Water Quality of Selected Rivers in Behrang River Catchment, Perak Malaysia

Kualiti Air Sungai terpilih di Lembangan Sungai Behrang, Perak Malaysia.

HUSNA NABILAH HAMIDON*[1], SUMAYYAH AIMI MOHD NAJIB[2] & SYAZWANI ALIAH[1]

[1] Postgraduate students in Dept. of Geography and Environment, Faculty of Human Sciences, Universiti Pendidikan Sultan Idris
35900 Tanjong Malim, Perak, Malaysia,
[2] Dept. of Geography and Environment, Faculty of Human Sciences,
Universiti Pendidikan Sultan Idris
35900 Tanjong Malim, Perak, Malaysia.

Corresponding author: husnanabilahhamidon@gmail.com

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ABSTRACT *Water quality is essential for human health, environment, agriculture and more aspects related to human lives. This study aimed to evaluate the water quality in selected four rivers around Behrang catchments, Perak, Malaysia. Sampling was carried out from November 2017 to January 2018 in five stations twice a week to identify changes in water body. The study was implemented using in-situ parameters and water samples from the rivers to be tested in laboratory. Physicochemical parameters include temperature, conductivity (CND), total dissolved solids (TDS), dissolved oxygen (DO), potential of hydrogen (pH), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia-nitrogen (NH3-N), and suspended solids (SS). The water quality was determined based on (INWQS), which categorises pollution levels from clean to contaminated in the order of Classes I, II, III, IV, and V. According to the land use, agricultural activity is dominant and main contributor to the water quality in Behrang catchments, and the results show that the rivers are in Class I and Class II.*

Keywords: Water quality, INWQS, Behrang catchments.

1. Introduction

Water is crucial to life to sustain on the Earth, so it requires proper attention in terms of its usage and treatment (Kumar et al. 2014). Demand for freshwater is rising due to population growth, water pollution and economic activity, as well as technological progress and reduced water resources (Schleich and Hillenbrand 2009; Boretti and Rosa 2019). Water is important for many activities, however there is significant percentage of humans who still does not have access to clean water for their survival, which is for drinking and personal hygiene. Besides, the quality and quantity of water required to satisfy each aspect vary considerably, depending on the demand types, geographical location, cultural traditions, standards of living, climatic characteristics and other individual and site-specific factors (Biswas, 1979).

In recent decades, the advancement of water supplies helps to accommodate the growth of world populations due to the rise in living standards. Due to its significance on human life and the natural ecosystem, the water quality of river has become a global concern. Therefore, the clean water supply is important for the survival of humans and other living organisms. Hence, the management of river basin is crucial to maintain the quality and sustainability of the present and future generations. Water resource protection measures include the land use management (Curk et al. 2020). The main source of water in Malaysia is from the river basins. There are 189 major river basins and 2986 river basins (Department of Irrigation and Drainage 2019). This includes the rivers within the state, rivers across the state and rivers across the country. The most important aspect is the condition of the river. Today, the state of the river has changed due to modernisation, mostly because of human activities. The quality of water is affected. Besides, the growth of human population necessitates higher demand for water, water supply management. The world is serious on the issues related to water nowadays since there are increase of pollutants that from municipal wastewaters, industrial wastewaters, domestic wastewater, and poultry farms if water supply is not managed effectively (Fulazzaky et al. 2009).

There are 11 issues that must be addressed to ensure the sustainability of water resources in the future. First is emphasised on water supply management. Second is institutional issues, followed by high rate of water wastage, changing weather patterns, high rate of non-revenue water (NRW), water sector privatisation, destruction and degradation of water catchments, legislation, water pollution, low water rate, and inefficient agricultural water use (WWF Malaysia, 2020). The scientists and engineers working in the field of water have to identify the use of new techniques such as tracers and modelling simulation to deal with the issues (Kumar et al., 2014). According to the Department of Environment (2018), river water quality is determined by two methods, namely the National Interim Standard of Water Quality (INWQS) and the Water Quality Index (WQI). INWQS lists 72 parameters that determine water quality. According to the INWQS standard, each parameter will determine the water quality based on the classes of uses. Meanwhile, WQI is a method of determining river water quality using six parameters namely dissolved oxygen (DO), pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia nitrogen, and suspended solids (SS). The data from the six parameters are used to calculate WQI values a specific formula.

River is important for the people of the surrounding area. This is because rivers are a source of irrigation for agricultural activities as well as being recreational places of the people around them. The land activities in the river basin must be planned and controlled to protect the water resource and quality (Al-Badaii et al. 2013). Therefore, it is important to safeguard and conserve the existing "our rivers" for the present and future needs. Moreover, lakes, rivers, and the catchment area are the main natural heritages that has to be preserved (Zullyadini et al. 2016).

2. Study Area

This study was conducted at Behrang Ulu in Behrang, Perak. Behrang is one of the towns in the Muallim district. The study area is located 12 km north of Tanjong Malim via Proton City and 7 km west of Behrang town or Behrang Station and 25 km south of Slim River in Perak. Behrang Ulu includes villages on the upper reaches of the Sg. Behrang. Subcatchments of the Sg. Behrang include Sg. Keroh, Sg. Sekiah, and Sg. Dara. Water sampling was carried out in downstream areas, as illustrated in Figure 1. Table 1 shows the exact location of the sampling stations while Table 2 shows the rainfall distribution at the sampling stations.

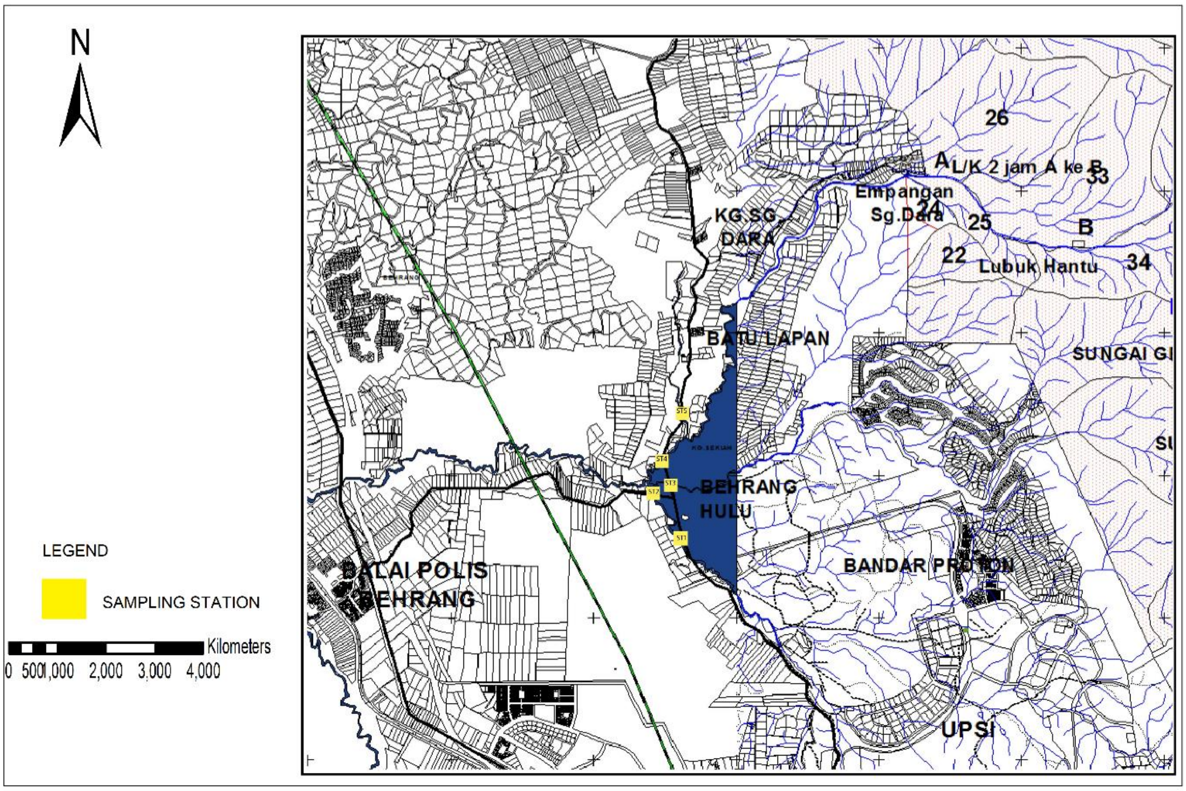

Figure 1: Sampling Stations in Downstream Areas

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Table 1. Location of Sampling Stations on Downstream Areas

Station	River	Latitude	Longitude
1	Sungai Keroh	3° 44′ 53.1″ N	101° 29′ 53.1″ E
2	Sungai Keroh	3° 45′ 24.2″ N	101° 29′ 34.5″ E
3	Sungai Sekiah	3° 45′ 28.3″ N	101° 29′ 41.0″ E
4	Sungai Behrang	3° 45′ 38.7″ N	101° 29′ 37.5″ E
5	Sungai Dara	3° 45′ 59.3″ N	101° 29′ 46.4″ E

Table 2: Rainfall Distribution at the Sampling Stations

Date	Rainfall Amount (mm)	Date	Rainfall Amount (mm)
21 Nov 2017	0	19 Dec 2017	0.0
22 Nov 2017	2.0	20 Dec 2017	3.6
23 Nov 2017	**45.0**	**21 Dec 2017**	**0.0**
24 Nov 2017	73.4	22 Dec 2017	1.0
25 Nov 2017	9.3	23 Dec 2017	0.4
26 Nov 2017	0.2	24 Dec 2017	2.3
27 Nov 2017	**0.0**	**25 Dec 2017**	**2.9**
28 Nov 2017	0.6	26 Dec 2017	21.3
29 Nov 2017	4.2	27 Dec 2017	6.5
30 Nov 2017	**23.5**	**28 Dec 2017**	**13.1**
1 Dec 2018	12.1	29 Dec 2017	2.8
2 Dec 2018	17.2	30 Dec 2017	14.3
3 Dec 2018	0.4	31 Dec 2017	0.6
4 Dec 2018	**4.8**	**1 Jan 2018**	**0.8**
5 Dec 2018	5.0	2 Jan 2018	3.3
6 Dec 2018	0.0	3 Jan 2018	0.2
7 Dec 2018	**0.0**	**4 Jan 2018**	**0.3**
8 Dec 2018	32.4	5 Jan 2018	0.8

9 Dec 2018	0.0	6 Jan 2018	2.2
10 Dec 2018	0.0	7 Jan 2018	0.1
11 Dec 2018	**2.2**	**8 Jan 2018**	**0.0**
12 Dec 2018	2.1	9 Jan 2018	66.7
13 Dec 2018	0.1	10 Jan 2018	4.2
14 Dec 2018	**29.6**	**11 Jan 2018**	**26.5**
15 Dec 2018	0.1	12 Jan 2018	9.0
16 Dec 2018	0.0	13 Jan 2018	19.8
17 Dec 2018	3.3	14 Jan 2018	0.1
18 Dec 2018	**1.9**	**15 Jan 2018**	**0.0**

Source: Weather Stations Department of Geography and Environmental UPSI (2018)

3. Methodology

Water sampling was conducted from November 2017 to January 2018 at five sampling stations twice a week to identify changes in the water body. Water samples were analysed in the Sultan Idris Education University (UPSI) Geography Laboratory to obtain the WQI parameters, which are pH, DO, BOD, COD, TSS and ammonia nitrogen. The six parameters were recorded based on the averaged values and classified based on INWQS. In fact, there are six classes; Class I, IIA, IIB, III, IV and V, as shown in Table 3.

Table 3: The classification according to the National Water Quality Interim Standard

Parameter	**Class**						
	Unit	I	IIA	IIB	III	IV	V
DO	mg/L	7	5-7	5-7	3-5	<3	<1
pH		6.5-8.5	6-9	6-9	5-9	5-9	-
TSS	mg/L	25	50	50	150	300	>300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Conductivity	µS/cm	1000	1000	-	-	6000	-
TDS	mg/L	500	1000	-	-	4000	-
BOD	mg/L	1	3	3	6	12	>12
COD	mg/L	10	25	25	50	100	>100
NH3N	mg/L	0.1	0.3	0.3	0.9	2.7	>2.7

Source: Department of Environment (2018)

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To simplify the data according to the INWQS parameters, the WQI indexing system is used to classify water quality by class. All parameters have a specific weight and a value represented by one value is to determine the WQI class. The WQI calculations are from predefined sub-indices such as SIDO, SIBOD, SICOD, SIAN, SISS and SIPH (Department of Environment Malaysia 2018). Table 4 shows the values involving the six sub-indexes. WQI is determined based on a formula by the Department of Environment Malaysia (2003) after each sub-index of the six parameters is calculated. Equation (1) shows the formula used to calculate WQI:

$$0.19 \times SIBOD + 0.16 \times SICOD + 0.22 \times SIDO + 0.15 \times SIAN + 0.12 \times SIpH + 0.16 \times SISS \quad (1)$$

Each parameter and the river water quality are classified according to the DOE guidelines once the WQI value is obtained to determine the pollution level. From the six classes of WQI (Class I, II, III, IV, and V), class I is deemed as clean while Class V is deemed as highly contaminated. WQI is the benchmarking tool for water quality, it is used by the agencies and parties involved in watershed management (Mohd Khairul Amri et. al 2018). Table 5 shows the water quality classification based on WQI from DOE.

Table 4: WQI Development Sub-Index Formula

Parameter	Value	Sub-index Equation
BOD (mg/L)	$x \leq 5$	$SIBOD = 100.4 - 4.23x$
	$x > 5$	$SIBOD = 108^{-0.055x} - 0.1x$
COD (mg/L)	$x \leq 20$	$SICOD = -1.33x + 99.1$
	$x > 20$	$SICOD = 103e^{-0.0157x} - 0.04x$
DO (%)	$x \leq 8$	$SIDO = 0$
	$x < 92$	$SIDO = 100$
	$8 < x < 92$	$SIDO = -0.395+0.030x^2 - 0.00020x^3$
NH3-N (mg/L N)	$x \leq 0.3$	$SIAN = 100.5 - 105x$
	$0.3 < x < 4$	$SIAN = 94e^{-0.573x} - 5 \vert x-2 \vert$
	$x \geq 4$	$SIAN = 0$

pH	$x < 5.5$ $5.5 \leq x < 7$ $7 \leq x < 8.75$ $x \geq 8.75$	$SIpH = 17.2 - 17.2x + 5.02x^2$ $SIpH = -242 + 95.5x - 6.67x^2$ $SIpH = -181 + 82.4x - 6.05x^2$ $SIpH = 536 - 77.0x + 2.76x^2$
TSS (mg/L)	$x \leq 100$ $100 < x < 1000$ $x \geq 1000$	$SISS = 97.5e^{-0.00676x} + 0.05x$ $SISS = 71e^{-0.0016x} - 0.015x$ $SISS = 0$

Source: Department of Environment (2018)

Table 5: DOE Water Quality Classification based on Water Quality Index

Parameters	Index Range		
	Clean	Slightly Polluted	Polluted
SIBOD	91 – 100	80 – 90	0 – 79
SIAN	92 – 100	71 – 91	0 – 70
SISS	76 – 100	70 – 75	0 – 69
Water Quality Index	81 – 100	60 – 80	0 – 59

Source: Zaki (2010)

4. Result and Discussion

4.1 Physicochemical parameters

Table 6 summarises the physicochemical analysis in the Behrang catchments. The mean surface water temperature was the lowest (25.50 °C) at Station 5 and highest (26.21 °C) at Station 2. There are variations across the sampling stations, with the highest value (29.4 °C) was recorded in December at Station 1 while the lowest (23 °C) was in January at Station 4 and Station 5. The pH values of water is acidic to slightly alkaline, with a range of 5.97-7.22. However, the mean pH range in this study falls within the acceptable limits of 6.5-9 (Class III) except Station 5 (6.45). Based on INWQS, all stations showed the average pH deemed as Class I and IIA. The times when the pH were below than neutral are caused by the use of land for agricultural activities.

Another parameter to measure water quality is dissolved oxygen (DO), with normal values between 7.10 mg/L and 11.71 mg/L. In this study, the highest value (8.77 mg/L) was recorded in December while the lowest (5.60 mg/L) was in January at Station 3. The results are within the acceptable levels of INWQS for Malaysian rivers, which is more than 5 mg/L and categorised under Class II. Meanwhile, conductivity (CND) values in this study ranged from 39.5 to 108.7 µS/cm. The values are inconsistent from November 2017 to January 2018, with Station 3 having the highest value while Station 4 had the lowest. The observed conductivity was below the allowable limits. So, the conductivity in this study was within the recommended level by INWQS, Malaysia and fell into Class I. According to Oram (2014), water conductivity also increases once the total dissolved substances in the water increases.

Total dissolved solids (TDS) was the lowest (26.12 mg/L) at Station 4 while the highest was (66.13 mg/L) at Station 2. TDS concentrations depends on the saturated and unsaturated zone and the quality of infiltrating water (Oram 2014). The reading was in Class I (good) despite the difference in the TSS concentration. This parameter is important indicator for drinking water and a general indicator for pollution. TDS refers to the amount of cations (positive charge) and anions (negative charge) in water. TDS include calcium, magnesium, potassium, sodium, bicarbonate, chloride and sulphate and a small portion of organic materials (Zullyadini et al. 2016). The highest TDS was in Sg. Keroh (Station 2), which was 83.8 mg/L while the lowest was in Sg. Behrang which was 25.35 mg/L. According to INWQS, TDS in this study was in Class I. The total suspended solid (TSS) was the lowest (28.73 mg/L) at Station 4 and highest (75.71 mg/L) at Station 2. The values of TSS in water samples ranged between the minimum of 6 mg/L at Station 4 and the maximum of 602 mg/L at Station 2. In fact, the TSS values in this study are within acceptable limit and categorised as Class III. High TSS readings can disturb the aquatic ecosystem by preventing sunlight from penetrating the water surface.

The biochemical oxygen demand (BOD) was the lowest at Station 1 with a mean of 0.65 mg/L and highest at Station 3 with a mean of 0.97 mg/L. In the four months of sampling, Station 3 and Station 5 had the highest and the lowest values, respectively. The BOD of the river were between 0.02 mg/L at Station 4 and 2.8 mg/L at Station 3. High BOD is attributed to inadequate treatment of sewage or effluents from agro-based and manufacturing industries (Environment Quality Report 2015). Meanwhile, the chemical oxygen demand (COD) was the lowest (7.31 mg/L) at Station 1 and highest (11.81 mg/L) at Station 4. The highest value of 43 mg/L was recorded in December and the lowest of 0 mg/L was in January at Station 4. According to INWQS, BOD and COD in this study are within the allowable limit of INWQS standard, in which the values less than 3 mg/L are classified as Class I (BOD) while the values off 50 mg/L or less are classified as Class III (COD).

The main sources of ammonia nitrogen (NH3-N) are animal farms and domestic sewage (Environment Quality Report 2015). The mean of NH3-N were between 0.02 mg/L (Station 4) and 0.07 mg/L (Station 2). The minimum value (0 mg/L) was recorded at all stations except Station 2 (0.01 mg/L) whereas the maximum (0.32 mg/L) was only recorded at Station 1. Based on INWQS, all sampling stations were classified as Class I (Station 4) and Class II in terms of NH3-N. Table 7 shows WQIs in all sampling stations.

Table 7: WQI in Sampling Station

Station	River	WQI	Class
ST1	Sg. Keroh	92	Class II
ST2	Sg. Keroh	90	Class II
ST3	Sg. Sekiah	92	Class II
ST4	Sg. Behrang	93	Class I
ST5	Sg. Dara	92	Class II

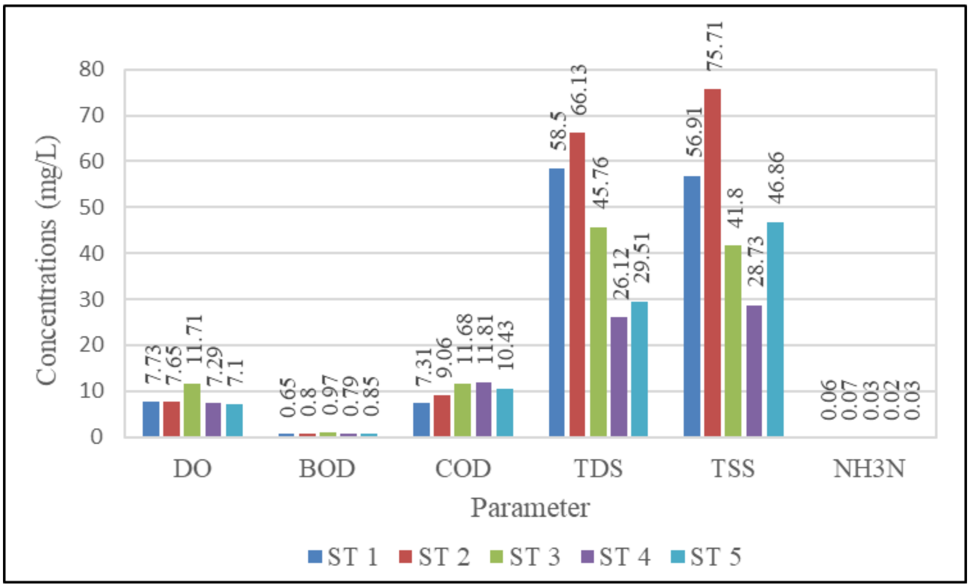

Figure 2: Summary of Physical and Chemical Parameters at Sampling Stations in the Behrang Catchment

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Table 6: Summary of Physical and Chemical Parameters at Sampling Stations in the Behrang Catchment

Parameter	Station 1			Station 2			Station 3			Station 4			Station 5		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Temperature	23.3	26.20	29.4	23.1	26.21	27.8	23.3	25.97	27.9	23	25.61	27.5	23	25.50	27.4
pH	6.33	6.62	7.22	6.11	6.57	7.22	6.31	6.61	7.22	6.38	6.65	7.22	5.97	6.45	6.92
Conductivity	86.1	91.35	103.3	85.6	94.89	104.6	45.3	72.98	108.7	39.5	58.14	92.3	43.9	57.98	80.8
TDS	54.5	58.50	63.7	41.6	66.13	83.8	27.95	45.76	69.8	25.35	26.12	30.6	26	29.51	33
TSS	8.27	56.91	309.33	10.4	75.71	602	12	41.8	111.33	6	28.73	148.93	6.8	46.86	336.4
DO	7	7.73	8.5	6.91	7.65	8.59	5.6	11.71	8.77	6.2	7.29	7.88	6	7.10	8.23
BOD	0.08	0.65	1.66	0.08	0.8	1.8	0.04	0.97	2.8	0.02	0.79	2.38	0.14	0.85	2.06
COD	1	7.31	15	1	9.06	19	1	11.68	22	0	11.81	43	2	10.43	27
NH3N	0	0.06	0.32	0.01	0.07	0.12	0	0.03	0.09	0	0.02	0.04	0	0.03	0.19

5. Conclusion

This study shows that the water quality in Behrang catchments according to the WQI classifications. The water quality in these catchments are still deemed positive at Class I and Class II. The rivers are clean and in good condition but requires monitoring so that they are free of pollution because the areas involve land use for residential areas and agricultural activities. The wastewater from residential areas and the use of pesticides in agriculture affect water quality in the rivers. Based on INWQS, most of the parameters measured in the sampling stations are in Class I and II.

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