Journal of Engineering and Applied Sciences
SINCE 2000
MEDWELL PUBLICATIONS

The Effect of Land Use Change on the Water Quality of Cisadane River Ofthe Tangerang City

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Key words: Water Quality, STORET Methode, GIS, Land Use Change, Indonesia

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Page No.: 2128-2134
Volume: 15, Issue 9, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: Cisadane river is one of the important rivers in Indonesia. In the Tangerang City segment, This river is a source of raw water for the provision of clean water in the city of Tangerang, a source of raw water for the Soekarno-Hatta international airport as well as for irrigation. The main problem in this river is the high level of pollution, even every year the quality of river water tends to decrease. While the development of Tangerang City itself is growing rapidly, The rise of settlement construction, industry and other infrastructure turns open land into built land. This study aims to analyze the level of river pollution, determine the most dominant parameters in river pollution and analyze the relationship between land use change and river pollution. The method used is the STORET Method, Statistical Analysis, GIS and Multiple Regression Linear Model. The analysis results show that the quality of river water is heavily polluted, the most dominant pollutant parameters are BOD, COD, DO and Fecal Coliform. For the relationship between the change of open land into developed land also affects river pollution. Industry growth also influences river pollution, especially on BOD, COD and DO parameters.

INTRODUCTION

Based on the Medium-Term National Development Plan (RPJMN) 2014-2019, the Cisadane watershed (DAS) is one of the 15 priority watersheds in Indonesia. This Cisadane River is the main river in the Cisadane watershed area, this river has also become an icon for the City of Tangerang as a Water Front City. In addition, the river is also the main source of raw water for the Indonesian Regional Water Utility Company (PDAM) to meet the needs of clean water in the City and Regency of Tangerang including the Soekarno-Hatta International Airport also makes Cisadane River water as the source of its raw water. Most of the industries in this city use this river water to carry out their activities, but unfortunately, the condition of the water quality of the Cisadane River in recent years has experienced quite severe pollution. The decrease in the water quality of the Cisadane River tends to continue to occur every year[1].

The development of the Tangerang City itself becomes very fast as one of the backup cities for Jakarta. The city of Tangerang has such a rapid development, the development of the industrial sector, business and. The increase in the population also causes the need for land for residential complex also increased. The population growth and the rapid urban development will bring

changes on the land use, this can have a negative effect in the form of high pollution burden, the faster the land use change, the faster the decrease in the river water quality[2]. The results of other studies related to urban development in the country of Vietnam also confirmed the magnitude of the effect of city development on the decrease in the surface water quality as well as the more population the more amount of waste generated. Changes in land use due to urban development can pose a threat to the sustainability and health of watersheds[3]. The correlation shows that the type of land use is significantly correlated with water quality variables in the U-Tapao watershed, Thailand[4].

Such rapid land use change is also in line with the growth of the residential complex and the industries. The number of industries in the city of Tangerang, especially in the area around the Cisadane watershed has increased every year, based on the Central Bureau of Statistics (BPS) of the City of Tangerang data, in 2010 the number of industries reached 510 units. Then it increased again in 2013-641 units while in 2016 the number increased again to 699 units. The increase in the number of these industries has an impact on the economy of the citizens but the problem is that some of these industries dispose their waste directly into the Cisadane River without prior management, causing a decrease in the water quality of the Cisadane river.

The purpose of this study is to determine the status of river water quality, to obtain the most dominant pollutant parameters as well as to analyze the correlation between land use change and the river water quality. Various steps are needed in controlling pollution and in improving river water quality management. The early step of this research is to analyze the current status of river water quality and then to analyze the most dominant parameters in the decreasing of the water quality. This dominant parameter in the river water pollution is what will be analyzed later with the impact of land use change.

MATERIALS AND METHODS

The research was located in the Cisadane River, Tangerang City segment of the Banten Province of Indonesia. The study was preceded by assessing the status of river water quality using the STORET method, then analyzing the most dominant pollution factors while the data distribution was tested with a normality test through the Kolmogorov-Smirnov test. For the land use change, an analysis was carried out using the Landsat 8 approach which was then interpreted. The database used is the results of the Landsat 8 in 2005, 2010, 2013 and 2016. GIS-based Landsat 8 imagery. One of the analytical methods used in this study is GIS and land suitability analysis. GIS is a computer-based information system that is designed to work with data that have spatial coordinates and geographical references[6]. GIS is used to make specific land use plans so that they can be integrated and multifunctional with other landscapes[5]. While the river water quality data used are based on secondary data from the City of Tangerang Environmental Agency (BLH), the previous research, and primary data in 2016. In order to obtain the correlation between changes in land use and river water quality, multiple linear regression is used.

RESULTS AND DISCUSSION

In total, the length of the Cisadane River in the Tangerang City segment is 15 km while the data from the Environmental Agency (BLH) of the Tangerang City Government there are 16 locations of water quality sampling periodically. The period of taking and testing samples in the duration of 5 years from 2010-2015, in a year the BLH of the Tangerang City took water samples as much as 2-3 periods, both in the rainy season and dry season. The data from the BLH is then compared to the primary data which was also taken at the same 16 locations and conducted a water quality test at the UI Sanitary Engineering Laboratory. The parameters used in the analysis included 9 parameters, namely, pH, BOD, COD, DO, TDS, TSS, Fecal Coliform, Total Coliform, and Ammonia. The image below is the location of river water quality sampling (Fig. 1).

For the 16 locations of water samples, each location has different land functions. In this study, only 3 types of grouping or clustering were taken at the sampling locations, namely the residential location, the industrial location, mixed (CDB Dominant) including Soekarno-Hatta international airport location, so that the analysis was based on 3 land clusters, according to the grouping of areas in the Cisadane watershed of the Tangerang City.

Determination of river water quality status: To analyze the quality status of the water was conducted by the STORET Method. As for the results obtained in the16 locations along the Cisadane river in Tangerang City, the scores at each location were summed, so that the total score from P1 to P16 was obtained. The final result for the sum up of the scores for each locations are as follows, P1 = -52; P2 = -75; P3 = -76; P4 = -61; P5 = -61; P6= -78; P7 = -86; P8 = -54; P9 = -58; P10 = -57; P11 = -65; P12 = -46; P13 = -76; P14 = -58; P15 = -55; P16 = -61.

Thus, based on this analysis, the Cisadane River from points P1 to P16 from 2010-2016, all exceeded the -31 figure which means that the condition of the water quality is poor or in a heavily polluted condition. The lowest total

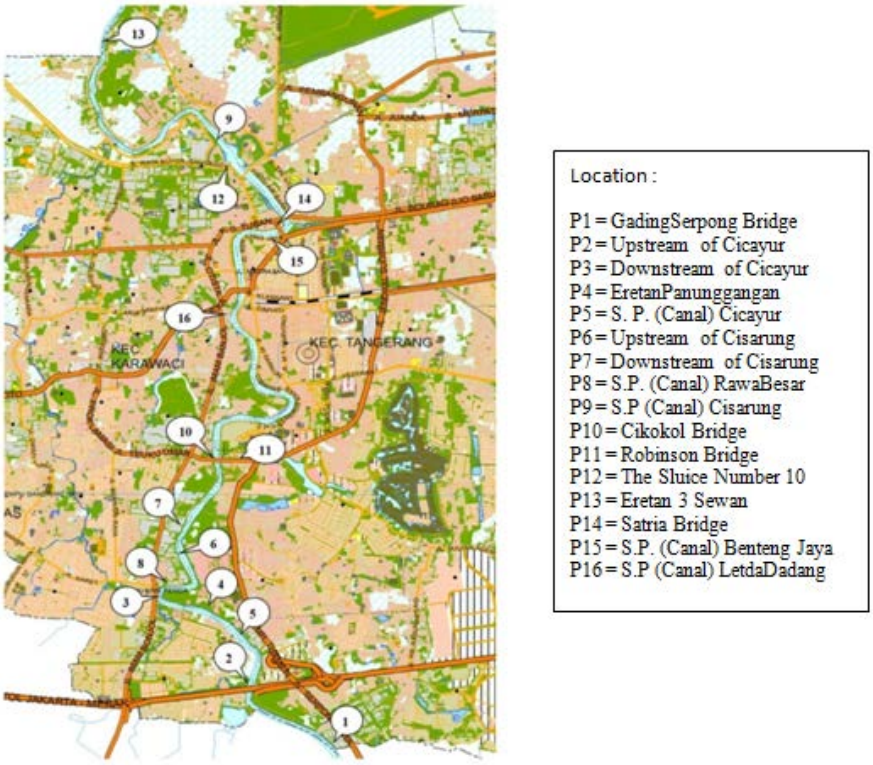

Fig. 1: River water quality sampling location

Table 1: River Water Quality Results Tables in 16 Locations

Parameter/unit	Standard (Class II)	Average value of each location 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Physics																	
TDS																	
mG/L	1000	145.53	288.41	293.14	150.94	157.01	342.86	521.29	155.99	87.54	129.61	120.44	136.91	190.9	136.23	125.8	131.54
TSS																	
mG/L	50	59.57	27.29	36.14	151.71	59.14	45	70.57	41.86	44.29	40.43	35.29	33.14	162	37.14	38.29	33.86
Chemistry																	
BOD																	
mG/L	3	11,37	61,78	65,84	11,56	17,86	83,65	115,82	9,67	18,45	18,83	28,56	17,05	16,11	13,80	13,84	28,37
COD																	
mG/L	25	18.97	91.51	107.16	18.45	31.61	139.07	193.57	14.38	28.19	30.7	45.56	26.27	25.93	18.56	20.91	38.95
DO																	
mG/L	4	4.4	2.86	2.27	3.86	3.74	2.17	1.39	3.67	4.08	3.83	3.33	3.3	3.13	2.98	2.44	3.88
NH-3																	
mG/L	(-)	2.54	8.65	10.93	2.12	1.75	13.4	10.71	2.1	2.55	1.25	1.2	2.13	6.37	2.44	2.35	3.03
pH	6-9	7,34	7,34	7,36	7,21	7,22	7,37	7,22	7,38	7,45	7,12	7,25	7,36	7,42	7,22	7.47	7.26
Biology																	
Fecal coli																	
Quantity/100 mL	1000	534.29	6744.71	8033	476.14	338.14	3246.14	13430.14	1703.29	1933.29	1191.86	5471.43	1574.71	11460	2671.43	1958.71	2518
Total coliform																	
Quantity/100 mL	5000	204.29	5589	8461.57	274.33	449.67	5446.33	23083	1243	1076.33	529.67	5943.67	554.33	13326.67	654.33	1047.67	2466.67

score was (-) 52 which was at P1 location (GadingSerpong Bridge), an area dominated by residential complexes while the highest was at P7 location (SP Cisarung Downstream) with a total score of (-) 86 was a mixed area (CBD). If comparing among the parameters, then of the 9 parameters above there are 2 parameters namely TDS and pH that meet the quality standards. While the parameters that give weight scores in each location there are 5 parameters, namely BOD, COD, DO, Ammonia and Fecal Coliform. To ensure that the data distribution is normal, then a normality test was carried out while looking for the most dominant factor in the river water pollution.

Pollutant source dominant parameter: To determine the most dominant parameters in the Cisadane river water pollution in the Tangerang City segment, an analysis was carried out using the following steps, started with finding the average distribution values of 9 parameters in 16 research locations and then which parameter values exceeded class 2 water quality standards and test the normality of the distribution of these numbers. The table below is a table of the average values of the 9 parameters located in 16 locations along the Cisadaneriver in the Tangerang City segment (Table1). Based on the table above, it shows that BOD is the most dominant pollutant

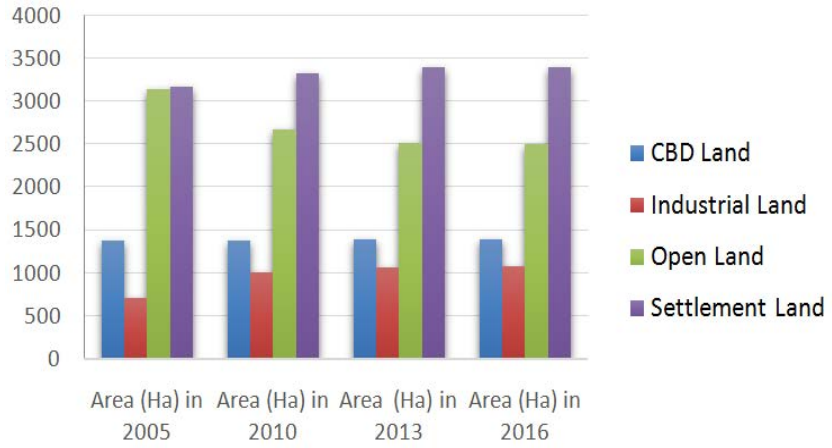

Fig. 2: Chart of land use change in Cisadane Watershed, Tangerang city in 2005-2016

parameter in all locations, for fecal coliform are pollutants in 14 locations. Whereas DO and COD, out of 16 locations there are 13 locations that exceed the minimum standard of class 2 water quality. Whereas Ammonia, in all locations there are its pollution values.

For the total Coliform parameter there are 6 locations in which numbers exceed the second class quality standard, TSS has 3 locations that exceed the quality standard. TDS, NH-3 and pH parameters still indicate appropriate quality standards or better than class 2 quality standards.

From the data above, the most dominant polluter parameters are BOD, Fecal Coli, COD and DO. These four parameters are tested for normality through the Kolmogorov-Sminorv test, to see whether the values are normal or not specifically for the most dominant parameters namely BOD, COD, DO and Fecal Coliform while the results are as follows (Table 2).

From the data above, the most dominant pollutant parameters are BOD, Fecal Coli, COD and DO. Normality test in the regression model is used to test whether the residual values generated from the regression are normally distributed or not. A good regression model which is a model that has a normally distributed residual value. From the data that existed for 6 years (2010-2016) a total of 112 data for each parameter, the Kolmogorov-Smirnov test result showed that the data were normally distributed. So, that the distribution of existing data meets the requirements.

Land use change analysis: Analysis of the land use change in the Cisadane watershed of Tangerang City using the method of Citra Landsat 8, from the management of this the Landsat 8 is then interpreted into a land use map with 5 types of land, namely, open land, residential land, industrial land, CBD dominant mixed land (including Soekarno-Hatta international airport) and water bodies. The Landsat 8 Recording used were in

Table 2: Normality test table Kolmogorov-Sminorv

Variables	N	BOD	COD	DO	Fecal coliform
		112	112	112	112
Normal	Mean	33.28	53.11	2.14	3955.33
Parametersa,b	SD	16.21	27.54	1.20	2010
Most extreme	Absolute	0.132	0.146	0.354	0.164
Tets statistic		0.132	0.146	0.354	0.164
Asymp. Sig. (2-tailed)		0.200cd	0.200cd	0.200cd	0.200cd

Analysis 2018

2005, 2010, 2013 and 2016. Based on the Landsat 8 analysis, the Cisadane watershed area of Tangerang City has experienced changes in land use every year, the area of open land has decreased every year. The increase in population also causes the need for land for residentials also increases. Interpretation results from the management of Landsat 8 show that the Cisadane watershed in the Tangerang City segment has experienced changes in the land use, from 2005-2016, the growth of residential land is relatively stable, the growth of industrial land is quite large and has an impact on the reduction in open land area. The following is a chart of land use change starting in 2005, 2010, 2013 and 2016 (Fig. 2).

The details of land use change based on area gradually from 2005 until 2016 are presented in the following figure and the table below, along with the results of the analysis Fig. 3 and Table 3. Based on the spatial analysis above, large changes (increase in area) occur in industrial land, then the residential land, its area of land, also grew positively (except in 2016) which declined with the curbing of illegal buildings around the river banks., then mixed areas or CBD also show positive land growth trends. While the change in the open land, the land area has experienced a substantial decrease.

Preliminary analysis shows that there is a correlation between the land use and the river water quality, the addition of industrial land area, residential land and mixed land, especially CBD which is identical to solid buildings, influencing the 4 most dominant water quality parameters on the river water pollution, namely BOD, COD, DO and Fecal Coliform.

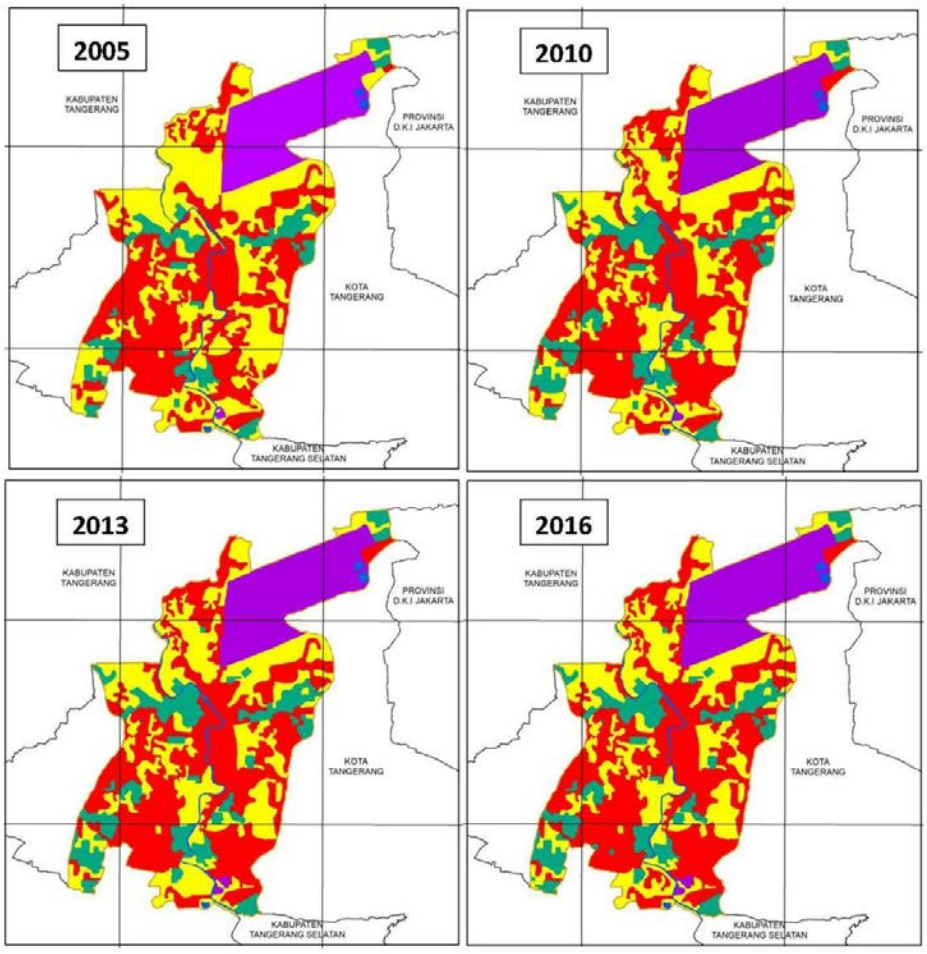

Fig. 3: Land Use Changes 2005, 2010, 2013 and 2016

Table 3: Changes in Land use 2005-2016

Land cover	Large (Ha) 2005	Change	Large (Ha) 2010	Change	Large (Ha) 2013	Change	Large (Ha) 2016
CBD	1374.085	7.043	1381.128	14.501	1395.630	1.690	1397.320
INDUSTRY	702.903	302.251	1005.154	64.106	1069.260	14.686	1083.946
OPEN LAND	3140.342	-462.243	2678.099	-155.912	2522.186	-16.172	2506.014
RESIDENTIAL	3172.530	152.949	3325.479	77.304	3402.783	-0.204	3402.580
TOTAL	8389.860		8389.860		8389.860		8389.860

Analysis, 2018

Correlation between land use and water quality: In this analysis, there were only 3 types of grouping or clustering taken at the sampling location, namely residential, industrial, mixed (Dominant CDB) locations, so the analysis was carried out based on those 3 clusters, according to the grouping of areas in the Cisadane watershed of the City of Tangerang.

Mathematically, it can be described as follows, simple linear analysis is a linear correlation between one independent variable (x) with the dependent variable (y). This analysis is to determine the direction of the correlation between the independent variable and the dependent variable whether it is positive or negative and to predict the value of the dependent variable if the independent variable increases or decreases. The data used is usually interval or ratio scale with the following formula:

Multiple linear regression

$$Y' = a + bX1 + cX2 + dX3 + eX4$$

Explanation:

Y' = Dependent variable (predicted value)
X1 = Independent variable (CBD Land)
X2 = Independent variable (Industrial Land)
X3 = Independent variable (Open Land)
X4 = Independent variable (Settlement Land)

- Constant (Y'value if X = 0)
- Regression coefficient (the value of increasing or decreasing of CBD land)
- Regression coefficient (the value of increasing or decreasing of industrial land)
- Regression coefficient (the value of increasing or decreasing of open land)
- Regression coefficient (the value of increasing or decreasing of Residential land)

The quality of the Cisadane river is measured based on the levels of the dominant pollutants found in the river water. Coefficients are parameters that must be estimated from the data. For the correlation of the water quality with the land use change, each has a regression model, thus, in this discussion there were three sample locations taken, namely the upstream of the river (the border of the City of Tangerang and the City of South Tangerang), the central part of the river and the downstream of the river (approaching the border with the Tangerang Regency) represented by P1, P11 and P9.

In a simple linear regression analysis, the data used must meet the normality and homogeneity assumptions. Data processing of multiple linear regression analysis using the SPSS version 22 application. The analysis was carried out based on 4 dominant parameters (BOD, COD, DO and Fecal Coliform) located in P1, P11 and P9. The following are the results of the analysis of each parameter.

BOD parameter

Water quality data as follows:

BOD	P-01	P-11	P-09
2005	2.00	5.34	12.68
2010	3.00	5.00	3.00
2013	14.00	14.00	26.00
2016	15.76	130.49	23.00

Regression Model as follows:

$P_1 \rightarrow Y = -102{,}89+0{,}116\ x_2-0{,}003\ x_3$

$P_{11} \rightarrow Y = -11074{,}7+8{,}44\ x_2+0{,}460\ x_3$

$P_{09} \rightarrow Y = 325{,}48-0{,}206\ x_2-0{,}031\ x_3$

$R = 1$

From the regression model above, it is stated that the growth of industrial land will have an effect on the river water quality as well as the decrease in the amount of open land will further lead to a decrease in the quality of river water BOD, especially, at the locations of P1 and P11. R = 1, shows a strong relationship between land.

COD Parameter

Water Quality data as follows:

COD	P-01	P-11	P-09
2005	21.00	33.51	63.85
2005	25.00	49.00	30.00
2010	25.00	24.00	31.00
2013	21.00	194.00	28.00

Regression Model as follows:

$P_1 \rightarrow Y = -375{,}91-0{,}290\ x_2\ -0{,}016\ x_3$

$P_{11} \rightarrow Y = -14974{,}9+12{,}35\ x_2\ +0{,}707\ x_3$

$P_{09} \rightarrow Y = 297{,}591-0{,}218\ x_2\ -0{,}012\ x_3$

$R = 1$

From the regression model above it is stated that the growth of industrial land (X2) will have an effect on the river water quality as well as a decrease in the amount of open land (X3) will further bring a decrease in the COD quality of the river water. R = 1, shows a strong relationship between land.

DO Parameter

Water Quality data as follows:

DO	P-01	P-11	P-09
2005	NA	NA	NA
2010	5.20	4.60	5.50
2013	5.50	5.20	5.00
2016	5.55	2.45	3.56

Regression Model as follows:

$P_1 \rightarrow Y = 13{,}298\ -0{,}003\ x_3$

$P_{11} \rightarrow Y = -423{,}69+0{,}170\ x_3$

$P_{09} \rightarrow Y = -219{,}382+0{,}089\ x_3$

$R = 1$

From the regression model above it is stated that the reduction in the amount of open land (X3) will further decrease the DO drop on the river water. This decrease is due to the land changes (industrial development, residential and other mixed areas). R = 1, shows a strong relationship between land.

FECAL COLLI Parameter

Water Quality data as follows:

Fecal	P-01	P-11	P-09
2005	7000.00	8900.00	18000.00
2010	1500.00	4300.00	4300.00

2013	1900.00	16000.00	6200.00
2016	240.00	7.80	23.00

Regression Model as follows:

$P_{11} \rightarrow Y = 1458.840,31\text{-}1172,156\ x_2\ \text{-}75,113\ x\_3$

$P_{09} \rightarrow Y = 554568,6\text{-}\ 450,08\ x_2\text{-}\ 26,607\ x_3$

$P_{01} \rightarrow Y = 148890,9\text{-}120,84\ x_2\text{-}7,048\ x_3$

$R = 1$

From the regression model above it is stated that the growth of industrial land will have an effect on the amount of the fecal colli pollution as well as a decrease in the amount of open land will further bring a decrease in river water quality (Fecal Coli). R = 1, shows a strong relationship between land.

CONCLUSION

The quality status of the water of the Cisadane River of Tangerang City is heavily polluted. The most dominant pollutant parameters are BOD, COD, DO and Fecal Coliform. Meanwhile, the correlation between the land use change and the water quality shows that the results of the four multiple linear regression models show that the change of the open land to built-up land will have an effect on the decreasing of the river water quality in all parameters. For industrial land growth, it also has an effect on river pollution, especially for BOD, COD and DO parameters. Thus, the tighter arrangements in anticipating changes in land use in the City of Tangerang are needed while for industrial growth it should be followed by an increase in the wastewater management in order to be more optimal in the controlling pollution from industry.

ACKNOWLEDGMENTS

The researcher thanks the support of GIS data to Mr. IksalYanuansyah from the Geo-Informatics Laboratory, Campus UIKA Bogor.

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