A STUDY ON WATER QUALITY STATUS OF VARSITY LAKE AND PANTAI RIVER, ANAK AIR BATU RIVER IN UM KUALA LUMPUR, MALAYSIA AND CLASSIFY IT BASED ON (WQI) MALAYSIA

Hasan F. Gafri, Fathiah M. Zuki*, Fatimah M. Zeeda, Nasaruddin Affan, Abdul Halim Sulaiman, Siti Norasiah

Department of Chemical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia

*Corresponding author E.mail: fathiahmz@um.edu.my

Abstract

Rivers and lakes are primary sources of water for towns and villages. However, the quality of these water bodies is currently deteriorating due to urbanization, industrialization, farming, and other anthropogenic activities. This study was conducted within January 25th to November 26th 2017at designated points at Pantai River, Anak Air Batu River, and Varsity Lake, University of Malaya, Kuala Lumpur, Malaysia, where the physic-chemical and biological characteristics were determined in order to increase the statistical basis of these regions. In the physic-chemical evaluation of the water samples, diverse parameters were measured, such as the pH, turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), ammonia, phosphate and nitrate attention, and biology. These parameters were compared with the Water Quality Index (WQI) standards of water quality. Overall, the result showed that the DO, BOD, COD, and SS fall within classes II, III, while Ammoniacal Nitrogen (NH3-N) falls within classes II, IV, and V, and pH and temperature fall within class I. The study area reported moderate levels of pollution between classes I and IIA due to urban activities. The results showed that the water collected from the study area was unsuitable for human consumption due to the significant presence of microbes.

Keywords: *Anak Air Batu River, Pantai River, Varsity Lake, water quality*

Introduction

There is total of 1400 million billion litres of water covering the planet, the vast majority of which are not potable, due to the fact that 97% of it is marine water, and only 3% constituting freshwater. The bulk of water is used for irrigation purposes (WHO, 2004). Rapid urbanization and population growth resulted in the growing demand for potable water, and subsequently, increased levels of pollution in Malaysia. This created huge quantities of human, commercial, and industrial wastes, which results in contaminated rivers. Water from contaminated rivers are unsuitable for human consumption, and providing their respective populations with

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clean and potable water remains a challenge for many governments. High levels of BOD from untreated or partly treated waste materials originate from industrialized and agricultural manufacturers, while NH_3-N comes from household sewage and other organic waste, and SS comes from excavation works (DOE, 2012). Contaminated water facilitates the spread of water-borne diseases (Nollet, 2000). A major cause of pollution is the disposal of waste directly onto the surface of the planet, examples of waste being manure, sludge, garbage, and industrial wastes (Jaini, 2003). The spread of intestinal diseases, for example, occurs directly via contaminated water. Diseases such as typhoid fever and bacillary dysentery, hepatitis A, and other gastrointestinal infections.

Rivers water pollution

Managing polluted rivers is essential due to the fact that 98% of total water being used for our day-to-day activities comes from the rivers. The agro-industry, which consumes 70% of the water resources in Malaysia, severely pollutes the rivers, from point sources and non-point sources. According to Department of Environment Malaysia (DOE, 2012), there are three parameters of contamination that significantly affect river quality; BOD, SS, and NH_3-N. An imagined BOD load of 848 tons per day in 2012 decreased by 39 %, as opposed to the number reported in 2011 (1,394 tons for each day). Moreover, the SS load in 2012 was reported to be 1383 tons per day, although the measurable NH3-N load was 232 tons per day. The DOE (2012) reported that the Klang River showed the most elevated BOD load (142 tons for per day), followed by Perak river at 114 tons per day, Sarawak River at 30 tons for each day, Jawi River (State of Pulau Pinang) at 26 tons for each day, and Muar River (State of Johor) at 24 tons per day. Klang River also reported the highest SS load (360 tons per day) and NH_3-N load (37 tons per day) amongst the rivers in Malaysia (DOE, 2012). The Water Quality Index (WQI) serves as a mean indication of water quality assessment via the determination of the physic-chemical parameters of the water's surface.

Lakes water pollution

A lake is an enclosed area of water surrounded completely by land with no direct access to the ocean, except via a river or stream that feeds or depletes the lake. Lakes are an important source of fresh water, as it represents a small portion of ~0.01 % of the amount of total water encompassing the earth (Hidzrami, 2010). Lakes in Malaysia represents ~ 90 % of the water supply in the country (ASM, 2010). The quality of lake water can be affected by external inputs entering the lake or reservoir of the watershed, and also the ecosystem of the lake, food and cycling, and internal loading. External inputs can be constant organic and inorganic materials or food wastes deteriorating the water quality of point and non-point sources. Sources incorporate discharge points of the household and municipal and agricultural liquid waste and industrial wastewater, while non-specific sources contain urban water runoff, agricultural runoff, sewage by pass tanks, and construction sites runoff. In Malaysia, there are no national standard specified or indicators of the quality of lake water as of 2014.

In 2009, the Academy of Sciences Malaysia (ASM), together with National Hydraulic Research Institute of Malaysia (NAHRIM), embarked on the development of strategies for the development and management of lakes and rivers in Malaysia (Ramadas, 2009). The accentuation on Integrated Lake Basin Management (ILBM) was first explained by the International Lake Environment Committee (ILEC, 2003). The strategic plan for sustainable management of lakes and reservoirs in Malaysia was introduced and endorsed during the 7th National Water Resources Council (NWRC) meeting on the 1st November 2012 (Ramadas, 2009). As per the Interim National Water Quality Standardization (INWQS), the water quality of the rivers based on the physic-chemical parameters falls within Class I. Class I is characterized as perfect and not requiring extensive treatment; purification or boiling is sufficient. This quality of water can also be used to preserve indigenous habitat (Wang et al., 1999).

Study area

University of Malaya is the premier university of Malaysia. It is located in the south-west of the capital city of Malaysia Kuala Lumpur. Anak Air Batu River is located next to Bangsar Estate. It reports a length of 1.02 km, at longitude: 101°39' 33.12"E and latitude: 30°08'11.76"N. These rivers are connected near UM (Faculty of Law), flowing into Klang River, and finally, the ocean. The rivers are contaminated with waste from food court villages and chemicals from the laboratories. Moreover, Varsity Lake is located at (30°25'27.52"N, 101°25'53.89" E) (Fig.1).

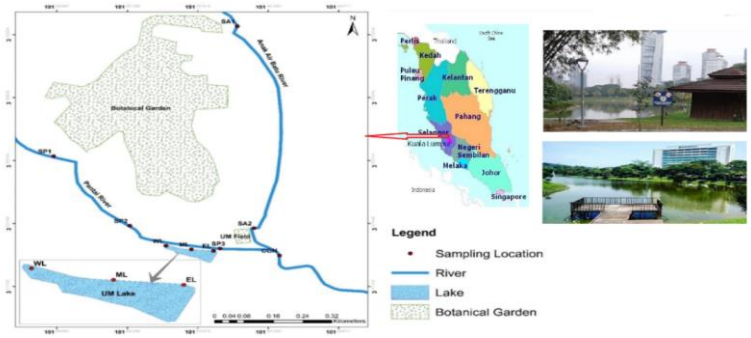

Figure 1
University Malaya campus and location of sampling point.

It is a man-made lake, which was constructed prior to the University. Its measures 250 m long, 85 m wide, and 6 m deep, in a trapezoidal-shaped geometrical structure. There are three main entrances to the provision of water; one of the lakes from the Faculty of Engineering and Built Environment, the Residential College (RC 2) (Kollege Tuanku Gorgeous). The basin water filters in the main entrance of the lake prevents the accumulation of excessive particulate matter in the water. There are two types of drainage outlets to the main drainage channel that drains water in case it gets overfilled (Ashraf et al., 2010). Once the surface water is

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contaminated, its quality cannot be restored by stopping the pollutants from its source. Hence, continuous monitoring of the water quality is important **(**Yisa and Jimoh, 2010).

The WQI serves as a basis for environmental assessment of a watercourse vis-à-vis the pollution load categorization and designation of classes of beneficial uses, as per the Interim National Water Quality Standards for Malaysia (INWQS). INWQS is divided into 5 classes, as tabulated in table 1.

This study concentrated on investigation of the most recent attributes of water quality at Pantai River, Anak Air Batu River and Varsity Lake, University of Malaya, Kuala Lumpur, Malaysia in the context of its physic-chemical and biological properties. Furthermore, also intend to determine the current Water Quality Index (WQI) Malaysia and the concentration of coliform bacteria and develop a database compiling the quality of water being consumed in those areas.

Table 1 *National Water Quality Standards for Malaysia (INWQS)*

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
NH_3-N	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
BOD	mg/l	1	3	3	6	12	> 12
COD	mg/l	10	25	25	50	100	>100
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	-
Color	TCU	15	150	150	-	-	-
TSS	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-

NH_3-N= Ammoniacal Nitrogen - BOD=Biochemical Oxygen Demand – COD=Chemical Oxygen Demand - DO=Dissolved Oxygen – TSS=Total Suspended Solid

Materials and methods

The physic-chemical and biological parameters were determined. Water quality parameters (temperature and pH) were measured in-situ using a pH meter (Model MP220), while the level of dissolved oxygen (DO) was measured using a DO meter (EUTECH instruments cyber scan waterproof series). Seven other physico-chemical parameters, such as the chemical oxygen demand (COD), biochemical oxygen demand (BOD), suspended solids (SS), Ammoniacal nitrogen (NH_3 -N), phosphate (PO_4), nitrite (NO_2) and nitrate (NO_3) were determined using HI83099 Multipara Meter Lab-Photometer. The turbidity DR/890 colorimeter (HACH) was also used in this work. The level of *Escherichia coli* (*E.coli*) and total *coliform* bacteria were determined in the laboratory using 3M Petrifilm *E. coli* Count Plates.

Collection of samples

Four points were designated along the Varsity Lake, University of Malaya, Kuala Lumpur, Malaysia, where four samples from different stations along Pantai and Anak Air Batu Rivers were selected. 2 L plastic (polyethylene) bottles were used to collect water samples during rainy/sunny days to check for discrepancies between

the results due to the timing activity of the organisms and nutrients being reliant on water temperature and emission of the sunlight in the morning hours between of 7:00 to 10:00am from January 25th to November 26th 2017.
The bottles were thoroughly washed using tap water, and distilled water. The sources and locations of samples are shown in in table 2.

Table 2**.** *Water samples location*

Sample number	Source	Location
L1	Varsity Lake	University of Malaya Kuala Lumpur (kayak station)
L2	Varsity Lake	University of Malaya Kuala Lumpur (middle)
L3	Varsity Lake	University of Malaya Kuala Lumpur (aerator)
L4	Varsity Lake	University of Malaya Kuala Lumpur (drain in front library)
R1	Anak Air Batu River	University of Malaya Kuala Lumpur (upstream)
R2	Anak Air Batu River	University of Malaya Kuala Lumpur (downstream)
R3	Pantai River	University of Malaya Kuala Lumpur (upstream)
R4	Pantai River	University of Malaya Kuala Lumpur (downstream)

Results and Discussion

Results of water quality of the study area were designated into four sections. The first section includes QWI parameters DO, COD, SS, BOD, NH_3-N, and PH. The second section includes the physic-chemical parameters such as turbidity, nutrient, nitrate, ammonia, and phosphate. Section three encompasses the biological parameters *E.coli* and Total *Coliform*, while Section four involves the comprehensive compilation of various parameters between this study and previous studies done in Malaysia.

QWI parameters include pH, temperature, DO, COD, SS, BOD and NH_3-N

pH and Temperature. The range of pH value of the Varsity Lake during the sampling time was from (7.35 - 8.12), with an average of (7.80). The range of pH values of the Pantai River was (7.02 - 8.1), with an average of (7.52). Contrarily, the range of pH value of Anak Air Batu River was (6.9 to 7.71), with an average of (7.31). The pH value at all stations are within the neutral range, rendering them suitable for the support of life. The pH value was ideal, as per NWQS, which classifies it into class I (Table 2). The INWQS threshold range of pH for Malaysian rivers is 5-9 (DOE, 1994). The low value of the river sampling was probably due to the free carbon dioxide or rainfall and runoffs from the nearby roads and surrounding areas. Amongst the samples taken from the different places, the range of the temperature value of the study area was (27.6 to 31.2 $^{\circ}$C), at an average of (29.11°C). Overall, the temperature values did not differ much from station to station. This could be due to the high level of exposure of the sun at this point of time and the location of the lake being on exposed land. However, the World Health Organization (WHO) and the U. S. Safe Drinking Water act standardized the allowable ranges of PH for drinking water to be from 6.5 - 8.5 (Cech, 2010).

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Dissolved Oxygen (DO). Diminished DO levels could be indicative of excessive presence of microbes and BOD (untreated sewage, partially treated sewage, organic discharges and anoxic discharges) going through the DO. The amount of DO in water from different sampling points are shown in figure2.

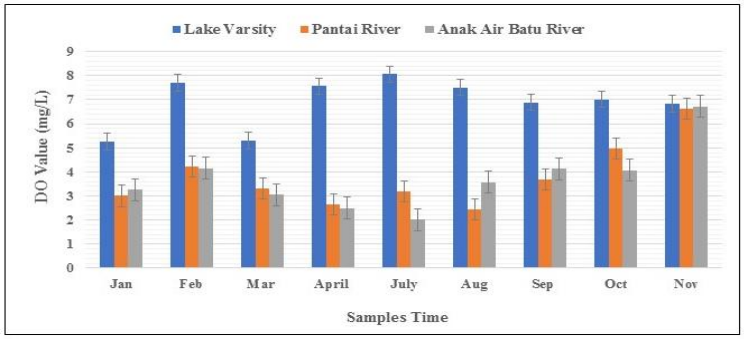

Figure 2
The amount of dissolved oxygen in water from different sampling points.

The figure shows the range of DO value of Varsity Lake during the sampling time being (5.26 - 8.07 mg/l), with an average of (6.901 mg/l). The highest value (8.07 mg/l) was recorded on July, while the lowest (5.26 mg/l) value was recorded on Jan. The range of DO value of the Pantai River was (2.43 - 6.62 mg/l), with an average of (3.787 mg/l). The highest value (6.62 mg/l) was recorded on Nov, while the lowest value (2.43 mg/l) was recorded on Aug**.** Meanwhile, the range of DO values of the Anak Air Batu River was (2.02 - 6.72 mg/l), with an average of (3.717 mg/l). The highest value (6.72 mg/l) was recorded on Nov, while the lowest value (2.02 mg/l) was recorded on July.

The results showed that the DO values of the lake in this study exceeded that of the other river stations. According to Cech (2002), DO is related to temperature, salinity, atmospheric pressure, and oxygen demand from aquatic plants and animals. The threshold of DO for the main Malaysian rivers, based on DOE (1994), are within 3-5 mg/l. The DO level in water decreases as the concentration of oxygen demanding organic matter and anaerobic bacteria increases in the water (Wandan and Zabik, 1996*).* Detailed lower estimations of DO in summer months is due to the higher rate of disintegration of organic matter, while constrained stream of water in the low oxygen holding environment is due to the high temperature. As per NWQS, it was found that the level of DO at most of the testing stations were class III (Michaud, 1991).

Chemical Oxygen Demand (COD). COD is useful as an indicator of organic pollution in the water. The range of COD value of the Varsity Lake during the sampling months was (10 - 54 mg/l), with an average of (27.92 mg/l). The highest value (54 mg/l) was recorded on Feb 2017, while the lowest value (10 mg/l) was recorded on July 2016. The range of COD value of the Pantai River was (2.7 - 25.5 mg/l), with an average of (17.43 mg/l). The highest value (25.5 mg/l) was recorded on Aug, Sep, and Oct 2017, while the lowest value (2.7 mg/l) was recorded on July

2016. The range of COD value of the Anak Air Batu River was (4.5 - 65 mg/l), with an average of 24.29 mg/l. The highest value (65 mg/l) was recorded on Oct 2017, while the lowest value (4.5 mg/l) was recorded on Abril, as per figure 3.

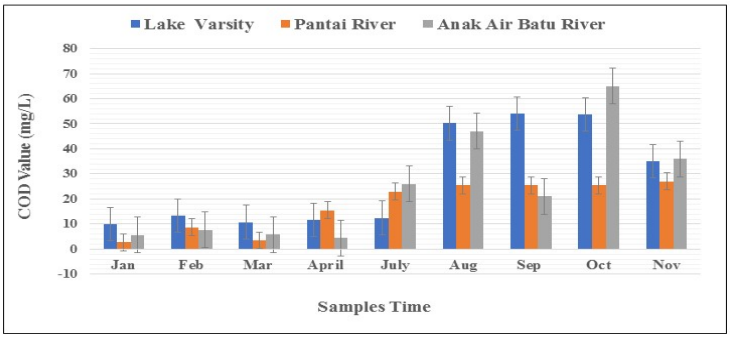

Figure 3
The amount of Chemical Oxygen Demand in water from different sampling points.
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In this study, the value of COD in most sampling stations was slightly higher, especially at R4 on Oct sampling. Increase in the level of COD in the waters are attributed to the increase in organic matter and inorganic chemicals (Shuhaimi et al.,2007), runoff from restaurant food wastes, and wastewater from the surrounding areas. Based on NWQS, the level of COD measured at all of the stations in the lake was classified as classes II and III, which is similar to the ones reported by the river stations. The COD values in Varsity Lake are slightly lower compared to the COD values at Lake Engineering in University Kebangsaan Malaysia, which was (51.09 - 64.37) mg/L (Gasim et al., 2008).

Biochemical Oxygen Demand (BOD$_5$). The amount of BOD depends on the type and amount of the prevalent organic chemicals, temperature, pH, the presence of nutrients, and trace elements necessary for growth. It is an empirical test to measure the amount of oxygen used by the microorganisms in aerobic oxidation, or breakdown of organic matter in the lake; the higher BOD, the more prevalent are organic matters in the water. Based on NWQS, the BOD value of the all stations was classified to be within classes II and III as per figure 4.

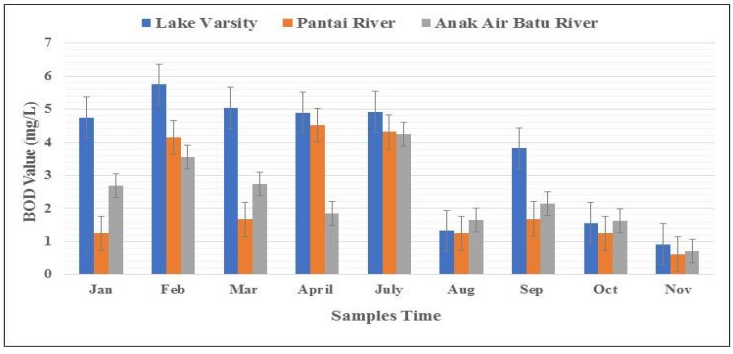

Figure 4
The amount of Biochemical Oxygen Demand in water from different sampling points
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The range of BOD_5 value of the Varsity Lake during the sampling time was (0.92 to 5.75mg/l), with an average of (3.66mg/l). The highest value (5.75mg/l) was recorded on Feb, while the lowest value (0.92 mg/l) was recorded on Nov 2017. The range of BOD_5 values of the Pantai River was (0.62 - 4.52 mg/l), with an average of (2.301mg/l). The highest value (4.52mg/l) was recorded on Abril, while the lowest value (0.62 mg/l) was recorded on April 2017. The range of BOD_5 value of the Anak Air Batu River was (0.72 - 4.24 mg/l), with an average of (2.357mg/l). The highest value (4.24 mg/l) was recorded on July, while the lowest (0.72 mg/l) was recorded on April 2017.

Suspended Solids (SS). The range of SS value of the Varsity Lake during the sampling time was (12 to 33 mg/l), with an average of (23.30 mg/l). The highest value (33 mg/l) was recorded on Aug 2017, while the lowest (12 mg/l) was recorded on August 2016. However, range of SS value of the Pantai River was (7.5 - 32 mg/l), with an average of (13.66mg/l). The highest value (32 mg/l) was recorded on Sep 2017, while the lowest value (7.5 mg/l) was recorded on Sep. The range of SS value of the Anak Air Batu River was (4.5 - 38 mg/l), with an average of (15.244 mg/l). The highest value (38 mg/l) was recorded on Sep 2017, while the lowest (4.5 mg/l) was recorded on July 2016, as per figure 5.

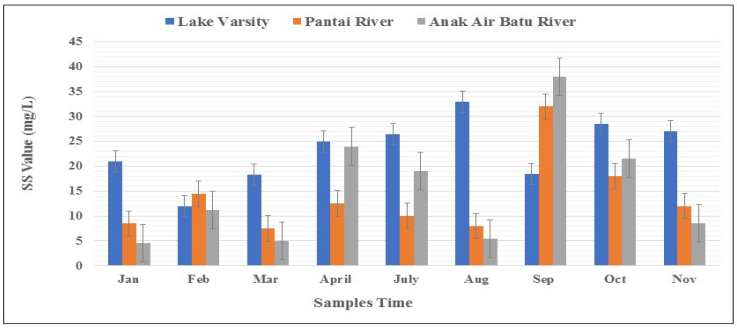

Figure 5
The value of suspended solids in water from different sampling points.
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The result of the SS value is high at September sampling, due to the rain during night time, which resulted in soil erosion that contributed more suspended solids in the area. Based on NWQS, the level of SS in the study area is classified as classes I and II. The results were slightly equal to the SS values reported for Tasik Chini, Pahang, which was (1.2 to 34.0 mg/l) (ASM, 2010).

Ammoniacal Nitrogen (NH_3-N). The range of NH_3-N value of the Varsity Lake during the sampling time was (0.06 - 0.57 mg/l), with an average of 0.297 mg/l. The highest value (0.57 mg/l) was recorded on Jan, while the lowest value (0.06 mg/l) was recorded on Feb and Oct 2017. The range of NH_3-N values of the Pantai River was (1.38 to 3.55 mg/l), with an average of (2.766 mg/l). The highest value (3.55 mg/l) was recorded on July, while the lowest value (1.38 mg/l) was recorded on Feb. The range of NH_3-N values of the Anak Air Batu River was (0.84 - 4.74 mg/l), with an average of (2.71mg/l). The highest value (4.74mg/l) was recorded on July, while the lowest value (0.84 mg/l) was recorded on Jan, as per figure 6.

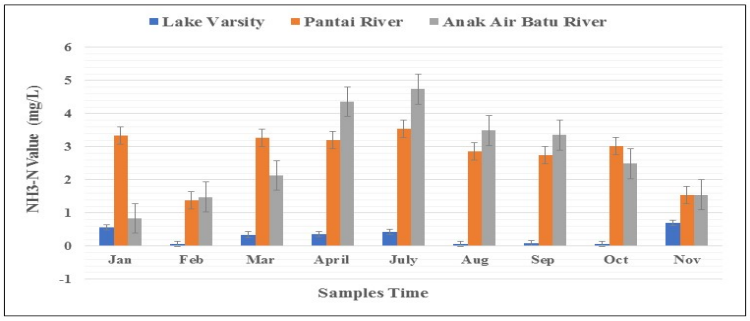

Figure 6
The amount of ammoniacal-nitrogen in water from different sampling points.
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NWQS recommended a threshold level of NH_3-N for Malaysian surface water of 0.90 mg/L for it to support aquatic life and supply water for consumption, industrial, and agriculture uses. Based on NWQS, the NH_3-N in lake sampling is classified as class II, while NH_3-N in the river sampling is classified as classes IV and V. However, NH_3-N values in this study are high compared to the NH_3-N value of 9 sampling stations in Chini Lake, where it was (0.003 - 0.57 mg/l), at an average of 0.17 mg /l (ASM, 2010).

Physical-chemical parameters includes turbidity, nutrient, nitrate, ammonia and phosphate

Turbidity. The turbidity range set by WHO is 5 NTU (WHO, 2014). The maximum range of turbidity values of the Varsity Lake is 45.5 NTU on Aug 2017, while its average value is 33.30 NTU. According to the bar graph, the turbidity at every sampling point met the limitations for INWQS at 50 NTU, except for the highest turbidity value recorded on Feb 2017 at (102 NTU) at Pantai River, and the lowest value recorded on Mar 2017 (5 NTU) at Anak Air Batu River. Figure 7 shows the turbidity of water in the study area.

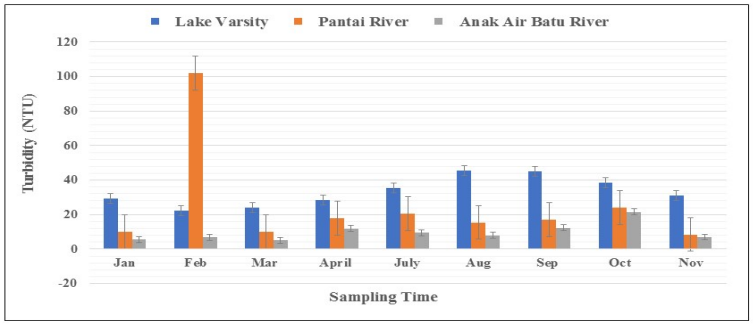

Figure 7
The turbidity values of water from different sampling points.
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Phosphate (PO_4). The minimum amount of phosphate found in study area water samples were (0.0 mg/l) on Abril and Aug 2017, while the maximum amount of phosphate was found in Anak Air Batu River, at 1.2 mg/l on July. The average value reported by the lake stations was (0.522 mg/l), while the value reported by

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the Pantai River stations was (0.433 mg/l). The concentration of PO_4 was low during lake sampling. Based on NWQS, the level of phosphate measured in the study area is classified as class I. The amount of phosphate in water from different sampling points is shown in table 3.

Phosphorus (P_2O_5). The minimum amount of phosphorus found in the study area water samples was (0.0 mg/L) at most of the lake sampling, while the maximum amount of phosphorus, at 0.9, was found in Anak Air Batu River on July and Nov 2017 samplings. The higher than average lake stations reported a concentration of phosphorus of (0.27 mg/L). Contrarily, the Pantai River stations reported a concentration of (0.2 mg/l), while the Anak Air Batu River reported a concentration of 0.438 mg/l. The amount of phosphorus in the water from different sampling points are shown in table 4. Higher P_2O_5 concentration identified at river samplings is presumably due to human activities, such as discharging of wastes from restaurants, clinics, and settlements. The level of P_2O_5 concentration was low during lake sampling. Based on NWQS, the level of phosphorus measured in the study area is classified as class I. The P_2O_5 values in this study did not converge to the value obtained by (Asharef et al., 2010), in his study of Varsity Lake, University of Malaya, which ranged from (0.2 to 33 mg/l).

Nitrite (NO_2) and Nitrate (NO_3). The range of nitrite concentration for lake sampling was (0.17 - 0.97 mg/l). The highest concentration (0.97 mg/l) was detected on July, while the lowest concentration (0.17 mg/l) was detected on Aug 2017. The average of Lake NO_2 volume was (0.549 mg/l). On the other hand, the range of nitrite concentration in the Pantai River sampling was (0.0 - 2.0 mg/l). The highest concentration (2.0 mg/l) was detected on August 2016, while the lowest concentration (0.0 mg/l) was recorded Sep 2016. The range of Nitrite concentration for Anak Air Batu River sampling was (0.0 - 1.85 mg/l). The highest concentration (1.85 mg/l) was recorded on Aug 2017, while the lowest concentration (0.0 mg/l) was recorded at most lake samplings. The NO_2 values of water from different sampling points are shown in table 3.

The main source of NO_2 was due to the runoff from the restaurant food wastes and wastewater from areas around the lake and the river. Based on NWQS, the NO_2 of the study area is classified as class I. Contrarily, the range of nitrate (NO_3) concentration for lake sampling was (0.6 - 0.97 mg/l). The highest concentration (0.97 mg/l) was recorded on July, while the lowest concentration (0.6 mg/L) was recorded on Sep 2017. The average concentration of NO_3 was (1.50 mg/l). Contrarily, the range of NO_3 concentration for Pantai River sampling was (0.0 - 4.65 mg/l). The highest (4.65 mg/l) was recorded on July, while the lowest concentration (0.0 mg/l) was recorded on Mar. The average NO_3 volume was (2.027 mg/l). The range of nitrite concentration in Anak Air Batu River sampling was (0.0 - 1.77 mg/l). The highest concentration (1.77 mg/l) was recorded on Aug 2017, while the lowest concentration (0.0 mg/l) was recorded at most of the lake samplings. The average NO_3 volume was (2.027 mg/l). The NO_3 values of water from different sampling points are shown in table 4. Based on NWQS, the NO_3 was

within the normal range, and classified as class I. When comparing it with the data from (Al-Badaii et al., 2013) on Chini Lake, it is on par, if not a little lower.

Table 3. *The Average values of four parameters of Water Quality in all stations from Jan 25th to Nov 25th 2017.*

Samples Time	Parameters											
	P_2O_5 (mg/L)			NO_3^- N (mg/L)			NO_3^- (mg/L)			PO_4		
	Varsity Lake	Pantai River	Anak Air Batu River	Varsity Lake	Pantai River	Anak Air Batu River	Varsity Lake	Pantai River	Anak Air Batu River	Varsity Lake	Pantai River	Anak Air Batu River
Jan	0.30	0.10	0.15	0.50	0.55	1.00	1.75	1.00	1.55	0.77	0.55	0.15
Feb	0.05	0.05	0.15	0.50	2,00	1.00	1.50	0.50	1.55	0.07	0.05	0
Mar	0.07	0.15	0.15	0.50	0	0.50	2.00	0	1.55	1.05	0.55	0.10
April	0	0.15	0.70	0.27	0.60	0	1.25	2.70	0	0	0.15	0.90
July	0.52	0.20	0.90	0.97	1.05	0	4.27	4.65	0	0.47	0.30	1.20
Aug	0	0.55	0.55	0.17	0.60	1.85	0.75	2.75	8.2	0	0.75	0.70
Sep	0.67	0.20	0.20	0.6	1.65	0	0.60	3.70	0	0.92	0.30	0.20
Oct	0.52	0.20	0.90	0.8	1.10	0	0.80	165	0	0.65	0.20	0.70
Nov	0.32	0.20	0.25	0.62	1.43	1,00	0.62	1.30	1.11	0.77	1.05	0.15

Section 3: biological parameters include *E. coli* and Total *Coliform.*

An external biological parameter, *Escherichia Coli (E-coli)* has been tested to investigate the current concentration of bacteria. Biological parameters *E.coli* and Total *Coliform* the best biological drinking water indicator for public health protection used to detect and estimate the level of faecal contamination of water.

Total coliform count. Total Coliforms (TC) are normally used as indicators of pathogens related to the faecal contamination of water by a major bacterial strain, such as *E.coli*. The total coliform count range set by WHO is 0-100 ml^{-1} (WHO, 2004). The range of *E.coli* number from the Varsity Lake during sampling was (0.25 - 51.5 CFU/1ml), with an average of (23.261 CFU/1ml). The highest number (51.5 CFU/1ml) was recorded on July, while the lowest number (0.25 CFU/1ml) was recorded on Jan. The range of *E.coli* number of Pantai River was (5 - 102 CFU/1mL), with an average of (51.166 CFU/1ml). The highest number (102 CFU/1ml) was recorded on July and Mar, while the lowest number (5 CFU/1ml) was recorded on Sep and Oct 2017. The range of *E.coli* number of Anak Air Batu River was (26.5 to 106 CFU/1ml), with an average of (61.87 CFU/1ml). The highest number (106 CFU/1ml) was recorded on Mar 2017, while the lowest (26.5 CFU/1ml) was recorded on Feb 2017, as per figure 8.

The major sources of *E.coli* bacteria in the rivers are from a sewage treatment plant. High concentrations of oil and grease particles decrease the concentration of oxygen due to the increase of bacterial growth in the water.

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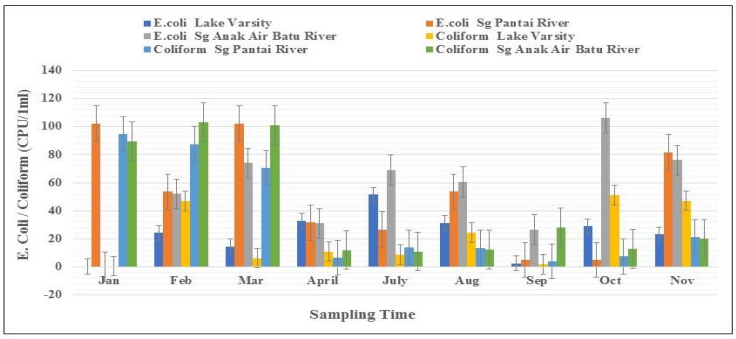

Figure 8
The value of suspended solids in water from different sampling points.
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Based on NWQS, the *E .coli* content of the study area falls within the normal range, and is classified as Class III. The coliform range of the Varsity Lake during the sampling time was (0.5 - 47.1 CFU/1ml), while the coliform range of Pantai River was (4 - 94 CFU/1ml). the *coliform* range of the Anak Air Batu River was (11 - 103 CFU/1ml). The minimum coliform count found in the study area was (0.5 CFU/1ml) on Jan 2017 at the Varsity Lake, while the maximum range of the coliform count was 103 CFU/1ml on Feb at Anak Air Batu River, as per figure 7.

Comparison of various parameters between present study and previous studies have been done in Malaysia.

The various parameters were compared between this study and those reported in past studies involving other lakes and rivers in Malaysia. The results of these comparisons are tabulated in tables 4 and 5.

Parameters	Unit	Varsity Lake, University of Malaya, Kuala Lumpur *(Present Study)*	Varsity Lake, University of Malaya, Kuala Lumpur *(Ashraf et al., 2010)*	Cempaka Lake, Bangi, Selangor, Malaysia *(Gasim et al., 2015)*
Temperature	^{0}C	27.6 to 31.2	22.18 to 23.18	26.02 to 28.37
DO	mg/l	5.26 to 8.07	6.2 to 6.88	1.63 to 4.94
BOD	mg/l	0.92 to 5.75	-	0.38 to 2.4
COD	mg/l	10 to 54	-	9.3 to 69
NH_3-N	mg/l	0.06 to 0.57	-	2.0 to 2.84
SS	mg/l	12 to 33	-	1.8 to 33.3
Turbidity	NTU	22.25 to 45,5	12.14 to 16.4	-
NO_2	mg/l	0.17 to 0.97	-	0.06 to 0.99
NO_3^-	mg/l	0.6 to 0.97	2.91 to 98.4	1.0 to 1.8
P_2O_5	mg/l	0.0 to 0.67	0.2 to 33	-
PO_4	mg/l	0.0 to 1.05	0.2 to 33	0.12 to 0.56

Table 4
The range comparison of various parameters between present and previous studies have been done on lakes in Malaysia.

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Table 6. *The range comparison of various parameters between present and previous studies have been done on rivers in Malaysia.*

Parameters	Unit	Pantai Rivers *(Present Study)*	Anak Air Batu River *(Present Study)*	Batu Ferringhi River *(Nithyanandam et al.,2015)*	Semenyih River, Selangor, Malaysia *(Al-Badaii et al., 2013)*
Temperature	°C	26.6 to 30.6	26.6 to 30.05	-	24.71 to 27.55
DO	mg/l	2.43 to 6.62	2.02 to 6.72	8.01 to 8.97	5.58 to 7.07
BOD	mg/l	0.62 to 4.52	0.72 to 4.24	5 to 10	0.63 to 4.56
COD	mg/l	2.7 to 25.5	4.5 to 65	30 to 64	8.6 to 63
NH_3-N	mg/l	1.38 to 3.55	0.84 to 4.74	0.1 to 0.3	0.02 to 0.89
SS	mg/l	7.5 to 32	4.5 to 38	-	11.7 to 58.1
Turbidity	NTU	3.5 to 102	5 to 21.5	-	4 to 206.7
NO_2	mg/l	0.0 to 2.0	0.0 to 4.65	-	-
NO_3^-	mg/l	0.0 to 1.85	0.0 to 1.77	-	4.23 to 8.33
PO_4	mg/l	0.05 to 1.05	0.0 to 1.2	-	0.08 to 0.95

It can be seen that there are no clear differences in the reported values between this study and previous studies, with the exception of certain specific parameters.

Conclusions

River pollution is currently increasing due to the huge quantities of liquid, rubbish, and solid wastes being dumped into the rivers, which severely degrade its quality. Wastes originating from multiple sources between point and non-point sources along the lake and river flow are due to human activities. The surrounding activities generated the wastes being discharged into the rivers and streams, coming from residential areas, waste discharge, and domestic sewage, restaurants (both organic and inorganic wastes). The results indicated the mean concentrations of certain parameters, such as the pH, SS, BOD, and phosphate for all samplings were within the normal range, and classified under classes I, II, and III. The mean temperature was classified as class I, but DO is classified as class III. The water temperature was (27.6 to 31.2^{0}C), which is suitable for bacterial growth. COD was classified as class II at lake stations, and classes II and III at river stations. Ammonial nitrogen was classified as Classes I, II, and III for lake sampling, and IV, V for river sampling. The calculated WQI values confirmed that the study area can be classified under classes II and III for all of the sampling stations. The water quality of Pantai River and Anak Air Batu River and Varsity Lake, University of Malaya falls into class III when compared to the National Water Quality Standards for Malaysia. The stations are considered to be polluted based on the Water Quality Index (WQI) due to an increase of wastes being discharged into the lakes and rivers.

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The main recommendations being made in this study to solve the problems of water crises are coming up with an efficient system for rubbish accumulation and transferring it outside the cities, sewage waste treatment, recycling wastes into useful products, such as fertilizers and educating the people via the media about protecting the environment.

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