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Land Use And Effect On Water Quality In Urban Catchment Area

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Abstract:- This research is aimed to analyze the quality of water in downstream of Parit Tokaya catchment area. The quality of water is analyzed at 7 points of water sampling. Water quality parameters analyzed were temperature, TSS, TDS, pH, DO, and BOD. Along the downstream of Parit Tokaya, water temperature ranges from 25 °C - 26.4 °C, the value of TSS 16 - 88 mg/l, the value of TDS 93.1 - 398 mg/l, pH ranges from 6.64 – 6.96, the value of DO 0.3 – 3.72 mg/l, and the value of BOD 19.83 - 102 mg/l. The total concentration of coliform at the point 1, point 4 and point 5 include the water quality standard, while at the other point it has exceeded the required threshold. Pathogenic E. Coli at the point 1, point 3, point 5, point 6 and point 7 obtained negative value (-), while at the point 2 and point 4 obtained positive value (+).

Keywords:- catchment area, Parit Tokaya, water quality

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I. INTRODUCTION

Water in the essential requirement for mankind for drinking, irrigation, industrial, and other purposes, but due to uncontroled utilization has led to decrease in water quality [1].

The development of Pontianak City has become an attraction for the surrounding areas and increasing the flow of urbanization. Increased urbanization has an impact on space requirements and land use change. Regions that originally functioned as water absorption areas to be reduced or even lost, especially in the catchment area of Parit Tokaya, the water catchment area is around 23.55% of the total area.

Common problems related to drainages in Pontianak City, especially in the downstream of Parit Tokaya catchment area are squatter in riverbanks, poorly maintained drainage condition, overgrown with grass and wild plants, so there is narrowing in some parts of the drainage. The habit of some people throw garbage in the drainage causes drainages to become dirty and polluted, so the quality of water decreases. Drainages in Pontianak City, currently still managed by the government through the Office of Public Works Pontianak City, Kalimantan River Basin I Ministry of Public Works of Republic Indonesia, Office of Sanitation and Gardening Pontianak City, Office of Environmental Pontianak City, economy and development affairs of South Pontianak district, economy and development affairs in the village. Non-governmental organizations are not involved in the management of drainage. Mutual assistance activities for the cleaning of drainage by the community are done at certain times only, for example during certain activities and not done continuously.

II. WATER QUALITY CLASSIFICTION

Water quality is a qualitative condition of water that is measured and tested based on certain parameters and methods and based on applicable rules and regulations [2]. The water quality can be expressed by the physical parameters of the water characteristics and the quality of river water. Physical parameters state the physical condition of water or the presence of visually observable/visible materials. The parameters are particle/solid content, color, taste, odor and temperature, while those included in river water characteristics are sedimentation and salinity [3].

Water contamination is indicated by the decrease of water quality up to a certain level of quality standard that causes water to not function in accordance with its designation. Water quality standard serves as a benchmark to determine the occurrence of water pollution and is a guide on the level of water quality that will be achieved or maintained in the control of water pollution.

The classification of water quality based on Indonesian Government Regulation No. 82/2001 on Water Quality Management and Water Pollution Control is set to 4 (four) classes, namely:

a. Class I, water whose designation may be used for drinking water, and / or other allotments which require the same water quality as that purpose;
b. Class II, water intended for use in recreational water facilities, freshwater fish farming, livestock, water to irrigate crops, and or other designations that require the same water quality as those uses;
c. Class III, water which can be used for the cultivation of freshwater fish, farms, water to irrigate crops, and / or other designations that require the same water quality as those uses;
d. Class IV, water which can be used to irrigate crops and/ or other designations that require the same water quality as those uses.

III. WATERSHED

The watershed is an area bounded by the ridges whose surface flows into a main river. On the basis of this definition the watershed can be defined as a unity of space consisting of abiotic elements (land, water, air), biotics (vegetation, animals, and other living organisms) and human activities that interact and interdependence with each other, an integral ecosystem, this means that if the linkage has been established then the management of forest, land, water, community and others must pay attention to the role of the components of the ecosystem [4].

Based on its function, watershed is divided into three parts, namely upstream watershed, central watershed, and downstream watershed. Upstream watersheds are based on managed conservation functions to maintain the watershed environment conditions that are not degraded, which can be indicated by watershed vegetation cover conditions, water quality, water retention, and rainfall. The central watershed is based on a river water utilization function that is managed to provide benefits for social and economic interests, which can be indicated from water quantity, water quality, water delivery capacity, and groundwater levels, and is related to irrigation infrastructure such as river management, reservoirs, and lakes. Upstream watersheds are based on river water use functions that are managed to provide social and economic benefits, which are indicated through the quantity and quality of water, water delivery capabilities, rainfall levels, and related to agriculture, clean water and wastewater [5].

IV. RESEARCH METHODOLOGY

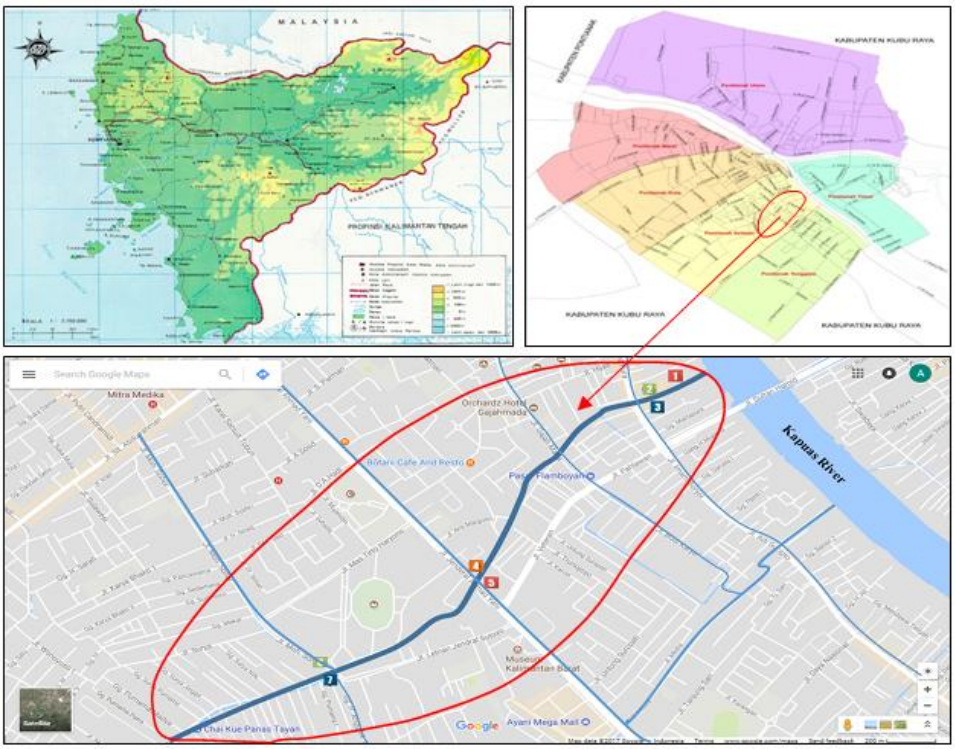

Fig.1: Water sampling location

Water quality observation is done at low tide to know the change of parameters of water quality in downstream of Parit Tokaya catchment area, because at low tide the water condition will be at the lowest water quality where there is no dilution as in the event of tidal or rain. Water sampling is carried out in accordance

with the Water Sampling Method (SNI 06-2412-1991), where a stream or drainage with a discharge of less than 5 m^3/sec, an example taken at a point in the middle of a river at 0.5 h from the water surface.

The water sample is then tested to determine its quality. The test results of water samples in the laboratory will be analyzed water quality parameters with reference to Indonesian Government Regulation No. 82/2001 on Water Quality Management and Water Pollution Control and Regulation of the Minister of Health No. 416/Menkes/Per/IX/1990 on Terms and Quality Supervision Water. The analysis will be carried out on the water samples taken at some point specified in the Parit Tokaya.

Data of water quality test results will then be processed using Multiple Linear Regression method with the following equation:

$$y = a + b_1x_1 + b_2x_2 + ... + b_nx_n \quad (1)$$

where:

y = dependent variable (predicted value),
$x_1, x_2, ... x_n$ = independent variable,
a = intercept (or constant),
b = regression coefficient (value increase or decrease)

V. Result And Discussion

Water sampling is conducted during low tide. Sampling is done at 7 points that have been determined, respectively on right and left of the canal. Water quality parameters analyzed were temperature, TSS, TDS, pH, DO, and BOD. Table I shows the results of water quality testing.

Table I: Water Quality Testing Results

Parameters	Unit	Location						
		1	2	3	4	5	6	7
Temperature	°C	25	26.4	26.4	26.5	26.4	26.5	26.4
TSS	mg/l	47	42	18	16	19	88	21
TDS	mg/l	93.1	287	283	289	275	398	246
pH	mg/l	6.96	6.64	6.68	6.68	6.71	6.82	6.73
DO	mg/l	3.72	1	2.4	0.8	3.2	0.3	3
BOD	mg/l	19.83	61	73	74	91	49	102
Total coliforms	MPN/100 ml	300	$16x10^7$	$16x10^7$	240	$16x10^7$	$16x10^5$	$16x10^7$
Pathogenic E. Coli	-	Negative (-)	Positive (+)	Negative (-)	Positive (+)	Negative (-)	Negative (-)	Negative (-)

A. Temperature

The water temperature at the point 1 is 25 °C. The water temperature at the point 2, point 3, point 5 and point 7 are 26.4 °C. The water temperature at the point 4 and point 6 temperature are 26.5 °C. Water temperatures at all observations points are included in normal temperatures (tropical) ranging from 20 °C to 30 °C. The value of the water temperature allows the aquatic flora and fauna to live. The water temperature along the Parit Tokaya is classified as class I water quality.

B. Total Suspended Solids (TSS)

The result of TSS measurement at low tide in downstream of Parit Tokaya at the point 1 is 47 mg/l, at the point 2 is 42 mg/l, at the point 3 is 18 mg/l, at the point 4 is 16 mg/l, at point 5 is 19 mg/l, at point 6 is 88 mg/l and at the point 7 is 21 mg/l.

The quality of the water at the point 6 with the TSS value is included in the class III water quality classification. Water quality at 6 other points with the TSS value is included in the class I water quality classification.

C. Total Dissolved Solids (TDS)

Indonesian Government Regulation No. 82/2001 sets the maximum standard limit for TDS parameters for class I water quality classification, the water that can be used for drinking water is 1000 mg/l.

The results of laboratory tests on water samples at all observation points indicate that the TDS value across the observed point ranged from 93.1 - 398 mg/l including the class I water quality.

D. pH

The pH value at low tide at all observation points are between 6.64 - 6.96. If pH <7 means acid and if pH> 7 means a base, then pH at all observation points are acid. This is due to the influence of peat land in the upstream, thus affecting the water acidity level in the Parit Tokaya.

E. Dissolved Oxygen (DO)

The results of the measured oxygen measurements (DO) at low tide at point 1 is 3.72 mg /l, at the point 2 is 1.0 mg/l, at the point 3 is 2.4 mg/l, at the point 4 is 0.8 mg/l, at the point 5 is 3.2 mg/l, at the point 6 is 0.3 mg/l and at the point 7 is 3.0 mg/l. The value of the dissolved oxygen concentration at the point 1, point 5 and point 7 are included in the criteria of river water quality class III. The value of dissolved oxygen concentration at the other points included in the class IV water quality criteria.

F. Biological Oxygen Demand (BOD)

The result of BOD parameter measurement at low tide at the point 1 is 19.83 mg/l, at the point 2 is 61 mg/l, at the point 3 is 73 mg/l, at the point 4 is 74 mg/l, at the point 5 is 91 mg/l, at the point 6 is 49 mg/l and at the point 7 is 102 mg/l. The BOD concentration value at all observation points has exceeded 10 mg/l, so it is not in accordance with the water quality standard.

G. Total Coliforms

The result of measurement of total parameters of coliform at low tide at point 1 is 300 MPN/100 ml, at point 2, point 3, point 5 and point 7 are $16x10^7$ MPN/100 ml, at the point 4 is 240 MPN/100 ml, and at the point 6 is $16x10^5$ MPN/100 ml. The total coliforms concentration values at the point 1 and point 4 are still within the first class water quality is 1000 MPN/100 ml, so it can still be used for raw water of drinking water, but at other points the total concentration of coliform is not accordance with the water quality standard. The total number of coliforms at low tide is well beyond the required threshold.

H. Pathogenic E. Coli

The result of measurement of pathogenic E. Coli parameter at low tide at the point 1, point 3, point 5, point 6 and point 7 obtained negative value (-) are accordance with the water quality standards, while at the point 2 and point 4 obtained positive value (+) indicating that at these points have contained pathogenic E. Coli bacteria and did not accordance with the water quality standard.

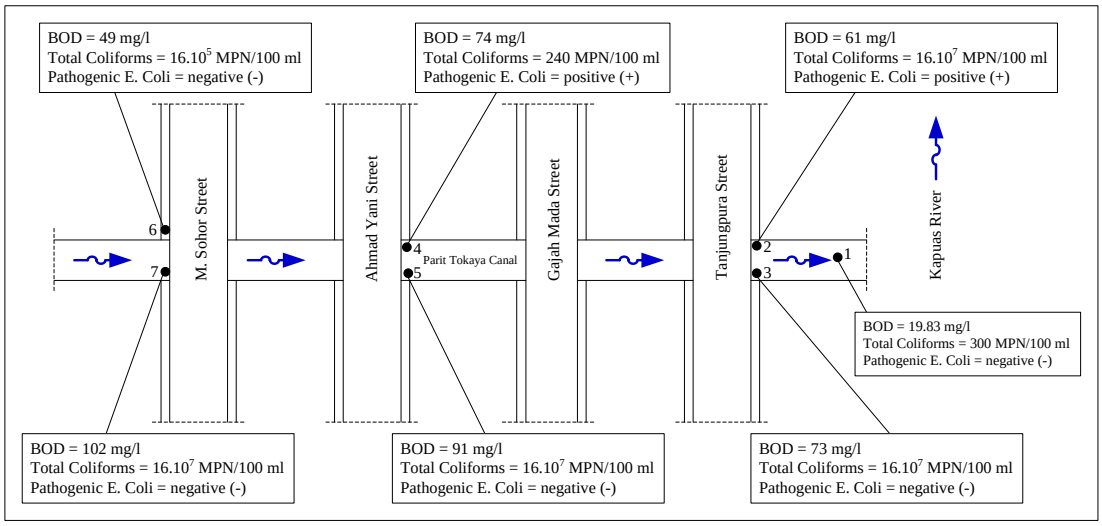

Figure 2: Distribution of BOD content, Total Coliforms and Pathogenic E. Coli at all observation points

Figure 2 shows the distribution of BOD content, total coliform, and Pathogenic E. Coli at all observation points. Based on water quality test results at some observation point, BOD parameter is the most dominant parameter, then total coliforms and pathogenic E. Coli. Based on the Regulation of the Minister of Health of the Republic of Indonesia Number 416/Menkes/Per/IX/1990 Concerning the Terms and Supervision of Water Quality, the third level of water quality parameters has exceeded the required quality standards. This indicates that at all observation points have been polluted.

The indicator used to assess the level of water pollution occurring in the Parit Tokaya is the BOD parameter. Results of analysis with multiple linear regression method showed that the BOD value is influenced by the value of TSS and DO as shown in Table II.

Table II: Analysis of Variance

	Coefficients	Standard Error	t Stat	P-value
Intercept	92.8247	1.3913	66.7140	0.0095
x_1	-0.4473	0.0213	-20.9703	0.0303
x_2	-13.9412	0.4129	-33.7625	0.0188

The regression equation is:

$$y = 92.825 - 0.447x_1 - 13.941x_2 \quad (2)$$

where:

y = BOD value,
x_1 = TSS value,
x_2 = DO value

Based on the regression equation obtained, BOD is significantly influenced by TSS and DO. This is indicated by the value of P-value for x_1 = 0.0303 and x_2 = 0.0188. DO have more influence than TSS to change BOD. Ideal conditions where water quality is in good condition will be obtained if the BOD value is small and the DO value is high. Small BOD value and high DO value can be achieved if the water condition is clean and not polluted by garbage, for that socialization or effort to invite people not to litter and apply clean life pattern must be done actively and continuously.

Land use is the end result of every form of human intervention to the earth's dynamic land that serves to fulfill both material and spiritual needs [6]. Changes in land use patterns to agricultural land, moor, and settlements and increased industrial activity will have an impact on hydrological conditions within a watershed (DAS). Various human activities in providing for their life come from industrial activities, households, and agriculture will produce waste that will contribute to the decrease of river water quality [7]. The source of pollutants entering the waters comes from industrial activities, agriculture, settlements, and urban centers [8], [9].

Land use in the downstream of Parit Tokaya catchment area is a largely built area, ie housing, shops, markets and others. The use of land as a urban solid has an impact on water quality in the downstream Parit Tokaya. As an illustration can be seen from the largest TSS value contained in the point 6. Large TSS values indicate erosion occurring in river or canal flow. This is due to tertiary canal condition that leads to the secondary canal in M. Sohor Street is the natural canal, so the chances of erosion of canal wall, while at the point 1 and point 2 value of TSS is big enough because the secondary canal there is still a natural canal. The smallest TSS values are at point 4 and point 5. Another indicator as a pollutant source is a small DO value. DO at the point 6 shows the smallest value caused by the settlement around M. Sohor Street, while at the point 4 source of pollution comes from settlement around Ahmad Yani Street. The source of pollutants at the point 2 comes from the settlements around Tanjungpura Street.

Another dominant pollutant source is BOD. Domestic waste causes oxygen content in low waters and high BOD [10]. BOD comes from domestic waste home and home industry which is discharged directly to secondary canal which leads to Parit Tokaya. The next predominant pollutant indicator is the total value of coliform. Coliform bacteria is an indicator of the contamination of faeces or faeces of humans and animals in the waters, so its presence in the water is not desired, whether in terms of health, aesthetics, cleanliness and the possibility of a dangerous infection. Some types of diseases can be transmitted by coliform bacteria through water, especially stomach diseases such as typhoid, cholera, and dysentery [7]. The total value of the coliform at the point 1 and the point 4 still include the threshold of the criteria for the quality of the river water class I, while at other points of observation is beyond the required threshold. Domestic waste water discharged without processing into the secondary canal that leads to the Parit Tokaya is one of the causes of pollution and the high value of total coliform in the canal. Another pollutant source that is quite dominant in Parit Tokaya is pathogenic E. Coli. Positive values (+) of pathogenic E. Coli obtained point 2 and point 4. The source of pollutants of the point 2 comes from the settlements around the secondary canal of Tanjungpura Street, while at the point 4 comes from the settlements located around the secondary canal of Ahmad Yani Street. Inadequate environmental sanitation conditions, for example, there is no communal WWTP (Waste Water Treatment Plant) in densely populated areas, so that household effluent discharged without processing into secondary canals leads to the Parit Tokaya is one of the causes of the discovery of contaminated pathogenic E. Coli water in the canal.

Changes in water quality conditions in the river basin are the impacts of disposal of land use around the river [11]. The quality of river water is strongly influenced by the quality of the water supply from the catchment area, while the quality of supply from the catchment area is related to human activities in it [12]. Based on the results of research that has been done can be seen that changes in land use will affect the quality of

river water, therefore controlling the development of the city becomes an important factor in the effort to maintain the function of the watershed area to stay preserved.

VI. CONCLUSIONS

1. The institution that handles the drainage management in Pontianak City including the drainage of Parit Tokaya is the Public Works Department of Pontianak City and Kalimantan River Basin I Ministry of Public Works of Republic Indonesia. Until now there is no drainage management institution that comes from self-supporting community
2. Throughout the trench the downstream waterway ranges from 25 °C - 26.4 °C, TSS value 16 - 88 mg/l, TDS value 93.1 - 398 mg/l, pH ranges from 6.64 to 6.96, DO values were 0.3 - 3.72 mg/l, and BOD values were 19.83 - 102 mg/l. The total concentration of coliforms at the point 1, point 4 and point 5 still include the water quality standard, while at the other point it has exceeded the required threshold. Pathogenic E. Coli at the point 1, point 3, point 5, point 6 and point 7 obtained negative value (-), while at the point 2 and point 4 obtained positive value (+).
3. The predominant water quality parameters along the Parit Tokaya drainage canal are BOD, total coliforms, and Pathogenic E. Coli. The third level of water quality parameters is based on Regulation of the Minister of Health of the Republic of Indonesia No. 416/Menkes/Per/IX/1990 on Terms and Supervision of Water Quality has exceeded the required quality standards. This indicates that there has been contamination along the downstream of Parit Tokaya drainage canal.

VII. RECOMMENDATIONS

1. More intensive socialization to the community not to throw garbage in the drainage and to prepare the means of garbage disposal near the residential area, especially in the settlement of the people around the drainage.
2. The management of the hotel, industry, health and market facilities should have an independent Wastewater Treatment Plant (WWTP), so waste water discharged meets the standards for disposal to drainage.
3. The soil canals should be replaced with concrete canals to reduce erosion of the canal wall.
4. Waste management with organic and inorganic waste separation and encourage the establishment of waste banks managed by the community independently.
5. Normalization of canals by dredging and cleaning drainage periodically to anticipate silting and narrowing drainages, so it remains in good condition and maintained.

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