Water Quality In Sungai Semantan Tributaries

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Abstract

It is important to study about the water quality of a river especially to the river which is the main source of drinking water. The consideration of sampling focused on the areas that show the highest potential to release pollution. All desired parameters including Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3N), pH, Dissolved Oxygen (DO), Suspended Solids (SS) and turbidity were tested. The WQI was calculated using DOE-WQI. The Drinking Water Quality Standard for by Malaysian Ministry of Health (MOH) also referred in order to classify the river water quality. The overall mean WQI value of Sungai Semantan tributaries is 87.62 and can be classified as Class II with the status of Slightly Polluted. It is because of low concentration of DO values and high concentration of BOD, COD, and NH_3-N due to the agriculture, plantation, and industrial activities nearby the river bank.

Keywords : water quality, pollution, index

1. Introduction

A polluted river can be easily identified by its appearance, colour, and odour. Water pollution brings many negative effects to humans, plants, and animals. It is important to study about the pollution of a river especially to the river which is the main source of drinking water. There are a few sources of water pollution such as runoff, industrial waste, soil sedimentation, mine waters, agriculture, commercial area, and many more from activities. All of these sources can be divided into two, namely point source and nonpoint source.

Point sources of pollution are defined as pollutants that are discharged into the receiver from a recognisable discharge point. Municipal and industrial discharges are examples of point sources. Meanwhile, diffuse pollutants, such as from agricultural waste, city surface runoff, and acid rain are typical nonpoint sources and are much more harder to recognise and control (Jining and Yi, 2002). The majority of nonpoint source-caused pollution problems are associated with pollutants carried by runoff from rain and snowmelt, other pollutant sources include spills and leaks, atmospheric deposition, and hydrologic modifications (Kansas Department of Health and Environment, 1997).

Most of the heavy metals from surface water and groundwater are usually removed during water treatment process. Based on that, the Malaysian Ministry of Health listed heavy metal parameters in the National Drinking Water Quality Standard to be complied by water agencies to ensure drinking water supply is safe for consumers (Ab Razak *et al.*, 2015).

1.1 Problem Statement

Recently, consumers in Selangor commented on the water supply that has been polluted. According to the World Health Organization (2011), in evaluating the quality of drinking water, consumers depend on their senses. Microbial, chemical, and physical water elements may affect the look, odour, or taste of the water. The consumer will assess the quality and tolerability of water on the basis of these conditions. Even though these matters might have no direct health effects, water that is highly turbid, coloured or has an unpleasant taste or odour may be highlighted by consumers as risky and may be prohibited. It is wise to be alert of consumer sensitivities and to take into account both health related guidelines and aesthetic criteria when evaluating drinking-water supplies and developing guidelines and standards. Changes in the ordinary appearance, odour, or taste of a drinking-water may indicate the changes in the quality of the raw water source or lacks in the treatment process and should be examined.

Astro Awani (2016) reported that the Department of Environment (DOE) has conducted a comprehensive water quality assessment on Sungai Semantan after Air Pahang Regulatory Body (BDKSAP) received public complaints on 07 and 08 October 2016 that raw water channelled to Selangor from the intake point at Sungai Semantan was polluted. The river water became coloured and smelly. The findings revealed that the water quality was affected by a factory in the Bentong Industrial Area which was carrying out maintenance work on its effluent treatment plant to boost its capability.

The DOE has identified the sources but its minister, Datuk Seri Wan Junaidi Tuanku Jaafar said that the pollution could have come from various resources (New Straits Time Online, 2016). The Minister has instructed the DOE to investigate more and identify the specific sources causing the pollution along the riverside reserved land and water catchment areas.

1.2 Aim and Objectives

The objective of the study is to evaluate the presence of pollution in water samples from Sungai Semantan tributaries which covered Sungai Bentong, Sungai Kelau, and Sungai Semantan. This includes the followings:

i. To conduct water quality assessment at Sungai Semantan watershed.

ii. To determine the Water Quality Index value for Sungai Semantan tributaries.

1.3 Scope of Study

This study focused on Sungai Semantan tributaries. Water sampling was carried out at selected points within the river basin which were identified to have the potential to cause pollution. The parameters that were measured for water are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3N), pH, Dissolved Oxygen (DO), Suspended Solids (SS), turbidity and temperature. Water quality measurement was held at Mempaga Water Treatment Plant.

1.4 Significance of Study

Water issues are serious and can bring massive impacts to the environment. This study aims to provide the information on Sungai Semantan water intake current conditions. Although this issue only involves complaints from consumers regarding the colour and odour of the water, and not considered as harmful to consumers, but it will be a national issue in a long time. Hopefully, the findings of this study will be useful for upcoming water resource management and planning.

2. Literature Review

2.1 Sungai Semantan Basin

Sungai Semantan water intake is located at 3°28'43.369N latitudes and 102°5'54.969"E longitudes. The water supplies are from Sungai Bentong, Sungai Kelau, and Sungai Semantan itself.

2.2 Water Quality

The DOE has been monitoring the river since 1978, to establish baselines and track changes in water quality and to identify sources of pollution. The parameters involved in the water quality determination are BOD, COD, NH_3N, pH, DO, SS, turbidity and temperature (Department of Environment, 2015).

2.3 Water Quality Index

The DOE used the Water Quality Index (WQI) to indicate the level of pollution and corresponding water classes and uses compared to National Water Quality Standards for Malaysia (NWQS). The WQI takes certain parameters into consideration including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3-N), Suspended Solids (SS), and pH. Water Quality Index (WQI) is one of the most effective tools to afford response on the quality of water to the policy makers and environmentalists. It concludes the overall water quality status at a certain time and location (Naubi *et al.*, 2016). WQI helps to determine the status of water quality whether it is clean, slightly polluted, or contaminated. WQI is applied by the DOE for the purpose of classification of water pollution levels. The index assists to identify the type of the pollution of water which was referred to the stations where the concentration of contaminations can be analysed (Nurfadzlina and Munirah, 2013).

Table 1 shows the river classification by WQI. Generally, WQI is a unitless digit varies from 0 to 100. A higher index value signifies good water quality (Ministry of Natural Resources and Environment Malaysia, 2009).

The index is determined based on the following formula:

$$\mathbf{WQI = 0.22SI_{DO} + 0.19SI_{BOD} + 0.16SI_{COD} + 0.15SI_{AN} + 0.16SI_{SS} + 0.12SI_{pH}}$$

(Zaki Zainuddin, 2010)

Where,

WQI = Water quality index.
SI_{DO} = Sub-index of DO.
SI_{BOD} = Sub-index of BOD.
SI_{COD} = Sub-index of COD.
SI_{AN} = Sub-index of AN.
SI_{SS} = Sub-index of TSS
SI_{pH} = Sub-index of pH.

Sub-index for DO (in % saturation):

$SI_{DO} = 0$ for DO < 8
$= 100$ for DO > 92
$= -0.395 + 0.030DO^2 - 0.00020DO^3$ for 8 < DO < 92

Sub-index for BOD:

$SI_{BOD} = 100.4 - 4.23BOD$ for BOD < 5
$= 108e^{-0.055BOD} - 0.1BOD$ for BOD > 5

Sub-index for COD:

$SI_{COD} = -1.33COD + 99.1$ for COD < 20
$= 103e^{-0.0157COD} - 0.04COD$ for COD > 20

Sub-index for NH_3-N:

$SI_{AN} = 100.5 - 105AN$ for AN < 0.3
$= 94e^{-0.573AN} - 5\ |AN - 2|$ for 0.3 < AN < 4
$= 0$ for AN > 4

Sub-index for SS:

$SI_{SS} = 97.5e^{-0.00676SS} + 0.05SS$ for SS < 100
$= 71e^{-0.0016SS} - 0.015SS$ for 100 <SS<1000
$= 0$ for SS > 1000

Sub-index for pH:

$SI_{pH} = 17.2 - 17.2pH + 5.02pH^2$ for pH < 5.5

$= -242 + 95.5pH - 6.67pH^2$ for $5.5 < pH < 7$
$= -181 + 82.4pH - 6.05pH^2$ for $7 < pH < 8.75$
$= 536 - 77.0pH + 2.76pH^2$ for $pH > 8.75$

Once the overall WQI score is known, it will be compared against a scale given in Table 2 to determine how good the river water is on the sampling day.

National Water Quality Standard for Malaysia (NWQS) is used to classify the use of rivers in Malaysia based on the classification that has been made from WQI. Table 3 shows the classification of water use based on the classification of the river.

According to the Ministry of Health (2004), the drinking water quality standards are applicable to all water intended for human consumption. The quality of drinking water is measured in terms of its microbiological, physical, chemical and radioactivity characteristics. Table 4 lists the characteristics and constituents with their recommended standard, which cannot be exceeded for the protection of customers. Recommended raw water criteria set out the maximum acceptance levels of the constituents in raw water, which if exceeded, will require special treatment for the water. For those below the recommended criteria, only conventional water treatment is necessary.

2.4 Water Pollution

Water pollution can be categorised into point sources and nonpoint sources. Sewage treatment plants and industrial wastes are called point sources because they are channelled to the receiving points. Meanwhile, agro-based developments and agricultural activities discharge are called nonpoint sources because of they do not come from a specific discharge point of activities but from the surface runoff or sedimentation.

3. Methodology

3.1 Site Description

According to the Department of Agriculture Pahang, the land use along the Sungai Bentong and Sungai Semantan include construction sites, residential areas, and industrial areas, meanwhile Sungai Kelau land use consists of the oil palm and rubber plantation, agriculture plots, and residential area.

3.2 Water Sample Collection

162 water samples collected at nine points were selected considering as the potential sources of pollution in the river and accessibility to sampling points along the river. Water samples were collected monthly at the same points from November 2016 to April 2017. Table 5 shows nine water sampling point locations and the pollution source consideration.

3.3 Water Quality Assessment

Water quality assessment was carried out at locations (in situ) and in the Mempaga Water Treatment Plant. All water samples were measured from unfiltered water samples. This study was based on seven parameters in Water Quality Index (WQI), namely:

i. Biochemical Oxygen Demand (BOD)
ii. Chemical Oxygen Demand (COD)
iii. Ammoniacal Nitrogen (NH_3-N)
iv. pH
v. Dissolved Oxygen (DO)
vi. Suspended Solids (SS)
vii. Turbidity

3.4 Data Analysis

Data analysis was done after the water assessment. The data was compared with the Water Quality Index by the DOE and National Standard for Drinking Water Quality by the Ministry of Health Malaysia.

4. Results and Analysis

4.1 Water Quality Assessment

The study purposely attempts to study the variation of water quality parameters along Sungai Bentong, Sungai Kelau, and Sungai Semantan. Table 6 shows the example of findings. The following figures show the trend of water quality parameter determined for sampling Point 1 to sampling Point 9 from November 2016 to April 2017 from upstream to downstream of the watershed.

4.1.1 Biochemical Oxygen Demand

BOD determines the strength of pollutants in terms of oxygen required to stabilise the wastes. High BOD in water sources of aquatic species to suffocate or die. BOD was analysed and results were shown in Figure 1.

High BOD value indicates that the water samples were contaminated. The highest value 14 mg/L of BOD was recorded at Point 2 on February 2017. Point 2 located downstream for both Sungai Bentong and Sungai Kelau. There is considered polluted by fish pond activity. BOD concentration was higher in the river during the rainy season. The lowest value 2 mg/L of BOD was recorded twice at Point 5 in December 2016 and January 2017. The source of pollution consideration at Point 5 comes from Bentong Industrial Park.

BOD values have a declining trend downstream of Sungai Bentong. Meanwhile, Sungai Kelau shows increasing trend downstream of the river. The increasing trend in BOD affected by local pollutant enters the river system at Point 7 and Point 2. According to DOE, BOD parameter for clean river water must below than 1 mg/L. Meanwhile, according to Malaysian Ministry of Health (MOH), the acceptable value of BOD for raw water is 6 mg/L. A few of points show the BOD value are exceeding both DOE and MOH limit. Most of the BOD values are in Class III which is

need extensive water treatment. Point 2, Point 3, Point 4, Point 5, Point 6 and Point 7 exceed MOH limit on February and March 2017 which is mean the river water is not recommended as the source of drinking water during stated months.

4.1.2 Chemical Oxygen Demand

Chemical Oxygen Demand (COD) were analysed and results were shown in Figure 2. The COD test is generally used to measure the quantity of organic and inorganic oxidisable compounds in water. High COD can stress the aquatic organisms and may lead to their death.

Point 5, located near to Bentong Industrial Park recorded the highest value 47 mg/L of COD on February 2017 and the lowest value 5 mg/L of COD on December 2016 and January 2017. The source of pollution consideration at Point 5 comes from Bentong Industrial Park. The highest value recorded during the rainy season and lowest COD values recorded during the sunny season.

Most of the COD values are at Class II according to DOE which is means water need conventional treatment and some points at the level of Class III which is need extensive water treatment. As refer to MOH, most of the points are exceeding the recommended limit for raw water quality of 10 mg/L. This is mean that the river water is not recommended as the source of drinking water without extensive water treatment before supply to the consumers.

4.1.3 Ammoniacal Nitrogen

NH_3N is the amount of ammonia toxicity pollution. During the study, the concentration of NH_3N was varied between 0.01 mg/L to 0.33 mg/L (Figure 3).

The NH_3-N parameter has an increasing trend downstream of Sungai Bentong and Sungai Kelau. The highest NH_3-N value recorded at Point 2 in March 2017 (0.33 mg/L). The maximum concentration was categorised as Class III due to agriculture activities (fish pond). The lowest value <0.01 mg/L was recorded twice at Point 9 (Kelau Dam) in December 2016 and January 2017. The higher value of NH_3-N in Point 2 is due to pollution caused by fish fertilisers, animal waste, and domestic sewage. Runoff process during March 2017 also brought together the entire contamination source to the river.

The value of NH_3-N content was in the range of the safe level, <0.4 mg/L (Hossain, Sujaul, and Nasly, 2013). The water quality of all sampling points was within the NWQS recommended maximum level 0.90 mg/L of NH_3-N and the maximum permissible limit of <1.5 mg/L set by the MOH for raw river waters.

4.1.4 pH

Figure 4 showed that pH for the Sungai Semantan tributaries water quality varied within 5.89 to 7.91. The average of pH value of the water approach 7. The lowest pH value 5.89 recorded at Point 7 on February 2017 and highest pH value 7.91 recorded at Point 1 in November 2016.

The river was found to be acidic mostly to neutral pH. The highest pH was noted due to the plantation activity discharges. However, the mean value of pH at points was in the permissible level of 5-7 (DOE) and 5.5-9 (MOH). It can be said that the river water is still safe and are less harmful to consumers.

4.1.5 Dissolved Oxygen

Dissolved Oxygen (DO) is the critical parameters for fresh water and an index of physical and biological process in water (Hossain *et al.*, 2013). DO is a measure of the amount of oxygen freely presented in water. Low DO in any river water makes aquatic species removed, weaken, or even die. Results of the analysis showed that most of the DO for nine stations is varied from 4.62 mg/L to 8.52 mg/L (Figure 5).

DO values were almost similar in both Sungai Bentong and Sungai Kelau. December 2016 shows the highest concentration of DO happened at Point 5. The higher DO values signify good water quality and best for a healthy ecosystem (Naubi *et al.*, 2016).

The lowest value of DO concentration also occurred on December 2016 at Point 1 (4.62 mg/L) and at Point 2 (4.71 mg/L). The data establish the deterioration of water quality. This occurs due to the organic materials released from plantation and fish pond. These industries removed their wastes directly into the river without proper pollution management. The sunny season made the pollution stays for long at the locations. If this condition continued without governance's monitoring and enforcement, then pollution will affect the quality of aquatic life and can lead to the death of aquatic life.

From the observed concentration of DO, the average value was recorded as 6.49 mg/L which indicated that stations were categorised as Class II according to NWQS level for Malaysia surface water. The water of that area needs conventional water treatment.

4.1.6 Suspended Solids

Suspended solids (SS) are natural pollutants and cause turbidity in the river water. Most of the SS present in the domestic waste are composed of organic material. The SS values of water samples in the study area varied from 6.0 mg/L to 307 mg/L (Figure 6).

Sungai Bentong and Sungai Kelau recorded the SS values increased significantly during the rainy season from January 2017 to March 2017. The highest concentration was observed at Point 3 on February 2017 possibility because of plantation effluent and higher concentration at Point 7 on March 2017 because of livestock contaminated during the rainy season. In addition, the strength and speed of flowing water during rainy season could erode the riverbank and contribute to the pollution of suspended solids, especially silt and organic matters (Hossain et al., 2013).River water of the study area mostly found to be in Class III according to the classification of DOE. The findings show that the river water needs extensive water treatment before supply to the consumers.

4.1.7 Turbidity

Turbidity shows higher values if there sedimentation and inorganic matter at the location. The turbidity of water samples in the study area varied from 13.2 NTU to 425 NTU (Figure 7). All points showed the highest concentration on February 2017 to March 2017 during the rainy season.

The turbidity value of water sample collected at Point 7 is the highest among all water samples (425 NTU). The second highest value of turbidity was found at Point 3. Figure 4.6 and Figure 4.7 support that higher SS concentration and higher turbidity concentration happened during the rainy season.

Referred to MOH, the values are in the range of acceptable value for raw water quality monitoring (< 1000 NTU) and save to deliver to consumers.

4.1.8 Temperature

Figure 8 show the variations of temperature values during the water sampling. The values range from 25°C to 29.1°C (the mean value is 27°C). The highest temperature (29.1°C) recorded at Point 3 and lowest temperature (25°C) at Point 9 in April 2017.

All point shows higher temperature in April 2017 because of it is the sunny season. River water temperature ranged between 26.5 and 30.7°C was not threatening river condition and the inhabitants (Naubi *et al.*, 2016).

4.2 Water Quality Index (WQI)

Water quality index was calculated based on the values of six water quality parameters obtained at each point. Based on the Sub-Index (SI) values, water quality classification was done and demonstrated at Table 7. Table 7 showed the variation of SI, WQI and the overall water quality status of the study area. As can be seen, lowest (worst) WQI was found at Point 6 (Bentong Industrial Park) with 85.12 and highest WQI at Point 9 (Kelau Dam) of 90.11. The study result revealed that, the river water of Sungai Semantan suitable for public consumption after conventional water treatment.

The result also shows that water quality in the upstream sections of Sungai Bentong and Sungai Kelau almost similar with downstream river sections. Average WQI score for Sungai Semantan tributaries was found to be 87.62 (slightly polluted). The causes of the contamination come from the plantation, agriculture activities and industrial activities along the river bank. These industries effluent flowed directly into the river without effective treatment.

5. Conclusion and Recommendations

5.1 Conclusion

This study has managed to meet the objectives.

Results from the study conducted at Sungai Bentong and Sungai Kelau shows that the water quality of Sungai Semantan watershed is moderately polluted. Referring to the Water Quality Index (WQI), Sungai Semantan watershed is in Class II classified as a slightly polluted river. The cause of

contamination in this location is due to the agriculture activities, plantation and industrial park which are carried out very close to the river bank. From the observation, the effluence flowed directly into the river without any treatment. This problem gets worse during the rainy season. Based on the National Water Quality Standard for Malaysia (NWQS), river water can be used only after conventional water treatment is done. Effective control measures and governance enforcement must be conduct at the location so it can be prevented before the contamination reaches a dangerous level and harm to the lives.

5.2 Recommendations

Water quality study can be influenced by various factors such as sampling time, the weather and so on. Therefore a longer period of monitoring is recommended to evaluate the actual status of the WQI in the study area.

The relationship between rainfall and river water quality should be mentioned or studied further. The information about the rainfall should be documented and discuss, but limited resources from the relevant departments, made it difficult to examine in this study. This is because some of telemetric stations did not have data for certain years.

Soil strata study should be conducted to support the findings. Soil sampling points should be tested to reflect more accurate findings of the soil conditions.

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APPENDIX

Table 1 : Water Quality Index

Parameter	**Class**				
	I	**II**	**III**	**IV**	**V**
NH_3-N	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
BOD	< 1	1 – 3	3 – 6	6 – 12	> 12
COD	< 10	10 – 25	25 – 50	50 – 100	> 100
DO	< 7	5 – 7	3 – 5	1 – 3	< 1
pH	< 7	6 – 7	5 – 6	< 5	< 5
TSS	< 2.5	25 – 50	50 – 150	50 – 30	> 300
WQI	< 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0

(Source: Ministry of Natural Resources and Environment Malaysia, 2009)

Table 2 : DOE Water Quality Classification based on Water Quality Index

Sub-Index and Water Quality Index	**Index Range**		
	CLEAN	**SLIGHTLY POLLUTED**	**POLLUTED**
BOD	91-100	80-90	0-79
NH_3-N	92-100	71-91	0-70
SS	76-100	70-75	0-69
WQI	81-100	60-80	0-59

(Source: Ministry of Natural Resources and Environment Malaysia, 2009)

Table 3 : National Water Quality Standard for Malaysia (NWQS)

(Source: Department of Environment, 2015)

Table 4 : National Standard for Drinking Water Quality

Parameters	Unit	Classes					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1.0	3.0	3.0	6.0	12.0	>12.0
COD	mg/l	10.0	25.0	25.0	50.0	100.0	>100.0
DO	mg/l	7.0	5.0-7.0	5.0-7.0	3.0-5.0	<3.0	<1.0
pH	-	6.5-8.5	6.0-9.0	6.0-9.0	5.0-9.0	5.0-9.0	-
Colour	TCU	15.0	150.0	150.0	-	-	-
Electrical Conductivity*	umhos/ cm	1,000.0	1,000.0	-	-	6,000.0	-
Floatables	-	n	n	n	-	-	-
Odour	-	n	n	n	-	-	-
Salinity	%	0.5	1.0	-	-	2.0	-
Taste	-	n	n	n	-	-	-
Total Dissolved Solid	mg/l	500.0	1,000.0	-	-	4,000.0	-
Total Suspended Solid	mg/l	25.0	50.0	50.0	150.0	300.0	300.0
Temperature	°C	-	Normal +2°C	-	Normal +2°C	-	-
Turbidity	NTU	5.0	50.0	50.0	-	-	-
Faecal Coliform **	counts/ 100 mL	10.0	100.0	400.0	5,000.0 (20,000.0)*	5,000.0 (20,000.0)*	-
Total Coliform	counts/ 100 mL	100.0	5,000.0	5,000.0	50,000.0	50,000.0	>50,000.0
Iron	mg/l	Natural levels or absent	1.0	1.0	1.0	1.0 (Leaf) 5.0 (Others)	Levels above IV
Manganese	mg/l		0.1	0.1	0.1	0.2	
Nitrate	mg/l		7.0	7.0	-	5.0	
Phosphorous	mg/l		0.2	0.2	0.1	-	
Oil & Grease	mg/l		0.04; N	0.04; N	N	-	

Parameter	Group	RECOMMENDED RAW WATER QUALITY	DRINKING WATER QUALITY STANDARDS
		Acceptable Value (mg/litre (unless otherwise stated))	Maximum Acceptable Value (mg/litre (unless otherwise stated))
Total Coliform	1	5000 MPN / 100 ml	0 in 100 ml
E.coli	1	5000 MPN / 100 m	0 in 100 m
Turbidity	1	1000 NTU	5 NTU
Color	1	300 TCU	15 TCU
pH	1	5.5 - 9.0	6.5 - 9.0
Free Residual Chlorine	1	-	0.2 - 5.0
Combined Chlorine	1	-	Not Less Than 1.0
Temperature	1	-	-
Clostridium perfringens (including spores)	1	-	Absent
Coliform bacteria	1	-	-
Colony count 22°	1	-	-
Conductivity	1	-	-
Enterococci	1	-	-
Odour	1	-	-
Taste	1	-	-
Oxidisability	1	-	-
Total Dissolved Solids	2	1500	1000
Chloride	2	250	250
Ammonia	2	1.5	1.5
Nitrat	2	10	10
Ferum/Iron	2	1.0	0.3
Fluoride	2	1.5	0.4 - 0.6
Hardness	2	500	500
Aluminium	2	-	0.2
Manganese	2	0.2	0.1

(Source: Malaysia Ministry of Health, 2004)

Table 5 : Water Sampling Points

Point	Latitude N	Longitude E	Source Consideration	Distance From Upstream (km)
	Sungai Semantan			
1	3°29'08.51"	102°05'55.89"	Plantation	37.15 25.06
2	3°28'14.16"	102°05'16.39"	Fish Pond	34.36 22.37
	Sungai Bentong			
3	3°27'43.61"	102°05'06.40"	Plantation	32.63
4	3°26'02.88"	102°02'34.15"	Residential Area	23.28
5	3°26'53.14"	101°59'46.18"	Industrial Park	13.24
6	3°29'36.31"	101°55'51.79"	Industrial Park	0
	Sungai Kelau			
7	3°28'08.76"	102°04'40.12"	Livestock	21.33
8	3°29'14.27"	102°02'21.89"	Residential Area	14.64
9	3°32'53.35"	101°58'57.77"	Dam	0

Table 6: Water quality assessment November 2016

Point	BOD (mg/L)	COD (mg/L)	NH_3-N (mg/L)	pH (unit)	DO (mg/L)	SS (mg/L)	Tur. (NTU)	Temp. (°C)
	AVERAGE							
SUNGAI SEMANTAN								
P1	5	15	0.17	7.91	6.38	111	174.4	27.0
P2	5	18	0.21	6.45	6.65	19	38.2	25.9
SUNGAI BENTONG								
P3	4	16	0.13	6.84	6.87	18	31.3	26.8
P4	3	8	0.17	6.87	8.27	19	34.6	26.9
P5	3	13	0.19	7.20	8.35	20	21.3	27.3
P6	3	19	0.18	7.15	8.19	23	65.3	27.1
SUNGAI KELAU								
P7	4	17	0.19	6.27	7.76	18	31.0	26.8
P8	4	16	0.05	7.66	7.76	6	12.5	26.2
P9	4	13	0.02	6.87	7.17	8	37.9	27.0

Table 7 : WQI Values And Water Status

Station	SI_{BOD}	SI_{COD}	SI_{NH3-N}	SI_{pH}	SI_{DO}	SI_{SS}	WQI	Class	Status
Sungai Semantan									
P1	82.40	78.71	99.46	96.89	101.40	71.62	88.56	II	Slightly Polluted
P2	79.26	73.61	99.29	95.79	102.85	66.77	86.54	II	Slightly Polluted
Sungai Bentong									
P3	80.96	76.27	99.75	94.09	107.70	54.30	86.22	II	Slightly Polluted
P4	80.96	79.37	99.86	93.85	109.67	64.73	88.81	II	Slightly Polluted
P5	77.04	74.04	99.76	97.43	108.58	71.68	88.50	II	Slightly Polluted
P6	75.60	67.07	99.92	98.80	108.86	57.73	85.12	II	Slightly Polluted
Sungai Kelau									
P7	79.26	78.26	99.63	93.39	106.67	55.29	86.05	II	Slightly Polluted
P8	82.40	77.82	99.88	96.58	107.94	63.93	88.65	II	Slightly Polluted
P9	80.96	77.38	100.21	95.92	106.03	78.00	90.11	II	Slightly Polluted

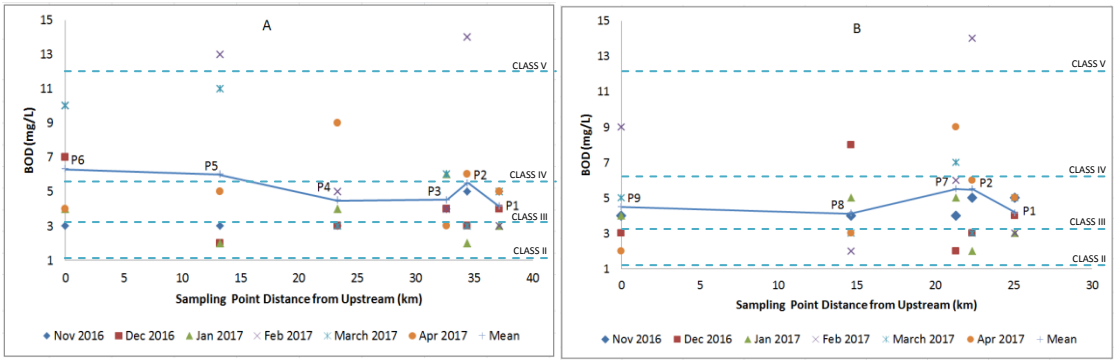

Figure 1 : BOD concentration along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

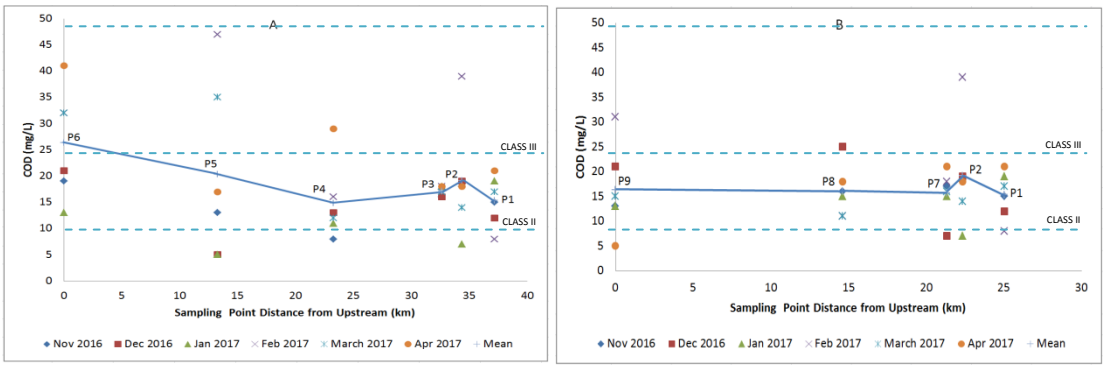

Figure 2 : COD concentration along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

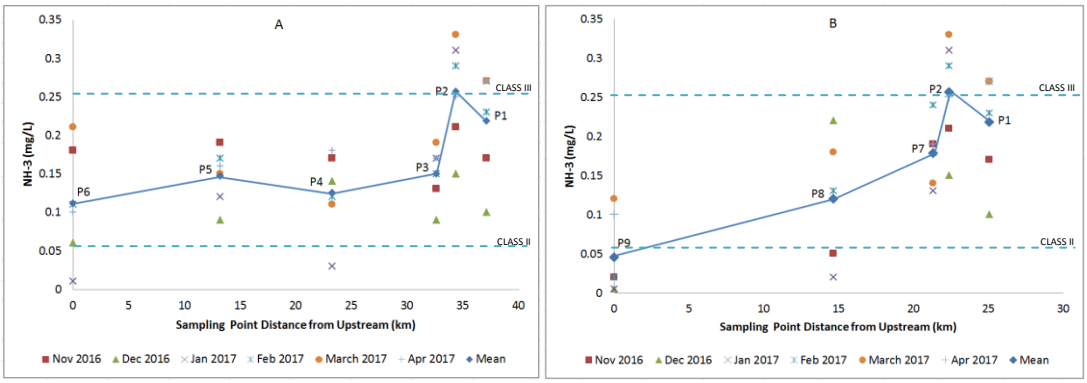

Figure 3 : NH_3-N concentrations along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

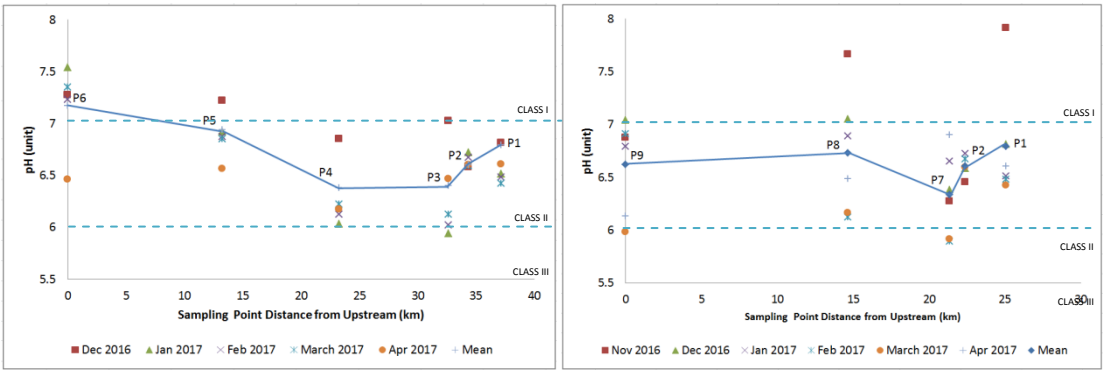

Figure 4 : Variation pH value along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

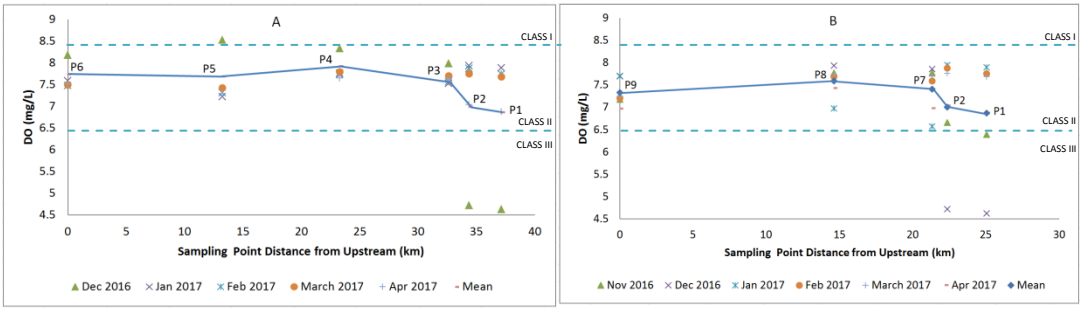

Figure 5 : DO Concentration along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

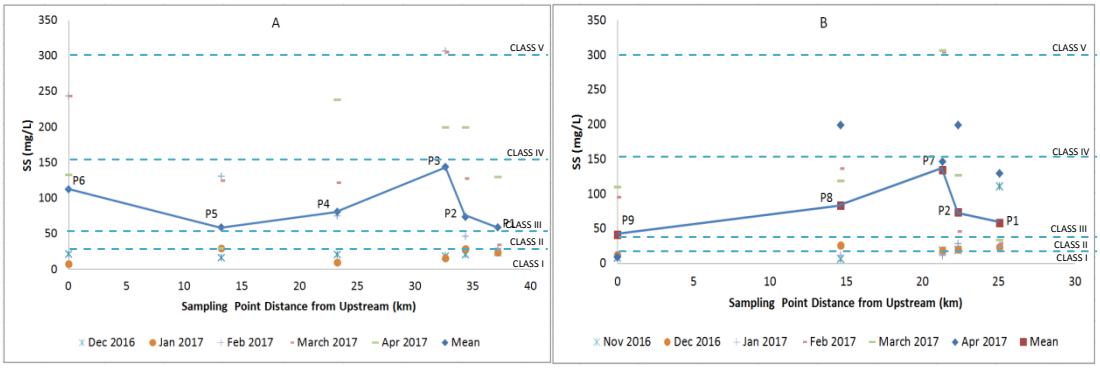

Figure 6 : SS Concentration along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

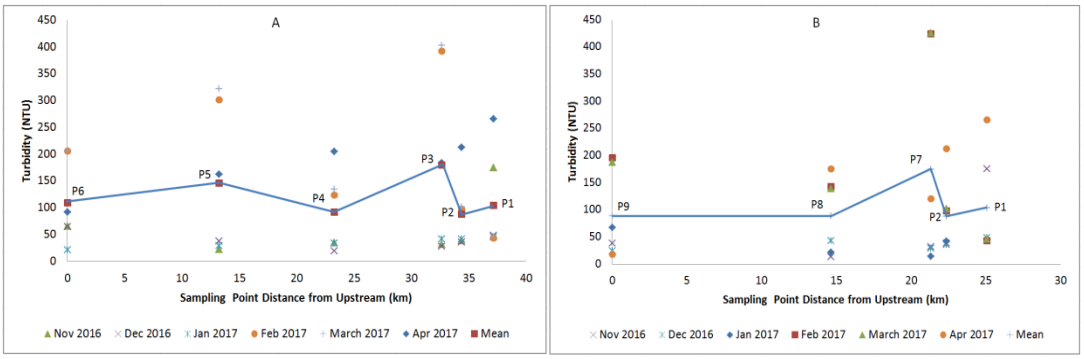

Figure 7: Turbidity Values along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017

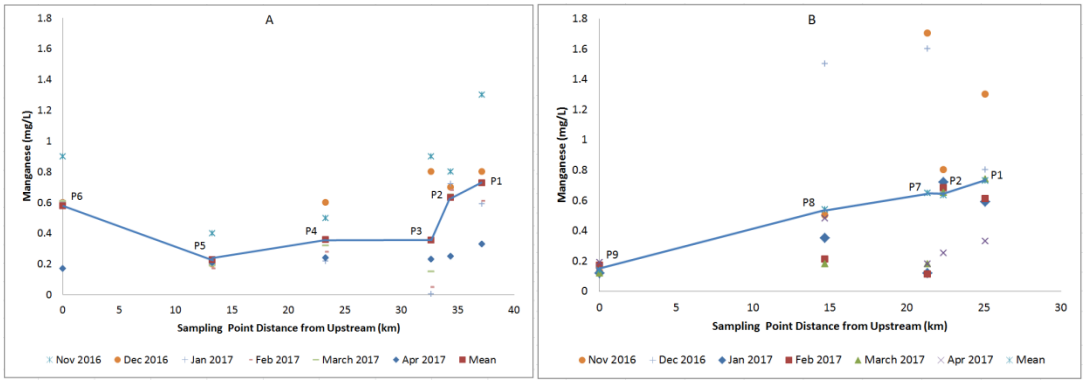

Figure 8 : Water temperature values along A) Sungai Bentong and B) Sungai Kelau from November 2016 to April 2017