Diversity Index (H'), Uniformity Index (E), and Dominance Index (C)

Table 6. Average Relationship Diversity (H'), Average Uniformity (E), and Average of Dominance Index (C).

Sampling Point	Average Diversity Index (H')	Average Uniformity Index (E)	Average of Dominance Index (C)
1	1.79	0.63	0.45
2	0.33	0.78	0.44
3	0.62	1.07	0.40
4	0.60	0.74	0.42
5	1.14	0.58	0.63
6	0.32	0.68	0.52
7	1.80	0.67	0.45

Within a community type diversity, uniformity and dominance can describe the disruption of aquatic ecosystems [7]. In a dominant community will control the community, so that if the dominant organism is lost it will cause important changes in the community, not only the biotic community but also in the physical environment. Dominance index is inversely related to diversity and uniformity whereas diversity and uniformity have a positive relationship [8]. The high diversity index shows the condition of the aquatic environment in the station is quite good and supports the life of biota in it. Crustacean group has a wide range of life from the muddy habitat to the clean waters and the Gastropoda group has a high adaptability to the environment and the type of feeder depositor on the mud surface [9]. Then from the group of Bivalves with *Corbicula javanica* type found with low abundance due to its nature cannot move actively and settled somewhere. Many studies which conclude that the Mollusca group can function as a bioindicator of freshwater pollution [10].

4. Conclusion

Macrozoobentos obtained as many as 23 species belonging to the 9 classes are 3 types of Bivalves, 7 types of Arthropoda, 2 types of Molusca, 4 types of Insects, 4 types of Oligochaeta, 2 types of Malacostraca, 1 Crustacea, 1 Diptera, and 1 Nematodes. The range of values of Diversity Index (H') 0.32-1.80, Uniformity Index (E) 0.58-1.07 and Dominant Index (C) 0.40-0.63. The results show the waters of the middle segment of Krukut River in medium contaminated state.

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