INTERNATIONAL JOURNAL OF SOCIAL SERVICE AND RESEARCH

POLLUTION LEVELS AND DETERMINANTS OF WATER HEALTH IN THE CITARUM RIVER, MUARA GEMBONG BEKASI, WEST JAVA

Sukma Awifan Krisnanti, Bayu Awifan Dwijaya
Faculty of Biology, Jenderal Soedirman University, Purwokerto 53112, Indonesia
Indoneisa Biodiversity Conservation Unit, Bekasi, west java, 17510, Inonesia
Email: sukmaawifan@gmail.com, bayu.goldha@gmail.com

Abstract

Restoration of water quality needs attention at rivers in Indonesia. Land occupation and land conversion are the main problems that have an impact on the handling of water quality in the Muara Gembong area. The research location in the field administratively is in Muara Gembong District, Bekasi Regency, West Java.Testing the quality of river water in this study was carried out directly in the field using digital measuring instruments including pH (electrometic principle), water temperature (mechanical expansion principle), DO (membrane polarography principle), TDS (electrometric principle), Phosphate (calorimetric principle), Brightness (measurement of distance units) and Salinity (principle of refraction). As for the TSS (gravimetric principle) and BOD (membrane polarographic principle) parameters, the test was carried out in Laboratory at the Secretariat of the Indonesian Biodiversity Conservation Unit (IBCU). The results of the Pollution Index showed that the research location was divided into 3 groups, namely moderate pollution (upstream and Muara Mekar), light pollution (Middle, Muara Bendera, Beting and Muara Bungin) and good condition (Muara Kuntul). The results of PCA analysis with a variance value of 60.458% showed that the location of the study was holistically affected by TSS and phosphate content as the dominant environmental parameters determining environmental conditions.

Keywords: Muara Gembong, Tributary of Citarum River, Water Quality

Received 1 August 2021, Revised 20 August 2021, Accepted 29 August 2021

INTRODUCTION

Water quality monitoring needs to be considered for every river in Indonesia. Sources of pollution can occur due to various factors, including industrial activities and human activities. The biggest challenges today often come from man-made activities, such as agricultural activities, plantations, cultivation and household waste. The habits of the surrounding human community play an important role in maintaining water quality in the area.

Several functions of watersheds and other landscapes are very meaningful to humans, especially in terms of the availability of natural resources and ecosystem services (such as food sources, housing and water resources). Some of these functions may work synergistically, and some of these functions can also be detrimental or even a source of conflict. Multiple functions separated in time and space can be effective at the same time and place (Bolliger et al., 2011).

Muara Gembong is located on the north coast of Java Island, close to DKI Jakarta, and has a relatively high threat of degradation. Since the Indonesian Minister of Agriculture designated it as a protected forest area through Decree No.92 / UM / 54 of 1954, mangroves in Muara Gembong have experienced various pressures such as land tenure, land conversion and land conversion/function. In the Muara Gembong area, land tenure and land conversion are major problems in water quality management. Most of the area has been transformed into ponds, rice fields, gardens and even settlements. The aim of scientific research is to provide space for local preservation and development. At the same time, the Indonesian Minister of Forestry issued No. 475 / Menhut-II / 2005, concerning the Transfer of Status to Muara Gembong.This study builds target indicators through analysis of the relationship between the Citarum creek estuary location and water quality using statistical relationships. Hydrological system analysis is carried out by describing the chemical-physical conditions of the watershed in the hydrological transformation process.

METHOD

The research location in the field administratively is in Muara Gembong District, Bekasi Regency, West Java. This research was conducted from July to September 2020. Geographically, the research location is located in the north of Java Island (Figure 1). The research method used was purposive stratified sampling method based on the flow of the Citarum River in Muara Gembong. The research location is known as an estuary area. Location 1. Muara Bendera 5 ° 56'12.6 "South Latitude 106 ° 59'45.6" East Longitude 2. Muara Mekar 6 ° 01'21.4 "LS 106 ° 59'50.2" East Longitude, Location 3. Middle of River 5 ° 59'25.5 " LS 107 ° 05'02.0 "East Longitude, location 4. Muara Beting 5 ° 55'28.9" LS 107 ° 02'07.0 "East Longitude, location 5. Muara Bungin, 5 ° 56'30.0" LS 107 ° 05'53.6 "East Longitude, location 6. Upstream (Hulu Sungai), 6 ° 02'14.5 "LS 107 ° 06'45.5" East Longitude,

Testing the quality of river water in this study was carried out directly in the field using digital measuring instruments including pH (electrometic principle), water temperature (mechanical expansion principle), DO (membrane polarography principle), TDS (electrometric principle), Phosphate (calorimetric principle), Brightness (measurement of distance units) and Salinity (principle of refraction). As for the TSS (gravimetric principle) and BOD (membrane polarographic principle) parameters, the test was carried out inLaboratory at the Secretariat of the Indonesian Biodiversity

Conservation Unit (IBCU).Water quality testing is carried out using methods according to applicable standards. Sampling was done in 3 replications at each research station. The data that has been obtained from the results of testing the physical and chemical parameters of river water, both in the field and in the laboratory, then analyzed the water quality of the Citarum River by comparing the test results with class II water quality standards based on PP RI No. 82 of 2001 concerning Water Quality Management and Water Pollution Control (see table 1) as a reference for the value of pollution on the pollution index.

Table 1
Class II Water Quality Standards

Lij	DO	BOD	P	T	pH	S	B	TDS	TSS
Class II	4	3	0.2	22-28	6.0-9.0	-	2	1000	50
Unit	ppm	ppm	ppm	C	-	-	m	ppm	ppm

Note: DO, Disolved Oxygen; BOD, Biological Oxygen Demand; P, phosphate; T, temperatut; pH, degree of acidity; S, Salinity; B, Brightness; TDS, Total Disolved Solid; TSS, Total Suspended Solid.

In this study, the determination of pollution is carried out using the Pollution Index method. The calculation formula using the Pollution Index method is as follows:

$$PI_j = \sqrt{\frac{(C_i/L_{ij})^2_M + (C_i/L_{ij})^2_R}{2}}$$

Information

Lij : The concentration of water quality parameters stated in the standard quality of water designation (j)

Ci : Concentration of water quality parameters (i)

PIj : Pollution Index for designation (j)

(Ci / Lij) M : Maximum Ci / Lij value

(Ci / Lij) R : Average Ci / Lij value

The results of the calculation of this Pollution Index can show the level of contamination of the Citarum River by comparing it with the quality standard according to the water class stipulated by PP RI No. 82 of 2001 concerning Water Quality Management and Water Pollution Control. So that information can be obtained in determining whether or not river water can be used for a certain designation according to the water class.

Table 2
Pollution Index Interpretation

IP Score	Description
0 - 1.0	Good condition
1.1 - 5.0	Lightly Polluted
5.1 - 10	Medium Polluted
> 10	Heavy Polluted

PCA (Principal Component Analysis) or also known as principal component analysis. PCA in this study was used to generate the analytical value of the survey variables used in determining the species that characterized ancient primary productivity.

$$Y_p = e'_p X$$

Information
Yp : variance,
e'p : eigenvectors
X : average

RESULTS AND DISCUSSION

The results of field samples were analyzed statistically at 7 station locations which were observed based on chemical and physical parameters that can be seen in the table below. The minimum value (low), maximum value (high), mean (average), variance and standard variance (data diversity) can be seen in the table below.

Table 3
Basic Statistics of Water Physics and Chemical Parameters

	DO	BOD	P	T	pH	S	B	TDS	TSS
Min	4.7	0	0.03	22.1	6.4	0	0.04	128	0
Max	8.9	5.4	4.2	31.1	7.6	30	0.48	2400	0.00000010
Mean	6.4	2.1	0.8	2.7	6.9	0.16	0.16	831.42	0.05047619
Variance	1.3	3.3	1.6	6.1	0.08	130	0.01	641758.2	0.00000000
Stand. dev	1.1	1.8	1.2	2.4	0.28	11	0.13	801.0981	0.02940683

Note : DO, Disolved Oxygen; BOD, Biological Oxygen Demand; P, phosphate; T, temperatut; pH, degree of acidity; S, Salinity; B, Brightness; TDS, Total Disolved Solid; TSS, Total Suspended Solid.

Dissolved oxygen parameters are used to determine the organic and inorganic loads of water. Dissolved oxygen content can reduce and oxidize dissolved compounds. Therefore, dissolved oxygen is very important to reduce water pollution. Measurement of DO (Disolved Oxygen) parameters in the Citarum River in the Muara Gembong area at 7 test stations showed that the dissolved oxygen value was still in the range of quality standards which were considered good according to Class II Standard Standard Types.

BOD is the amount of dissolved oxygen needed by decomposing bacteria to decompose organic pollutants in water. The greater the BOD concentration in a water, the higher the concentration of organic matter in the water (Yudo, 2010). The results of monitoring BOD parameters, stations that do not meet quality standards are at the estuary bloom station and the central station with values of 3.6 ppm and 5.3 ppm respectively (See figure 2). The greater of BOD level, it is an indication that the waters have been polluted. The levels of BOD in water with low levels of pollution and can be categorized as good waters range from 0-10 ppm (Salmin, 2005). The increase in the BOD figure can come from organic materials from domestic waste and other wastes (Rahayu, 2009). The high BOD value is due to the disposal of waste from settlements to rivers and from agricultural land (Anhwange, Agbaji, &

Gimba, 2012). The quality of River water itself is still within this range or limit, but the greater of BOD level from upstream to downstream indicates that these waters have been polluted due to domestic and agricultural waste discharges.

The results of monitoring of phosphate parameters at each observation station indicate fluctuations at each observation station. Phosphate values that meet Class II standards are only at Muara Kuntul Station and Muara Bungin Station, which are 0.17 ppm and 0.12 ppm respectively. When compared with the value of phosphate according to type II water quality standards, in terms of phosphate parameters, the water quality of the Citarum River has not met the established water quality standards. Phosphate is a type of phosphorus that can be used by plants. The properties of phosphorus are very different from other main elements that make up the biosphere, because this element is not present in the atmosphere (Effendi, 2003). In agricultural areas, phosp hate comes from fertilizers which enter rivers through drainage and rainwater (Winata, INA, A. Siswoyo, 2000). There are still agricultural activities along the Citarum River,

Based on the measurement results of the water temperature parameters of the Citarum River in Muara Gembong at each test station location, it shows that there are differences that are relatively unstable (See the graph in Figure 2). When compared with the class II water quality standard (Table 1), which is a deviation of 3 from the natural state, the river water quality condition is still within the standard limit. This research was conducted in February 2021 which is experiencing high rainfall due to the influence of the western monsoon. During field sampling, researchers experienced significant weather changes from heavy rain to dry heat in the same day, so that the temperature research data tended to be relatively unstable due to significant weather changes at the time of this sampling.

The results of monitoring pH parameters at each observation station show the pH value at all stations in safe conditions, where the value is within the class II quality standard with a pH value range between 6-9, then the water quality condition of Citarum River when viewed from pH parameters water is still within the water quality standard limit according to its allotment. The fluctuation in pH value is influenced by the presence of organic and inorganic waste discharges into the river (Yuliastuti, 2011). The increase in the pH value of Citarum River water is due to the activity of disposing of organic waste originating from domestic waste and waste originating from agricultural activities around the river that enter the river. Normal water that meets the requirements for life has a pH of around 6.5–7.5 (Ward, 2004). The pH value of uncontaminated water is usually close to neutral (pH 7) and fulfills the life of almost all aquatic organisms (Syofyan, I., Usman, 2011). So that the average pH value of Citarum River water at each station ranges from 6.5-7.2, it fulfills the requirements for the life of aquatic organisms.

The salinity values in this study were obtained with an average range between 0-29 ppt. This salinity level is related to the existence of the research location on the distance from the sea. However some stations experienced a bit of such a anomaly at the Muara bendera which are close to the value of 0 or fresh water, because the time before sampling there was heavy rain, so that it affected the drop in salinity levels even though the location was in the estuary end facing the open sea. This parameter is not used in the analysis of quality standards because salinity is not a parameter studied in monitoring class II water quality standards or the like.

Measurement of brightness parameters at all research locations has shown unexpected values in accordance with existing quality standards. The brightness value measured using a sechi disk is too low Its value (Mankovsky, 2019). This indicates the low ability of the waters to absorb sunlight, this is due to the influence of turbidity that occurs in the Citarum River.

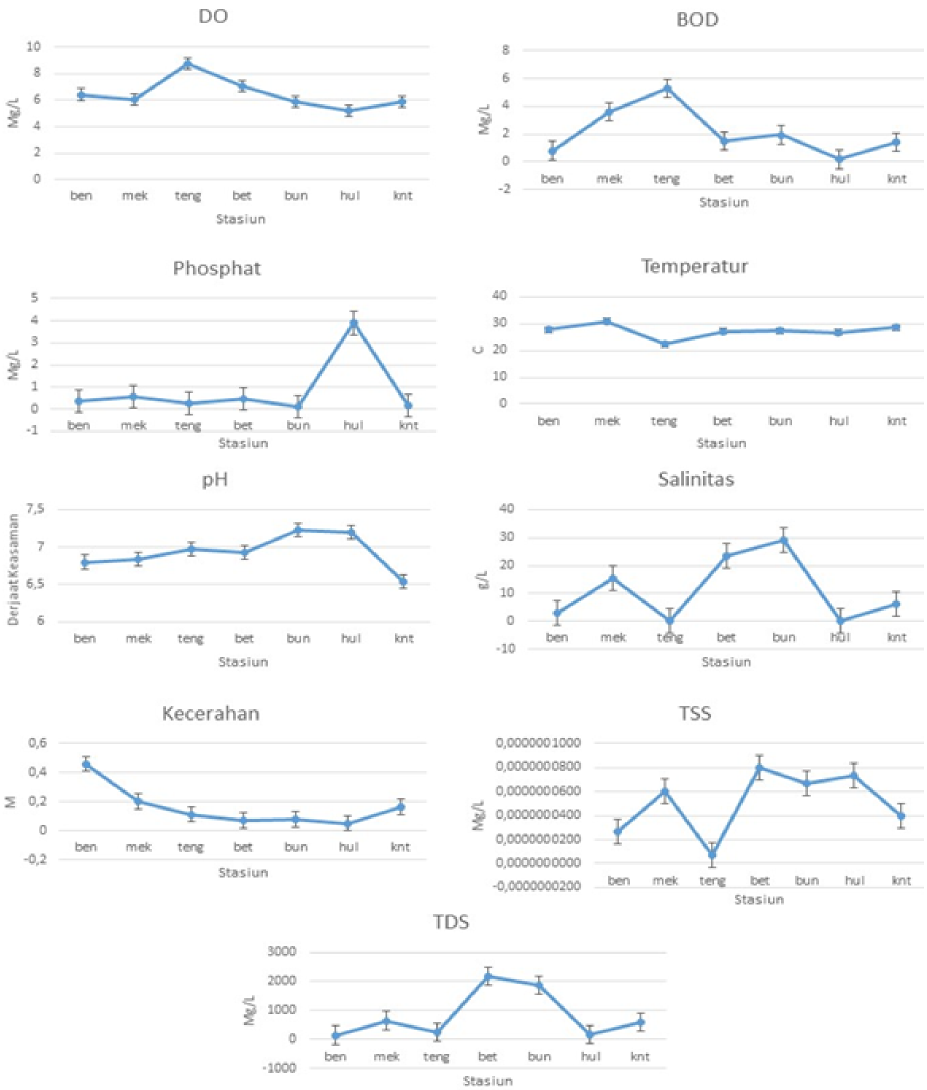


Figure 2. Graph of the value of environmental parameters at various stations (ben, Muara Bendera; Mek, Muara Mekar; teng, Tengah Sungai; bet, Muara Beting, bun, Muara Bungin; hul, Hulu Sungai, knt, Muara Kuntul)

TSS (Total Suspended Solid) at each observation station shows results that are in accordance with class II quality standards. TSS consists of silt, fine sand and microorganisms, which are mainly caused by soil erosion or soil erosion that is carried into water bodies (Effendi, 2003). thus causing the soil solids that enter the river flow through the run off to increase.

TDS (Total Dysolved Solid) at the research location tends to be safe except at the Muara Beting and Muarar bungin locations that exceed the standard permissible threshold, with each value of 2176.67 ppm and 1855 ppm where the quality standard threshold is 1000 ppm. TDS content of these waters reflects the solutes in the waters, the higher the TDS value of a water, the potential to carry high concentrations of solutes and have the potential to become pollutants in an aquatic environment (Liu, Ma, Abuduwaili, & Lin, 2020).

Table 4
Pollution Index Analysis Results

Station	Pi	Interpretation
Upstream	5.34	Moderately Polluted
Middle	4.02	Lightly Contaminated
Muara bendera	1.01	Lightly Contaminated
Muara Mekar	5.75	Moderately Polluted
Muara Beting	2.16	Lightly Contaminated
Muara Bungin	1.74	Lightly Contaminated
Muara Kuntul	0.83	Good condition

Pollution Index analysis which is evaluated at the research location shows the varying levels of pollution. The tributary of the Citarum river that was studied empties at Muara gembong, consisting of 4 estuaries and added upstream and middle. The level of pollution that can consist of moderate pollution, low pollution and good condition based on class II quality standards. Detailed interpretation of each location can be seen in the table below.

The moderate level of pollution that occurs at the upstream station is caused by chemical factors in the form of a high dissolved phosphate content. Dissolved Phosphate content gave the highest contribution to the pollutant assessment at that location. The phosphate value from in situ analysis was 3.883 ppm, where the permissible grade II quality standard was 0.2 ppm. Furthermore, the factor that contributes to pollution at the station is the level of brightness, which is a factor of water physics.

The moderate level of pollution that occurs at the estuary is caused by chemical and physical factors in the form of phosphate, BOD and brightness values. Dissolved phosphate content gave the highest contribution to pollutant assessments at the Muara Mekar. The phosphate value from in situ analysis was 0.56 ppm. The BOD value at this station also tends to exceed the standard threshold with a value of 3.6 ppm where the permissible quality standard is 3 ppm. Furthermore, the factor that contributes to pollution at the station is the level of brightness, which is a factor of water physics.

The level of light pollution occurs at the middle of river, muara bendera, muara beting and muara bungin. Pollutants that contribute to the center station include BOD, phosphate and brightness. Contaminating factors that contribute to Muara Bendera stations include phosphates and brightness. Contaminating factors that contribute to muara being stations include phosphate and brightness. Pollutant factors that contribute to the muara bungin station include brightness and TDS. Good conditions at the muara kuntul station are known to have no problems where all the values of the chemical parameters are in accordance with the standard quality limit, except at the brightness level.

Table 5
Eigenvalues and Main Component Variance

PC	*Eigenvalue*	*% variance*
1	3.449990	38,333
2	2.375070	26.39
3	1.991220	22,125

The results of the PCA multivariate analysis used in this study were carried out to obtain parameters that play an important role in field conditions in the Citarum Tributary of the Muara Gembong area. PCA analysis functions to reduce data that are considered unaffected and form data from new dimensions so that the main parameters that play an important role in it can be identified. The Eigenvalues that appear with a power of more than 1.00 can be used as the main component which will be used further on the resulting charge values. The eigenvalues of PC1 (F1) are 3.449, the eigenvalues of PC2 (F2) are 2.375 and the eigenvalues of PC3 (F3) are 1.991. These three main components will be considered in the load value analysis (see table 5).

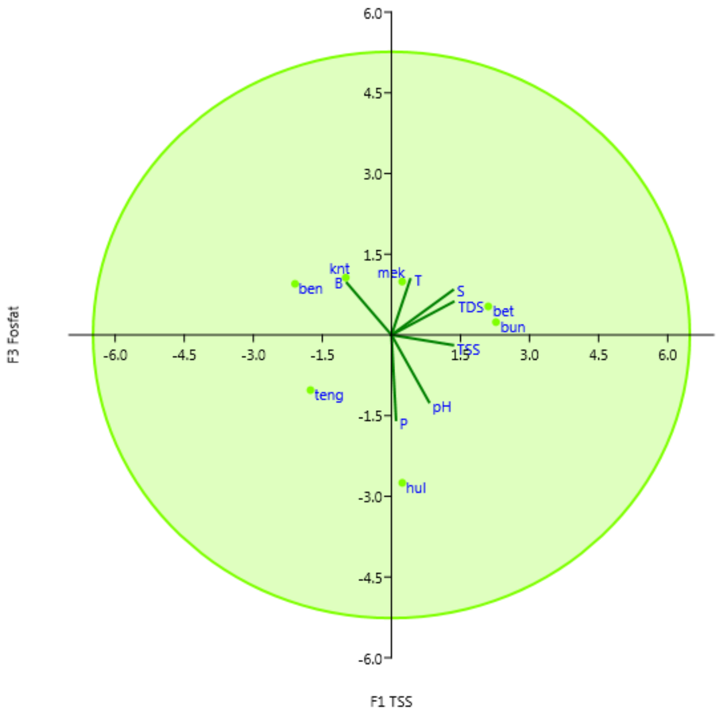
Table 6
Main Component Payload Value

	PC 1	PC 2	PC 3
DO	-0.39463	0.3927	-0.076924
BOD	-0.32892	0.38741	-0.017468
P	0.18551	-0.35192	-0.5269 *
T	0.29423	-0.25511	0.45776
pH	0.22833	0.18191	-0.49076
S	0.35692	0.40504	0.26769
B	-0.22475	-0.31676	0.40365
TDS	0.3351	0.45687	0.17092
TSS	0.52227 *	0.023647	-0.044215

Note: DO, Disolved Oxygen; BOD, Biological Oxygen Demand; P, phosphate; T, temperatut; pH, degree of acidity; S, Salinity; B, Brightness; TDS, Total Disolved Solid; TSS, Total Suspended Solid.

The load values on PC1, PC2 and PC3 can be observed in table 6. A load value of more than 0.5 (+/-) is used as a parameter formed in the new dimension and is considered to have an influence on field conditions statistically. When seen in Table 6, it can be seen from PC1 that the TSS load value has the largest contribution to water conditions. PC3 shows the value of phosphate load as the largest contribution to water conditions. PC2 in the results of this analysis did not provide sufficient contribution compared to the load values on PC1 and PC3.

The results of PCA analysis show that the main parameters affecting the health of the waters are the phosphate value and TSS value. Phosphate values affect many stations, especially upstream stations (see graph in Figure 3), where this upstream area is the first source of water input before connecting to the center and to various other estuaries in Muara Gembong. The TSS value in this study contributed to the health of the waters at the research location, especially at Muara Beting and Muara Bungin. The results of this PCA analysis as a whole have a variance value of 60.458%.



CONCLUSION

Environmental parameters observed in the Citarum tributary which empties into the Muara Gembong area include chemical and physical parameters, namely, DO, BOD, phosphate, temperature, TDS, TSS, pH, salinity and brightness. The results of the Pollution Index showed that the research location was divided into 3 groups, namely moderate pollution (upstream and Muara Mekar), light pollution (Middle, Muara Bendera, Beting and Muara Bungin) and good condition (Muara Kuntul). The results of PCA analysis with a variance value of 60.458% showed that the research location was holistically affected by the TSS value parameter and the phosphate content as the dominant environmental parameters determining environmental conditions.

REFERENCES

Anhwange, B. A., Agbaji, E. B., & Gimba, E. C. (2012). Impact assessment of human activities and seasonal variation on River Benue, within Makurdi Metropolis. *International Journal of Science and Technology*, *2*(5), 248–254. Google Scholar

Bolliger, Janine, Bättig, Michele, Gallati, Justus, Kläy, Andreas, Stauffacher, Michael, & Kienast, Felix. (2011). Landscape multifunctionality: a powerful concept to identify effects of environmental change. *Regional Environmental Change*, *11*(1), 203–206. Google Scholar

Effendi, H. (2003). *Study of Water Quality: For Management of Natural Resources and Aquatic Environment.* Yogyakarta.: Publisher Kanisius. Google Scholar

Liu, Wen, Ma, Long, Abuduwaili, Jilili, & Lin, Lin. (2020). Distributions, Relationship and Assessment of Major Ions and Potentially Toxic Elements in Waters of Bosten Lake, the Former Largest Inland and Freshwater Lake of China. *Water*, *12*(10), 2859. Google Scholar

Mankovsky, V. I. (2019). Influence of the Composition of Suspended Matter on the Secchi Disk Depth. *Atmospheric and Oceanic Optics*, *32*(3), 284–288. Google Scholar

Rahayu, S. And Tontowi. (2009). "Research on the Quality of Bengawan Solo Water During the Dry Season". *Journal of*

Water Resources.

Salmin. (2005). "Dissolved Oxygen (DO) and Biological Oxygen Needs (BOD) as One Indicator To Determine Water Quality". *Oseana's Journal*. Google Scholar

Syofyan, I., Usman, and P. Nasution. (2011). "Study of Water Quality for Fish Health in Aquaculture in the Kampar Kiri River". *Journal of Fisheries and Marine Affairs*.

Ward, Vishnu Arya. (2004). Impact of Environmental Pollution. *Revised Edition, Publisher Of Andi, Yogyakarta*. Google Scholar

Winata, INA, A. Siswoyo, and T. Mulyono. (2000). "Comparison of Total P and N Content in River Water in Plantation and Rice Fields". *Journal of Basic Science*.

Yudo, S. (2010). The condition of the water quality of the Ciliwung River in the DKI Jakarta area is seen from the parameters of organic, ammonia, phosphate, detergent and coli bacteria. *Journal of Air Indonesia*. Google Scholar

Yuliastuti, E. (2011). Study of Ngringo Karanganyar River Water Quality in Water Pollution Control Efforts. *Thesis. Diponegoro University Graduate Program, Semarang.* Google Scholar