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Water Pollution and Water Quality Status of Kahala River Kenohan District Kutai Kartanegara, Indonesia

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Abstract

This study was conducted in the Kahala River, Kenohan District, Kutai Kartanegara, East Kalimantan, Indonesian. The sampling was carried out on 6 stations, with two seasons, the monsoon and the dry season. The results showed that the quality of the studied river based on the STORET index varied. The category of Station-I till Station-V shown in the Moderately Polluted, but the different result shown at Station-VI it is indicated in the category of Heavily Polluted, where there are some key parameters such as TSS, pH, DO, BOD_5, COD, $CaCO_3$, Cd, Cu and MBAS where the result is disreputable. The cross-section profile of the upstream to downstream sections shown a variation, where there are differences valley structures or the riverbed layers on each station.

Keywords: Water Pollution, Kahala River, STORET Index, Water Quality Status.

INTRODUCTION

Water has an important role in the sustainability of a life cycle which is the basic substance of primary needs that it needs its existence. (Sikder, 2015) Water is a chemical compound formed by the hydrogen bonding (H_2) with the element of oxygen (O) forming the H_2O liquid chemical substance that has a tasteless, odorless and nearly colorless. The water freezes at 0^0C while boiling at 100^0C, in the condition at the pressure of 1 atm. (Schroeder, 1977) The size of one molecular water is very small which is, the diameter is about 3A (0.3 nm or $3x10^{-8}$ cm) in the form of a liquid phase, gas phase (vapor) and solid phase. In the liquid phase, water is a weak electrolyte with an equilibrium reaction: (Smol, 2008)

$$2H_2O \rightleftarrows H_3O^+ + OH^- \quad (1)$$

Kenohan District is included in the area of Kutai Kartanegara and is traversed by a large river, the Belayan River. From the river Belayan there is also a tributary, the Kahala River which is forms a stretch along the area of Kahala village as the local communities give the name of the river. The length of Kahala River is about 77 Km. (I. Efendy and H. Rahmah, 2018) Kahala River is utilized by the riverside communities for carrying out to the daily activities, so it can be interpreted that the Kahala village is very dependent on the Kahala River. Also, industrial and plantation activities that will have a direct influence on river water quality. (Antoni Grzywna, 2016)

Human activities must be convenient for water quality. Generally, the water can be used for drinkable and domestic water supply, water industrial purpose, irrigation system, agriculture activities, aquaculture, etc. (Sikder, 2015) The determination of clean water standard is not simple, because very depends on certain factors that are interrelated between the water source and the usability. According to the agreement that clean water is not determined based on the purity of the water but on its normal conditions. (Tirkey Poonam, 2015) The Determination of water pollution and water quality status can be through using a traditional an approach for the river water evaluating are usually to be approach based on the comparison parameter values with the local normative system. (Cude, 2001)

The STORET (Storage and Retrieval of Water Quality Data System) index method is a commonly used method to determine the water quality status. By using the STORET index method, the water analysis parameters can be determined by its status, whether they have met or exceeded water quality standards. In principle, the STORET index method compares water quality analysis with the standard value of water quality which is previously determined to the water quality status. This method to be used in determining the water quality status by using a scoring system referring to the "United States Environmental Protection Agency (USEPA)". (Barokah, 2017)

The basic profile of the river can be interpreted as a characteristic of the shape or pattern of the valley and river cross-sections. Based on the research developments, the river profile process met four levels. (Wardhana, 1999)

1. Youth Period, located in the upstream area of the river which has a considerable height of relief. Founded an upright erosion, forming a V-shaped Valley.
2. Maturity Period was found in the middle of the river, which is characterized by a reduction in water flow velocity, due to the reduced relief heights, hardened sediments meander often occurs.
3. Old Age Period was found in downstream areas with a low altitude which is characterized by no upright erosion and lower carrying capacity of sedimentation in the center. Seawater pressure on the estuary causes delta frequently.
4. Rejuvenation, a part of the river that can be said as a young period was passing through the youth period. The bottom surface of the river may be inaugurated by uplift and become a plain and the water flow becomes a separate flow pattern. (Lobeck, 1939)

EXPERIMENTAL

Material and Methods:

The study was conducted in the beginning of January 2019 until completion. The location of the study was conducted on the Kahala River and its tributaries. The sampling location is divided into several stations. (Allahbakhh Javid, 2014)

Station-I (Teluk Bingkai River) located upstream of the Kahala River. Sampling coordinates (0°00'57.0"N 116°22'55.1"E). Station-II (Loa Surut River) located upstream of the Kahala River. Sampling coordinates (0°00'50,0"N 116°23'13.2"E). The approximate distance between Station-I and Station-II is 1 km. Station-III (Lamin Pulu River) located upstream of the Kahala River. Sampling coordinates (0°01'05.2"S 116°21'28.7"E). The approximate distance between Stations-II and Station-III is 8.5 km. Station-IV (Kahala River). Sampling coordinates (0°01'22.3"S 116°21'42.6"E). The approximate distance between stations-III and Station-IV is 1.5 km. Station-V (Upstream Kahala River). This station is a part of the assembly point of the two rivers, that is the Teluk Bingkai River and Loa Surut River. Sampling coordinates (0°00'42.2"N 116°23'03.7"E). The approximate distance between Station-IV and Station-V is 6 km. Station-VI (Downstream Kahala River). This station is a part of the assembly point of the two rivers, that is the Lamin Pulu River and Kahala River. Sampling coordinates (0°01'23.6"S 116°21'44.8"E). The approximate distance between Station-V and Station-VI is 6.8 km. (I. Efendy and H. Rahmah, 2018)

Analysis of sample was carried out in the Laboratory of FMIPA, Mulawarman University and Baristand Samarinda Laboratory.

General procedure:

The sampling was carried out on 6 stations, according to the specified studies. Water samples were taken using a portable water sampler and then transferred onto the sample bottle. For each sampling point, 3 bottles were taken with the treatment of 1 bottle without preservatives and 2 other bottles using preservatives H_2SO_4 and HNO_3 until pH 2. The measurement of water quality can be determined based on two methods that are in situ (directly on the locate) and ex-situ (in the laboratory). The measurements of water quality using a ‘Water Checker’ for in situ parameters such as water temperature, pH, DO and H_2S. While TSS, NH_3-N, NO_2-N, BOD_5, COD is measured in ex-situ using a Spectrophotometer. (Rahim, 2019)

Components Reviewed:

The environmental studied were expected to be significantly impacted and which became the determining degradation factor of river function, which includes:

a) Hydrological Parameters
   - Flow rate of the River
   - River Cross-Sectional Areas Profile

b) River Water Quality of the Studies

c) River Water Status

Data Analysis:

Hydrological Parameters

Equation (2) shows, flowrate is the multiplication between the vertical cross-section area (river profile) and velocity.

$$Q = A \times V \quad (2)$$

note: Q = Flow rate (m^3/s);

A = Cross-sectional area (m^2);

V = Velocity (m/s)

Flow velocity is measured using 'Current Meter'. For cross-sectional area can be measured using GPS tracking data. To measure the cross-sectional area by determining the river profile previously. The cross-sectional area of the river (A) is the sum of all areas by multiplying the interval between an interval of the width and depth of the rivers, while the formula is written as follows: (Verbist, 2009)

$$A\ (m^2) = L_1D_1 + L_2D_2 + \ldots\ L_nD_n \quad (3)$$

note: L = Width (m)

D = Depth (m)

Water Quality

The sampling conditions are represented by two seasons, the monsoon and the dry season. The Evaluation of water quality convenient to the provision of river water, as a source of clean water in accordance with Government Regulations. (see Table 1)

Table 1. Water Parameters, Quality Standards and Analysis Methods

Parameters	**Unit**	**Quality Standards**	**Methods**
TDS	mg/L	1000	SNI 06-6989.27-2005
TSS	mg/L	50	SNI 06-6989.3-2004
Turbidity	NTU	-	SNI 06-6989.25-2005
Color	PtCo	180	SNI 06-6989.24-2005
Temperature	^oC	Deviation 3	SNI 06-6989.23-2005
pH	-	6 - 9	SNI 06-6989.11-2005
DO	mg/L	≥ 4	SNI 06-6989.14-2004
BOD_5	mg/L	3	APHA 2012 (Section 5210-B)
COD	mg/L	25	SNI 6989.73:2009
Chloride	mg/L	600	SNI 6989.19:2009
Hardness	mg/L	50	SNI 7644.2010
Nitrite (NO_2-N)	mg/L	0.06	SNI 06-6989.9-2004
Nitrate (NO_3-N)	mg/L	10	SNI 6989.74:2009
Ammonium (NH_3-N)	mg/L	-	SNI 06-6989.30-2005

Parameters	**Unit**	**Quality Standards**	**Methods**
Sulfate (SO_4)	mg/L	-	SNI 6989.20:2009
Ferro (Fe)	mg/L	-	SNI 6989.4:2009
Mangan (Mn)	mg/L	-	SNI 6989.5:2009
Lead (Pb)	mg/L	0.03	SNI 6989.8:2009
Cadmium (Cd)	mg/L	0.01	SNI 6989.16:2009
Zinc (Zn)	mg/L	0.05	SNI 6989.7:2009
Copper (Cu)	mg/L	0.02	SNI 6989.6:2009
Chromium VI (Cr^{+6})	mg/L	0.05	SNI 06-6989.17-2004
Mercury (Hg)	mg/L	0.002	SNI 6989.78: 2011
Oil and Grease	mg/L	1	SNI 6989.10:2011
Phosphate (PO_4-P)	mg/L	0.2	SNI 06-6989.31-2005
Fluoride	mg/L	1.5	SNI 06-6989.29-2005
Surfactant (MBAS)	mg/L	0.2	SNI 06-6989.51-2005
Fecal Coli	MPN/100 mL	-	Most Probable Number (MPN)
Total Coliform	MPN/100 mL	-	Most Probable Number (MPN)

Source: Gov. Regulation No. 82 of 2001, Class II and Regional Kaltim Regulation No. 2 of 2011, App. 3

Water Status

The Determination of water quality status is conducted based on the Ministry of Environment Decree number 115 of 2003 about the Guidelines for Determination of Water Quality Status. Clause 2 mentioned that the STORET method can be used to determine water quality status. This index consists of three categories of water quality parameters (physics, chemistry, and biology). Principally, the STORET method compares water quality data with water quality standards previously to determine water quality status. (Barokah, 2017)

The steps using STORET method in determining status of the water quality as follows:

1. Analysis of data collection of water quality and velocity periodically (time series data) in several times;
2. The results of each water parameter compared with the water quality standards in accordance with the water classification;
3. If the measurement results meet the water quality standard (water measurement results < water quality standard) then a score of 0 will be given;
4. If the measurement results do not meet the water quality standard (water measurement results > water quality standard), then a score negative (-) will be given according to the water classification.

The method used in determining the status of water quality by using an assessment system that refers to the "United States Environmental Protection Agency (USEPA)". Classification of water quality in four classes, that is: (Asdak, C., 1995)

1. Class-A : very good condition, score = 0 {good condition}
2. Class-B : good condition, score = (-1) – (-10) {lightly polluted}
3. Class-C : moderately good condition, score = (-11) – (-30) {moderately polluted}
4. Class-D : Bad condition, score = (-31) {heavily polluted}

RESULTS AND DISCUSSION

River Water Discharge

The maximum flow rate data is needed to design the riverbank of community, while minimum flow rate data is needed for other various purposes. The flow rates of the Kahala River at each sampling station quite varied as shown in Table 2.

Table 2. Velocity, Cross-Sectional Areas and Flow rates

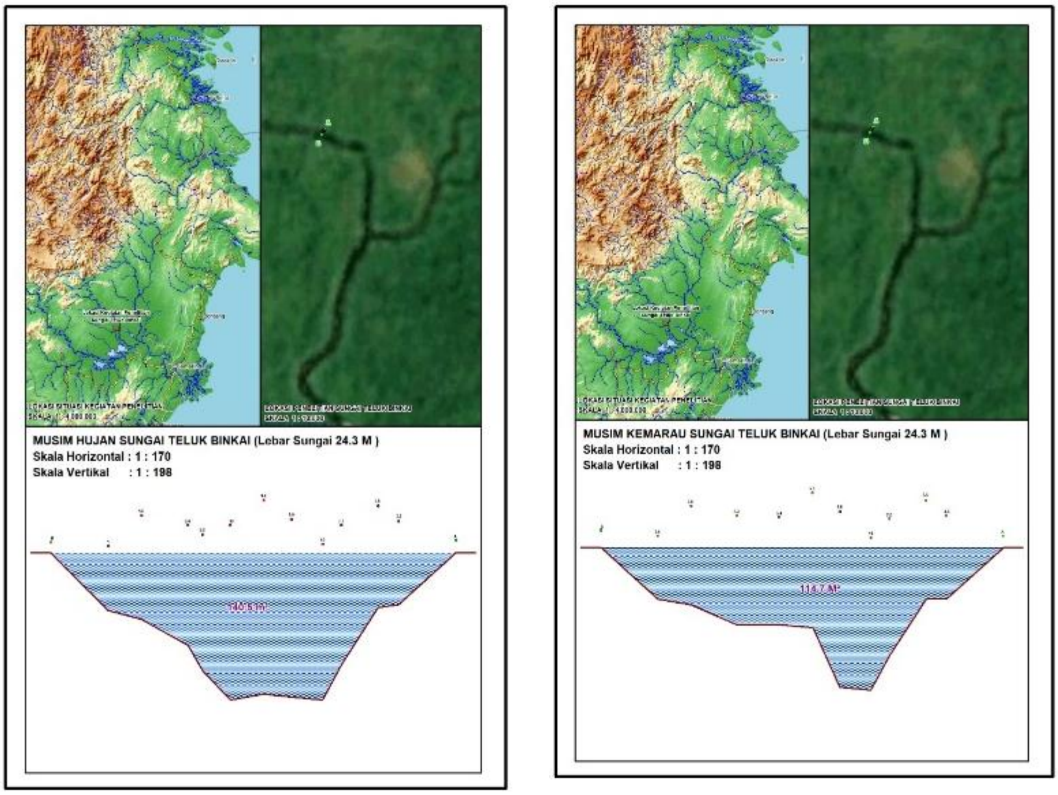
Sampling Point	Monsoon			Dry Season		
	Velocity (m/s)	Cross-section (m^2)	Flow rate (m^3/s)	Velocity (m/s)	Cross-section (m^2)	Flow rate (m^3/s)
Station-I	0.43	140.5	59.79	0.30	114.7	34.24
Station-II	0.22	73.5	16.15	0.18	78.0	14.06
Station-III	0.32	228.0	73.55	0.24	248.9	60.71
Station-IV	0.51	226.0	115.90	0.41	165.9	67.71
Station-V	0.44	350.6	155.82	0.36	346.9	126.15
Station-VI	0.45	342.4	155.64	0.37	333.1	123.37

Source: Primary Data, 2019

In the monsoon, the average river flow rate is 96.14 m^3/s. The highest river water flow rate at Station-V is 155.82 m^3/s and the lowest river water flow rate at Station-II is 16.15 m^3/s. During the dry season, the average river water flow rate is 71.04 m^3/s. The highest river water flow rate at Station-V is 126.15 m^3/s, and the lowest river water flow rate at Station-II is 14.06 m^3/s.

Teluk Bingkai Riverbed Profile (Station-I)

The river bed profile at Station-I represents the differences path of the valley as shown in figure 1. During the monsoon (A), the cross-sectional area of the river is 140.5 m^2, while the river valley showing relatively similar conditions on both sides were detected in significantly different on the left side with the bottom slightly slope, with 24.3 m and 10 m in width and depth, respectively. In the dry season (B) the cross-sectional area of the river is 114.7 m^2. On the right side, the lowest point is found and the river valley shows a fractured structure with 10 m of depth

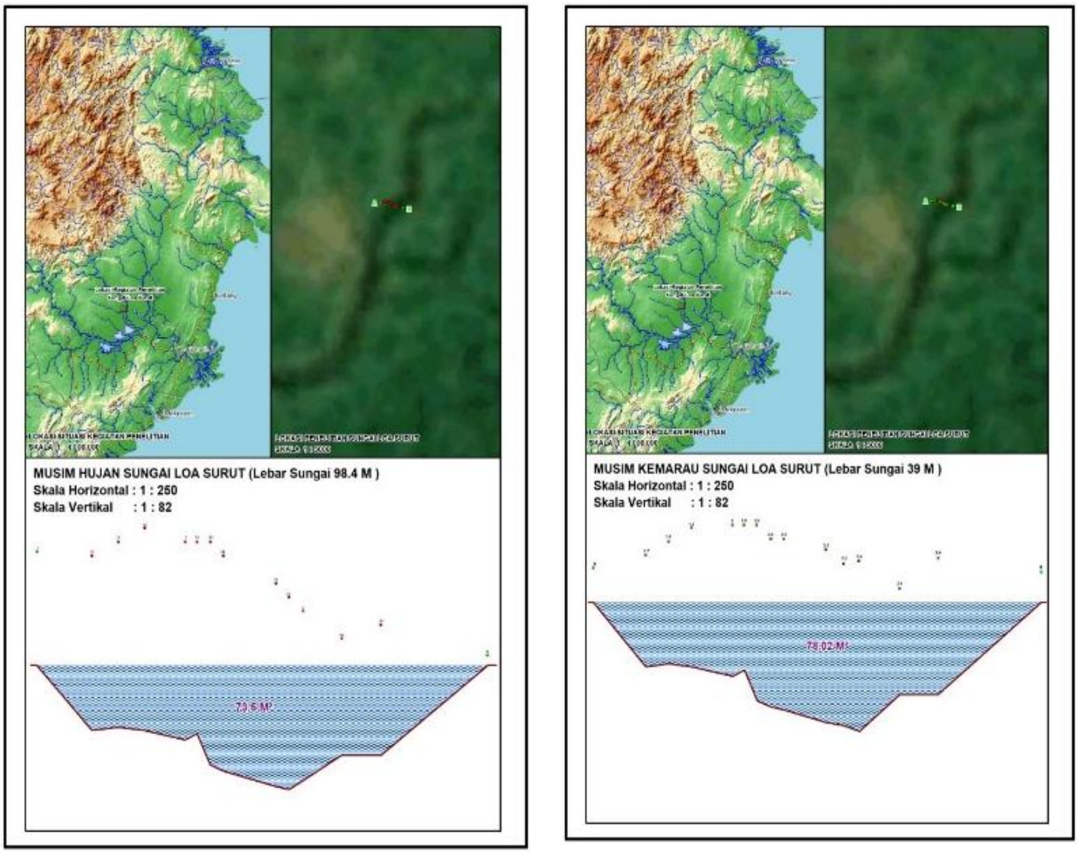


(a) **(b)**

Figure 1: The Riverbed Profile at Station-I (Teluk Bingkai River)

Loa Surut River Profile (Station-II)

The river bed profile represents for both seasons there is no significant difference, commonly almost the same as shown on figure 2.



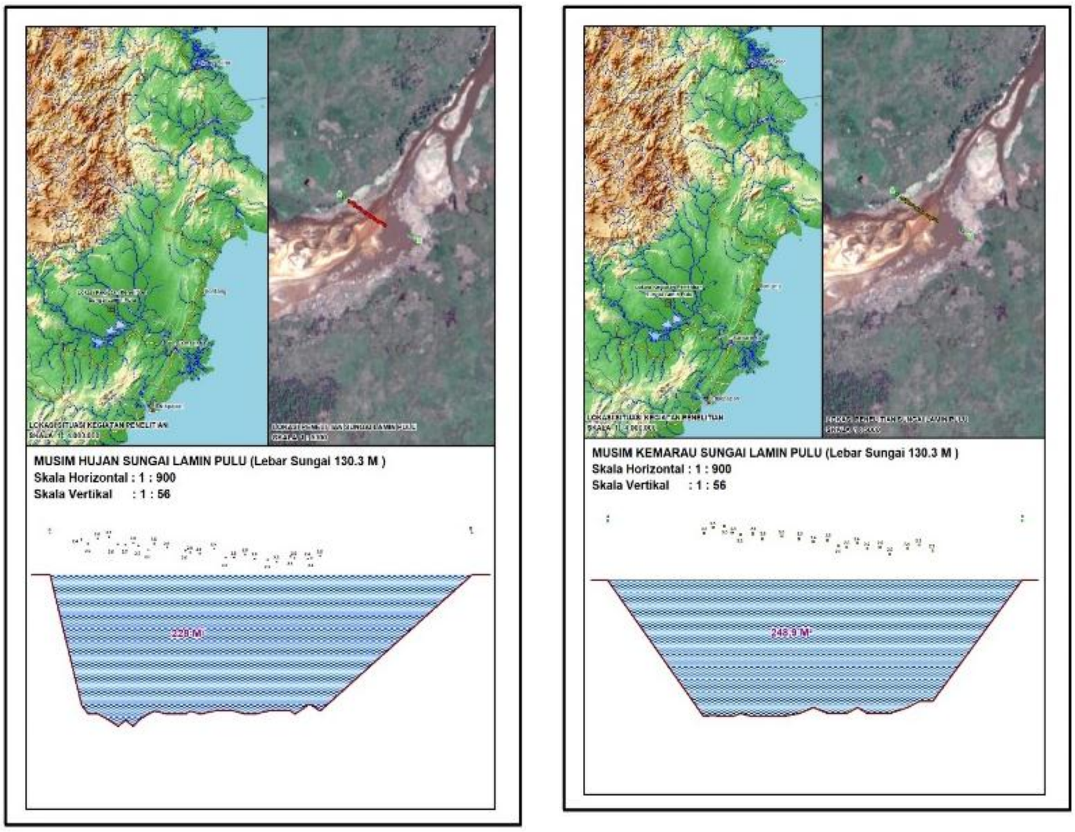
(a) (b)

Figure 2: The Riverbed Profile at Station-II (Loa Surut River)

During the monsoon (A), the river morphometric structure is slightly sloping due to several fractures at the bottom with 98.4 m, 3.3 m and 73.5 m² in width, depth and cross-sectional area of the river. In the dry season, a river cross-sectional area is 78.02 m², the river's width is smaller compared to the monsoon (A) which is 39 m. The lowest point of the river is 3.4 m.

Lamin Pulu River Profile (Station-III)

The river bed profile at Station-III is flat and a large canal occurs. On the right and left side there was differences of depth on the valley, as shown in figure 3.



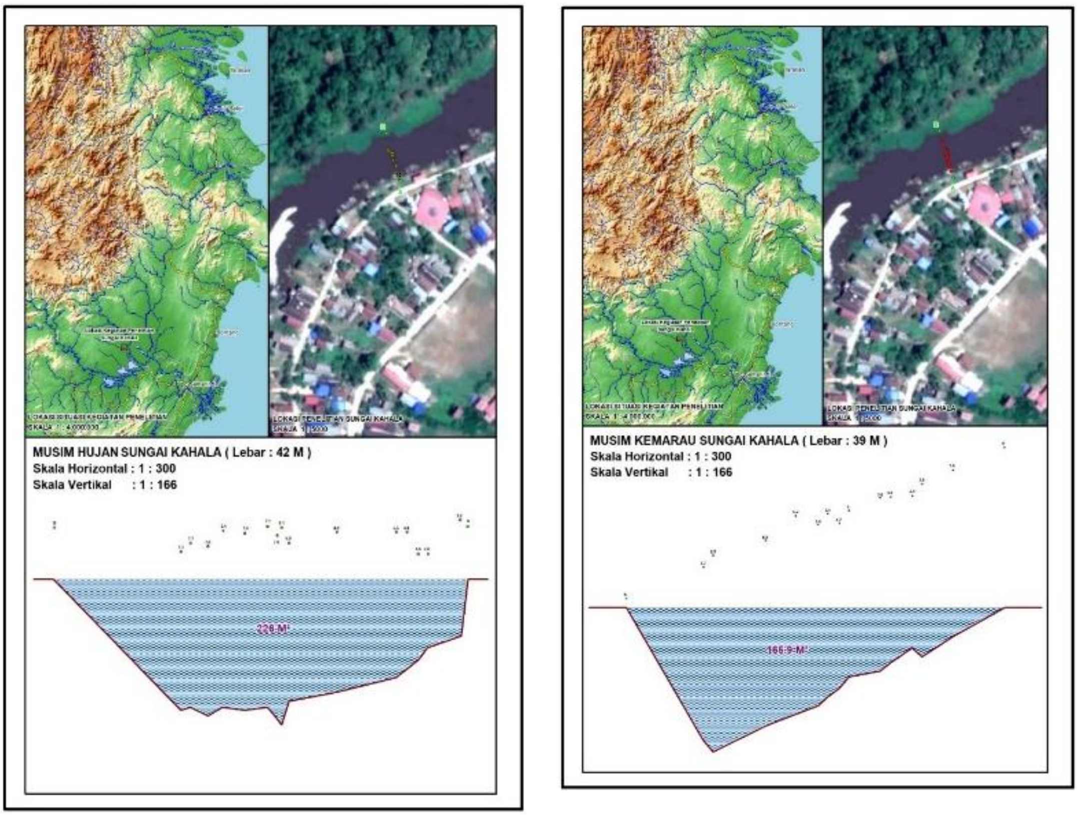
(a) **(b)**

Figure 3: The Riverbed Profile at Station-III (Lamin Pulu River)

The river bed profile for monsoon (A) with 130.3 m, 228 m² and 2.8 m in width, cross-sectional area and depth, respectively. There is no significant difference between dry (B) and monsoon (A) season, with 248.9 m², 2.6 m, and 130.3 m, in cross-sectional, depth and width, respectively.

Kahala River Profile (Station-IV)

At Station-IV, the cross-section of the Kahala river has a significant difference in the two seasons, as shown in figure 4.



(a) **(b)**

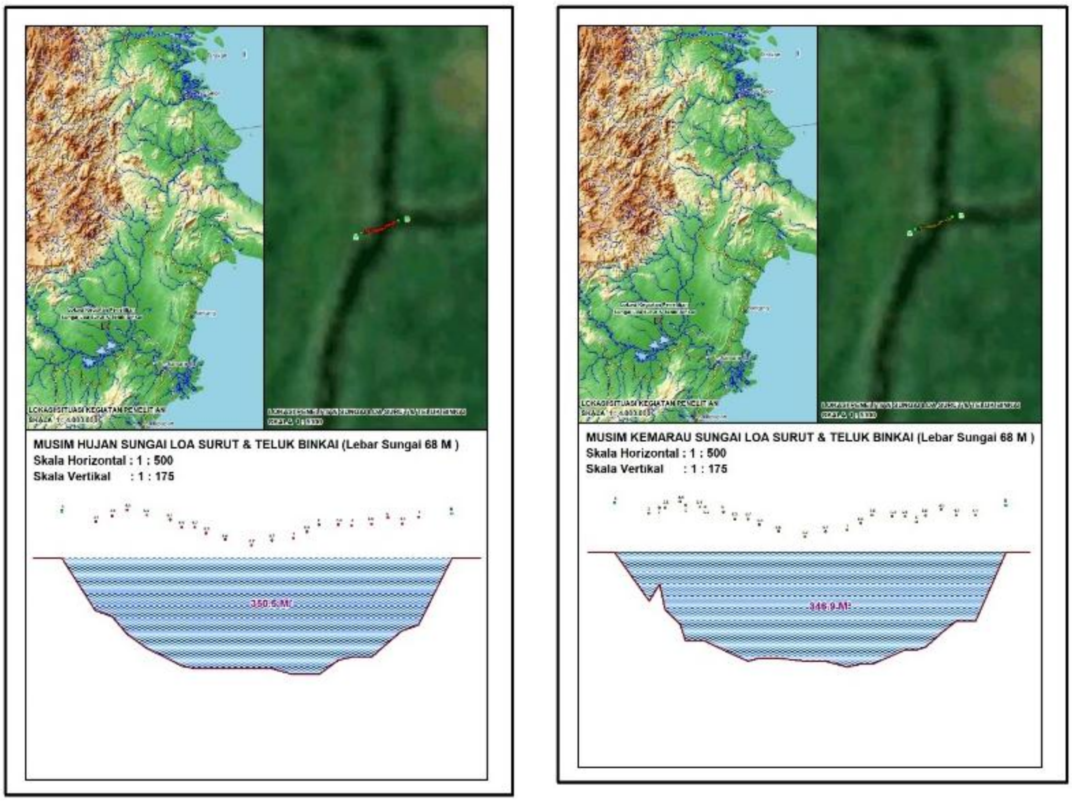
Figure 4: The Riverbed Profile at Station-IV (Kahala River)

A deep valley occurs on the riverbed profile in the monsoon (A). There is a difference between the left and right side of the valley where on the right side is more rapidly than the left side. The lowest point of the riverbed is in the middle with 7.9 m, 42 m, and 226 m^2 in depth, width and the cross-sectional area of the river, respectively. In the dry season (B) the lowest point of the river is significantly different on both sides. This condition can be assumed because there is a lot of activities occurs on the right side of the river. The lowest point of the river is on the right side with 8.3 m, 39 m and 165.9 m^2 in depth, width and cross-section areas, respectively.

Kahala Hulu River Profile (Station-V)

At the Station-V, the cross-sectional areas of the Teluk Bingkai River and Loa Surut River did not mention any significant difference in the two monitoring seasons as shown in figure 5.

The river bed profile in the monsoon (A), the cross-section of the river is designed onto a half-circle. On the left and right side of the valley is various. The lowest point of the riverbed is in the middle with 7 m, 42 m, and 226 m² in depth, width and the cross-sectional area of the river, respectively. There is no significant difference between the dry (B) and monsoon (A) seasons, but there is a small fracture on the left side of the valley. The lowest point of the riverbed is to be found in the middle with 7 m, 68 m and 346.9 m² in depth, width and the cross-sectional area of the river, respectively.



(a) **(b)**

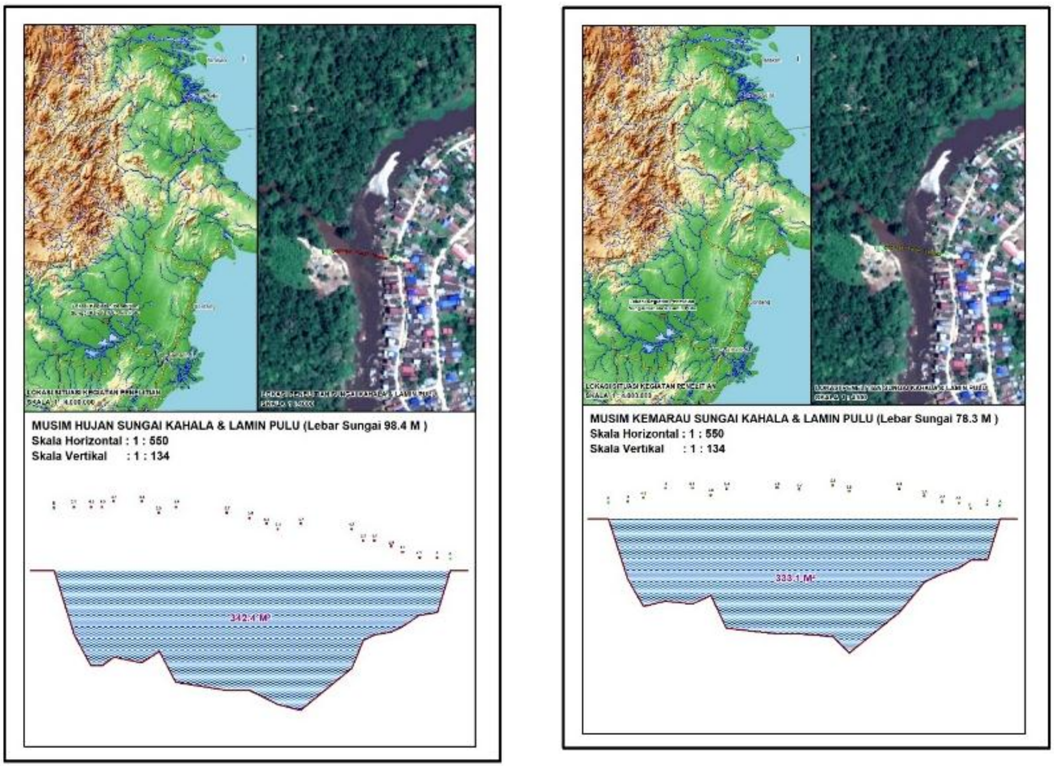
Figure 5: The Riverbed Profile at Station-V (Kahala Hulu River)

Kahala Hilir River Profile (Station-VI)

There is no significant difference cross-section of the Kahala River (Station-VI) on the monsoon and dry seasons. At the bottom of the river, several fractured occurs with a rapid valley on the left side of the river, as shown in figure 6.

During the monsoon (A), the river bed profile has the lowest point with 6.7 m, 98.4 m and 342.4 m² in depth, width and the cross-sectional area of the river, respectively. The river profile in the dry season period (B) is not much different from the monsoon where there is a rapid valley on the left side and a fractured occurs in the bottom of the river.

The lowest point with 6.5 m, 78.3 m and 331.1 m² in depth, width and the cross-sectional area of the river, respectively.



(a) **(b)**

Figure 6: The Riverbed Profile at Station-VI (Kahala Hilir River)

During the monsoon (A), the river bed profile has the lowest point with 6.7 m, 98.4 m and 342.4 m² in depth, width and the cross-sectional area of the river, respectively. The river profile in the dry season period (B) is not much different from the monsoon where there is a rapid valley on the left side and a fractured occurs in the bottom of the river. The lowest point with 6.5 m, 78.3 m and 331.1 m² in depth, width and the cross-sectional area of the river, respectively.

Water Quality

The water quality result has been further analyzed and still within the allowed range on the water quality standards (see Table 1). The river water quality, during the Monsoon and dry seasons represented in Table 2 and Table 3.

Table 2: River Water Analysis in Monsoon

Parameters	Unit	Quality Standards	Station					
			I	II	III	IV	V	VI
TDS	mg/L	1000	5.66	15.31	3.06	13.14	6.55	3.49
TSS	mg/L	50	11	17	39	18	176	143
Turbidity	NTU	-	10.7	24.5	15.9	38.3	13.9	18.2
Color	Pt-Co	180	8.1799	4.1418	4.2382	6.1560	7.1602	6.2216
Temperature	^{0}C	+/- 3	27.0	27.1	26.8	26.7	27.3	26.7
pH	-	6 - 9	6.10	6.80	6.00	6.90	6.80	6.20
DO	mg/L	≥ 4	**2.24**	5.35	5.24	5.32	**3.77**	4.82
BOD5	mg/L	3	0.1066	0.1974	0.4442	0.5932	1.8916	2.2043
COD	mg/L	25	**98.213**	**120.617**	14.481	10.115	**28.465**	8.062
Chloride	mg/L	600	0.4612	0.9753	0.4116	0.4876	0.4901	0.4911
Hardness	mg/L	50	21.5384	46.1538	30.7112	30.7692	**92.3076**	39.7692
Nitrite (NO_2-N)	mg/L	0.06	0.0140	0.0185	0.0172	0.0146	0.0179	0.0134
Nitrate (NO_3-N)	mg/L	10	0.1291	0.1101	0.1381	0.1276	0.1231	0.1181
Ammonium (NH_3-N)	mg/L	-	0.1011	0.1021	0.1312	0.1217	0.1216	0.1107
Sulfate (SO_4)	mg/L	-	7.3181	6.4740	5.0129	7.3181	7.0909	5.8571
Ferro (Fe)	mg/L	-	0.615	0.243	0.183	0.621	0.689	0.388
Mangan (Mn)	mg/L	-	0.226	0.174	0.139	0.211	0.249	0.162
Lead (Pb)	mg/L	0.03	0.022	0.021	0.027	0.024	0.021	0.025
Cadmium (Cd)	mg/L	0.01	0.010	0.000	0.007	0.008	**0.014**	0.000
Zinc (Zn)	mg/L	0.05	0.037	0.029	0.023	0.049	0.036	0.033
Copper (Cu)	mg/L	0.02	**0.023**	0.012	0.004	0.012	**0.026**	0.011
Chromium VI (Cr^{+6})	mg/L	0.05	0.015	0.017	0.017	0.015	0.018	0.018
Mercury (Hg)	mg/L	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Oil and Grease	mg/L	1	0.002	0.001	0.025	0.056	0.010	0.046
Phosphate (PO_4-P)	mg/L	0.2	0.0031	0.0095	0.0124	0.0106	0.0126	0.0099
Fluoride	mg/L	1.5	0.0481	0.0011	0.0048	0.0133	0.0964	0.1672
Surfactant (MBAS)	mg/L	0.2	**0.2091**	0.1821	**0.3696**	**0.3091**	0.2001	**0.3752**
E. Coli	MPN/ 100 mL	-	23	46	52	80	52	240
Total Coliform	MPN/ 100 mL	-	102	96	164	188	200	550

Source: Primary Data, 2019

Table 3: River Water Analysis in Dry Season

Parameters	Unit	Quality Standards	Station					
			I	II	III	IV	V	VI
TDS	mg/L	1000	4.56	15.05	2.90	6.77	34.90	7.72
TSS	mg/L	50	32	49	29	23	3	15
Turbidity	NTU	-	6.8	51.8	10.8	19.0	44.3	12.5
Color	Pt-Co	180	8.2661	4.1606	6.2411	8.1702	8.1631	6.2151
Temperature	^{0}C	+/- 3	26.8	26.8	26.8	26.8	26.8	26.8
pH	-	6 - 9	**5.34**	6.19	**5.65**	**5.89**	6.79	**3.54**
DO	mg/L	≥ 4	6.04	6.84	7.07	5.29	5.26	7.66
BOD5	mg/L	3	0.9216	0.1001	0.9912	1.2916	1.0096	4.3201
COD	mg/L	25	**205.021**	**246.842**	**41.841**	12.552	29.288	18.318
Chloride	mg/L	600	0.4612	0.9761	0.4411	0.4870	0.4981	0.4791
Hardness	mg/L	50	28.9276	39.1514	30.1617	34.3815	**98.3177**	41.7921
Nitrite (NO_2-N)	mg/L	0.06	0.0178	0.0193	0.0227	0.0231	0.0193	0.0202
Nitrate (NO_3-N)	mg/L	10	0.1721	0.1651	0.3061	0.2121	0.1921	0.3018
Ammonium (NH_3-N)	mg/L	-	0.1524	0.1049	0.2134	0.2001	0.1217	0.2196
Sulfate (SO_4)	mg/L	-	8.0201	6.7762	12.0121	10.1241	5.9197	9.0782
Ferro (Fe)	mg/L	-	0.572	0.243	0.692	0.416	0.194	0.142
Mangan (Mn)	mg/L	-	0.274	0.147	0.274	0.152	0.162	0.183
Lead (Pb)	mg/L	0.03	0.024	0.022	0.018	0.013	0.016	0.012
Cadmium (Cd)	mg/L	0.01	0.008	0.006	**0.012**	0.000	0.000	0.000
Zinc (Zn)	mg/L	0.05	0.023	0.026	0.038	0.032	0.029	0.022
Copper (Cu)	mg/L	0.02	0.012	0.015	**0.026**	0.012	0.008	0.007
Chromium VI (Cr^{+6})	mg/L	0.05	0.006	0.003	0.007	0.003	0.004	0.005
Mercury (Hg)	mg/L	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Oil and Grease	mg/L	1	0.0720	0.0040	0.0310	0.0670	**6.3410**	**13.0900**
Phosphate (PO_4-P)	mg/L	0.2	0.0049	0.0091	0.1781	0.0191	0.0172	0.0108
Fluoride	mg/L	1.5	0.2161	0.0011	0.0906	0.0174	0.0107	0.2127
Surfactant (MBAS)	mg/L	0.2	**0.2016**	**0.2011**	**0.3616**	**0.4612**	0.1063	**0.4617**
E. Coli	MPN/ 100 mL	-	312	61	91	81	84	212
Total Coliform	MPN/ 100 mL	-	648	100	190	216	291	506

Source: Primary Data, 2019

Teluk Bingkai Water Quality (Stasiun-I)

In the monsoon, the measurement result of Chemical Oxygen Demand (COD) is 98.213 mg/L, where a load of pollutants exceeds water quality standards. This condition is caused by residential activities and the mining industries. The measurement of dissolved oxygen (DO) water is 2.24 mg/L, indicating that the condition is less than a good according to the requirement. The Oxygen water is considerably used by microbes to degrade organic matter so that the soluble oxygen in water is low. The measurement result of methylene-blue alkyl sulfonate (MBAS) is 0.2091 mg/L, slightly above than quality standard, this is made by the cleaning equipment that is relatively higher frequency because this is routine activity at any times, moreover a lot of work equipment / heavy-duty equipment in the mining workshop. For a concentration of heavy metals, only the copper (Cu) content slightly above the standard quality of the result of 0.023 mg/L. Similar to the other pollutants, this is due to the activity of the mining industry. (Horan, 2003)

In the dry season, the measurement of COD and MBAS parameters have the same characteristics as monitoring in the monsoon. The difference is only for the degree of acidity (pH), which is 5.34, this measurement result is outside the threshold of the standard quality range.

Loa Surut Water Quality (Stasiun-II)

In the monsoon at Station-II, the measurement result of each parameter showed a good condition except for the COD. The value of COD was 120.617 mg/L, exceeded quality standards. This condition is caused by several things such as the activities of the plantation. The waste produced from process activities contains organic materials involved to increase COD content in the water.

The measurement result of COD during the dry season is 246,482 mg/L, exceeding the standard quality. The measurement result of MBAS is 0.2011 mg/L, a little bit exceeding the standard quality. Cleaning activities that caused increasing MBAS content in the water. (Effendi, 2016)

Lamin Pulu Water Quality (Stasiun-III)

The river water condition in Station-III at monsoon, generally has a good quality, only the MBAS parameters exceeded the quality standard, the result is 0.3696 mg/L. This condition is caused by a large number of laundry activities in the community area around the Lamin Pulu river.

In the dry season, the measurement result of the pH is 5.65, outside the threshold of the standard quality range. The measurement result of COD is 41.841 mg/L. This condition indicates that in the dry season, the organic matter water content is increasing within the decreasing of water volume during that period. The organic matter on the river is generally difficult to decompose. This indicates that a large amount of oxygen needed for the process of aerobic bacterial decomposition from organic materials. (Horan, 2003)

Kahala Water Quality (Stasiun-IV)

The Kahala river profile in the monsoon has good condition, only MBAS parameters which are the results was exceeded standard quality, the measurement result of 0.3091 mg/L. The laundry activities using detergents, soaps, and shampoos it contains organic materials, which is can be increasing MBAS content in the waters. (Horan, 2003)

In the dry season, the MBAS parameter of 0.4612 mg/L, the result was exceeded standard quality. The measurement result of pH water at 5.89, it was outside the threshold of the standard quality range.

Kahala Hulu Water Quality (Stasiun-V)

During the monsoon, at the sampling location of Station-V when compared to the other locations, the measurement results of Total Suspended Solid (TSS) are indicated to exceed the standard quality with a value of 176 mg/L. The river structure and river bed profile as a source TSS value effect in the river water, where the specified profiles can be affected to the water molecular movements, in that case, the water spin can cause the slurry and the deterioration of soil that can be affected to the TSS. The measurement results following parameters COD, DO, $CaCO_3$ and MBAS with 28.465 mg/L, 3.77 mg/L, 92.3076 mg/L and 0.2001 mg/L respectively. Those all results exceeded the water standard quality it caused many populations around to the river edges. For heavy metal concentrations, the analysis results of several heavy metals exceeded standard quality as follows: Cd concentration values of 0.014 mg/L and the Cu concentration values of 0.026 mg/L. This condition may cause by the community activity and the mining process activities. (Prakash Raj Kannel, 2007)

The same condition occurs in the dry season, the measurement for those parameters exceeded the water standard quality as follows COD and $CaCO_3$ content with 29.288 mg/L, and 98.3177 mg/L respectively. The different conditions occur in the dry season within the concentration of oil and grease exceeded water standard quality of 6.3410 mg/L, it caused by the decomposition of organic material both from animals and vegetations and also due to the motorboats mobilization which is that indicated of accidental leakage and the other things. (Prakash Raj Kannel, 2007)

Kahala Hilir Water Quality (Stasiun-VI)

At Station VI, the location is across sectional areas of the Kahala River and Lamin Pulu River. During the monsoon, the measurement result for those parameters exceeded water standard quality as follows TSS and MBAS content with 143 mg/L, and 0.3752 mg/L respectively. In this station, the location mentioned a high population around the river edges, where there are many activities carried out by communities.

The different conditions are shown in the monsoon, the measurement result following parameters pH, oil and grease, BOD and MBAS content of 3.54, 13.090 mg/L, 4.3201 mg/L and 0.4617 mg/L respectively. These results exceeded the water standard quality and range. The low pH degree due to many ammonium compounds, which influence the pH degree quality while the ammonium can be ionized (ammonium compounds are not toxic). A high BOD_5 content can produce gas compounds, which influence marine life. The refueling of motorboats activities will have an impact on the oil and grease contents. The laundry activities using detergents, soaps, and shampoos it contains the organic materials, which is can be increasing MBAS content in the waters. (Prakash Raj Kannel, 2007)

Water Quality Status

The study result based on the STORET method for determining the status of the water quality, while the classified status obtained in the Kahala River and its tributaries was moderately polluted with an average STORET score of (-23). (Asdak, 1995) The results of the quality status according to the STORET method as shown in Table 4.

Table 3: Kahala River and Tributaries Water Status

Station	River	Classification	Criteria	STORET	Quality Status
Station-I	Teluk Bingkai	C Class	Moderately good condition	-30	Moderately Polluted
Station-II	Loa Surut	C Class	Moderately good condition	-12	Moderately Polluted
Station-III	Lamin Pulu	C Class	Moderately good condition	-28	Moderately Polluted
Station-IV	Kahala	C Class	Moderately good condition	-12	Moderately Polluted
Station-V	Kahala Hulu	C Class	Moderately good condition	-24	Moderately Polluted
Station-VI	Kahala Hilir	D Class	Bad condition	-34	Heavily Polluted

Source: Primary Data, 2019

The study results on each station from Station-I till Station-V found, that the water's quality status was moderately polluted with an index score of (-30), (-12), (-28), (-12) and (-24) respectively. The different result occurs at the Station-VI, which is the waters quality status was Heavy Polluted with an index score of (-34), according to the river status with class-I. (Barokah, 2017)

CONCLUSIONS

The riverbed profile of the Kahala River from Station-I until Station-VI is generally shown in a fairly varied condition. The difference in river bed profile is due to differences in the valley structure on each station that may be caused by vegetation density conditions and its structure at the Kahala River.

Community activities around the river edge influence water quality. There are many various activities in the location of the study such as a high density of population on the riverside, mining, plantation industry and other activities where has a specific impact on the river water quality of the studies.

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