WATER QUALITY MONITORING AT LATA JANGGUT, LATA KEDING & LATA TURBO

By

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DECLARATION

I declare that this thesis entitled "Water Quality Monitoring at Lata Janggut, Lata Keding & Lata Turbo" is the result of my own research except as cited in the references. The thesis has not been accepted for my degree and is not currently submitted in candidature of other degree.

Signature: ________________________

Name: HANIS SHAHIRA AMANI BINTI AHMAD AZMAN

Date: 01/01/2020

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Water Quality Monitoring at Lata Janggut, Lata Keding and Lata Turbo.

ABSTRACT

This study aims to identify the water quality of Lata Janggut, Lata Keding and Lata Turbo which this area are used for recreational purposes in creating a healthy recreational water area. The significance of this study is to ensure the water body of Lata Janggut, Lata Turbo and Lata Keding is able to support recreational activity. Water qualities in this 3 study area were determined by using the guideline and parameters provided by the Department of Environment. Water monitoring of the three study area are conducted on July, August, September and November with a total of 3 point selected at random in each study area. The parameters assessed are divided into two which is in-situ parameters and ex-situ parameters. The in-situ parameters analysed in this study is the water pH, temperature, dissolved oxygen, total suspended solid and turbidity while the ex-situ parameters analysed are biological oxygen demand (BOD), chemical oxygen demand (COD) and ammoniacal nitrogen (AN). The in-situ and ex-situ parameters analysed are physical parameters and chemical parameters of water. On the final month of water monitoring, it was found that water quality of Lata Turbo was 81.04 (class 2), Lata Keding was 73.58 (class 3) and Lata Janggut was 76.75 (class 2). Overall, the water quality in all three study areas can be classified as class II that the can be used for recreational activity and are safe to be used for recreational and other purposes with conventional treatment.

Pemantauan Kualiti Air di Lata Janggut, Lata Keding dan Lata Turbo

ABSTRAK

Kajian ini dijalankan dengan tujuan untuk mengenal pasti kualiti air di Lata Janggut, Lata Keding dan Lata Turbo yang digunakan untuk tujuan rekreasi dalam mewujudkan kawasan air rekreasi yang sihat. Kepentingan kajian ini adalah untuk memastikan keadaan air di Lata Janggut, Lata Turbo dan Lata Keding boleh digunakan untuk aktiviti riadah. Kualiti air di ketiga-tiga kawasan kajian ini ditentukan dengan menggunakan garis panduan dan parameter yang disediakan oleh Jabatan Alam Sekitar. Pemantauan air di tiga kawasan kajian dilakukan pada bulan Julai, Ogos, September dan November dengan jumlah 3 titik kawasan kajian telah dipilih secara rawak. Parameter yang dinilai dibahagikan kepada dua iaitu parameter in-situ dan parameter ex-situ. Parameter in-situ yang dianalisa dalam kajian ini adalah pH, suhu, oksigen terlarut, jumlah pepejal dan kekeruhan air manakala parameter ex-situ yang dianalisa adalah *biological oxygen demand* (BOD), *chemical oxygen demand* (COD) dan *ammonical nitrogen* (AN). Parameter in-situ dan ex-situ yang dianalisa adalah parameter fizikal dan parameter kimia air. Pada bulan akhir pemantauan air, didapati bahawa kualiti air di Lata Turbo adalah 81.04 (kelas 2), Lata Keding adalah 73.58 (kelas 3) dan Lata Janggut adalah 76.75 (kelas 2). Secara keseluruhannya, kualiti air di ketiga-tiga kawasan pengajian dapat diklasifikasikan sebagai kelas II yang boleh digunakan untuk aktiviti riadah dan selamat untuk digunakan bagi tujuan rekreasi dan boleh digunakan untuk tujuan lain tetapi perlu melalui rawatan air secara konvensional.

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LIST OF ABBREVIATIONS

AN	Ammoniacal Nitrogen
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
HCl	Hydrochloric Acid
MDJ	Jeli District Council
NaOH	Sodium Hydroxide
NWQS	National Water Quality Standard
PTFE	Polytetrafluoroethylene
TSS	Total Suspended Solid
WQI	Water Quality Index
YSI	Yellow Spring Instrument

LIST OF SYMBOLS

°C	Degree Celsius
ml	Millilitre
km	Kilometre
%	Percentage
mg/L	Milligram per litre

CHAPTER 1

INTRODUCTION

1.1. Background Study

River is one of the major sources of fresh water supplies to the human society. River is important to the environment as they carry a large quantity of water from in land to the sea. Formation of river begins when the collection of rainwater from reservoirs on the top of the mountain or also can be called as the headwater. When this headwater flows down the mountain, it flows as a small stream and then these small streams will join with other streams and form a river. The river will carry and channel the rainwater and ground water to the ocean (Pillai, 2018). As river flows, they carry water and nourish the entire ecosystem for living things to survive. Rivers flows and carries water to villages, farms, agriculture, housing area and many more. A healthy river can provide clean water for human needs. Humans use water for recreational activity, tourisms, agricultural and for daily activity (NSW, 2018).

As the global population keep on increasing rapidly, water pollution is one of the global concerns as water is the necessity of life. When the quality of river system decreases, it shows the declination of the ecosystem health. Human population and the natural ecosystem will be affected badly. Human will have difficulty to have access to clean water supply and food source that come from the underwater will also depleted.

In order to avoid water pollution and maintaining the water quality, legal approaches were taken to identify and classify the river water quality in Malaysia. Rivers in Malaysia were evaluated by using the national water quality standard and evaluated based on the nineteen parameters. The National Water Quality Standard (NWQS) is the standard there are applied to surface water parameters that were used to identify the 6 classes of water use.

1.2. Problem Statement

Recreational water activities give benefits to human wellbeing and health. However, a water based recreational area can increase the risk of people to be exposed to the physical, chemicals and biological hazard. The chemicals hazards are contamination of chemicals such as heavy metals, chemical spills or improper waste discharge to the recreational area. The biological hazard usually hazard that increase the risk of exposure to health issues that are affected by microbial contamination in the recreational water. The exposure of chemical and biological hazard of recreational area to the public increase especially during weekends and holidays when there is high amount of visit to the recreational area. The outbreaks of health issues are mostly caused by chemical and microorganism contaminations in the water (WHO, 2003).

1.3. Objective

a) Determination of National Water Quality Standard (NWQS) for Lata Janggut, Lata Keding and Lata Turbo.

1.4. Significant of Study

The significance of this study is to identify the water quality of Lata Janggut, Lata Keding and Lata Turbo recreational purposes in creating a healthy recreational water area. Determination of water quality in this 3 study area is important to make sure they are safe to be used as a recreational area. Healthy recreational water is important as the recreational areas are visited by a lot of people for recreational activity. If the water quality of the three study area were found to be lower that the safety standard, it can create many health risk such as injuries, infection, exposure to chemicals and death. Depletion in water quality also can indicate the decreasing in the health of an ecosystem. Determination of water quality is important because from the results and parameters, the source of river pollution can be identified and method to prevent and solve the problem can be planned properly.

CHAPTER 2

LITERATURE REVIEW

2.1. River Water

Water is essential for human. Human body consist of approximately 60% of water which were used by the organs, cells and tissue in maintaining and regulating the body functions and temperature. Human loses water through respiration, breathing and also through sweating. Due to the loss of water from daily activity, it is important for human need to keep their body hydrated every single day (Laskey, 2015). In the sustainable development goals, the sixth goal of sustainable development goal is to ensure access to water and sanitation for everyone. Water shortage affects human life all around the world. Even though, there are approximately 2.1billion people had already gained access to clean water, the clean water resource and supply were gradually decreasing due to increasing water pollution. Water pollution had currently become a global concern (Nation, 2018).

Since water is an essential to life, a legal guideline for national water quality standard is important to protect and control water from pollution. Every river in each country around the world should meet this water quality standard as this NWQS show that the surface water is safe to be used for multiple purposes and it would not harm human and nature. One of the concerns in water quality is regarding the safe and clean drinking water. Safe drinking water is one of the most basic human rights, and it is one of the goals of designing the water quality standards. It is important to have this national water quality standard so that every human population can have a clean water supply. Other than that, water quality standards aim to protect the aquatic life and wildlife, be able to provide safe water source that can be used and contact with human body.

2.2. Surface Water

Surface water is the water body that were found on the surface of the earth. Surface water includes the rivers, lakes, waterfalls, streams and the sea. Solid forms of water are also included in the types of surface water. Surface water is the water that were collected on the surface from the hydrological cycles (Society, 2019). Hydrological cycles or known as water cycles is the circulating movement of water from the earth surface and the atmosphere. Process that takes place in this water cycles are evaporation, precipitation and runoff. Evaporation of water body on earth occur with the help of sunlight which elevate the water vapour to the atmosphere. This water vapor will then accumulate in the earth's atmosphere and form clouds. Clouds then will continue collecting water vapours from earth's surface and slowly become concentrated. When the clouds in the atmosphere are concentrated with water vapours, the water vapours will falls back to earth through the process called as precipitation. As for the melted snows that reach the earth surfaces are through the runoff process. Water from precipitation and runoff process then collected in the earth water bodies as surface water like rivers, ocean and lakes while and some of the water penetrate the earth surface and become groundwater (USGS, 2019).

2.3. Water Quality Standard

Water quality standards are authorized guidelines that were approved by the Environmental Protection Agency from all over the world. National water standards indicate the condition of surface water that is safe and can be used for drinking, recreational and safe to be use in our daily basis. This water standard protects the human and environment health by making sure the water quality in every area meet the requirement of national standard of water quality. Moreover, national water quality standard also a legal approach in controlling the amount of water pollution around the world. Water quality standard are designed in order to protect the aquatic life, for recreational, as a public drinking water supply and to be used in agricultural, industrial and other purposes. (Agency, 2017)

Fawaz Al-Badaii et al (2013) stated that in a water quality research with the title of Water Quality Assessment of Semenyih River, Selangor the water quality of this river were determined by measuring physical, chemical and biological parameters that are required to classify class of water based on National Water Quality Standard. The parameters checked for the river are temperature, pH, dissolve oxygen, total dissolve solid, turbidity, nitrate, ammonia nitrogen, phosphate, sulphate, total suspended solid, biochemical oxygen demand, chemical oxygen demand, oil and grease, and the last parameter are fecal coliform. According to the parameters and water quality research done in the year of 2013, Semenyih river water quality are in the normal range but varies based on the season and location of sampling. Therefore, Semenyih river water can be used for domestic purpose after undergo an extensive water treatment.

Furthermore, the other water quality monitoring that had already done is the analysis of water quality in Sungai Batu Ferringhi. This is a case study after a patch of black water has been spotted at Ferringhi beach. The black water is believed to be a source of pollution. Nithyanandam et al. (2015) proposed that to investigate the water quality index of Sungai Batu Ferringhi. Water Quality Index (WQI) is assessed based on the chemical, biological and physical parameters.

The chemical parameters are chemical oxygen demand, biological oxygen demand, dissolved oxygen and ammoniacal nitrogen. The biological parameters measured are the fecal coliform while the physical parameters are pH, temperature and total suspended solid. From the case study, water quality of Sungai Batu Ferringhi is classified as class II and E-coli bacteria were identified as one of the pollution. Thus, Sungai Batu Ferringhi requires a conventional water treatment for recreational use before it came in contact with human body (Rajesh Nithyanandam, 2015).

Malaysia Department of Environment (DOE) had come out with the classification of surface water based on 72 parameters as a guideline in identifying the water class. Basically, all the parameters measured by using the WQI or NWQS are to identify the class and improve the quality of surface water source. Determination of water quality are done to assess and finding the source of pollution which pollutes the water source in Malaysia. Water Quality Index and National Water Quality Standard are important in preserving and maintaining the quality of water source so that water source is safe to be used for multiple purposes.

Table 2.1, shows the water classification and its suitable usage based on water quality while Table 2.2 shows the list of parameters for water classification.

Table 2.1: Classes of water (Source: EQR2006)

CLASS	USES
Class I	Conservation of natural environment.
	Water Supply I - Practically no treatment necessary.
	Fishery I - Very sensitive aquatic species.
Class IIA	Water Supply II - Conventional treatment.
	Fishery II - Sensitive aquatic species.
Class IIB	Recreational use body contact.
Class III	Water Supply III - Extensive treatment required.
	Fishery III - Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

Table 2.2: Parameters for Water Classification by DOE (Source: EQR2006)

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 - 0.3	0.3 - 0.9	0.9 - 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 - 3	3 - 6	6 - 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 - 25	25 - 50	50 - 100	> 100
Dissolved Oxygen	mg/l	> 7	5 - 7	3 - 5	1 - 3	< 1
pH	-	> 7	6 - 7	5 - 6	< 5	> 5
Total Suspended Solid	mg/l	< 25	25 - 50	50 - 150	150 - 300	> 300
Water Quality Index (WQI)	-	< 92.7	76.5 - 92.7	51.9 - 76.5	31.0 - 51.9	> 31.0

2.4. Recreational Water

Recreational water refers to the lakes, river, waterfalls and coastal waters that were used by the public for recreational activities such as swimming, hiking, water activity and other outdoor activities that include the use of water (Collins, 2019). Recreational water is frequently to came in contact with human body, thus it is important to ensure the water quality of recreational water are safe and meet the water quality standard requirement. Based on the EPA report of recreational water, in order to determine whether a water body are able to support recreational activity, the attributes of water body focussed are the physical, chemical and biological characteristics. It is also depending on the risk that may impact human health and the ecosystem. Human health risk of recreational water are caused by the chemicals and pathogens contamination in the water body. People are exposed to the risk through skin contact, consuming marine life of the polluted area and by swallowing water.

CHAPTER 3

METHODOLOGY

3.1. Study Area

Study area of this research situated at Lata Janggut, Lata Keding and Lata Turbo. These entire three rivers are located in Jeli, Kelantan. This three study area was chosen for the classification of water classes based on the NWQS and for the comparison of water quality of recreational area.

Lata Janggut are located around 13km away from Jeli main city. It is a river based recreational area that were open to public long time ago. Lata janggut in the 1960s were known by the villagers as a fishing spot. It was well known among the villagers because of the variety type of fish species can be found in this river. This river situated remotely far from the main road. It can be easily accessed as the place had been already commercialised by the Jeli District Council (MDJ). The local authority also had built several facilities to ensure comfort for the visitors of Lata Janggut. Nowadays, Lata Janggut is one of the most visited river based recreational area by tourist in and out of Kelantan. It was often visited by tourist especially during school holidays.

Lata Keding, Bukit Kudung were situated in the Jeli district of Kelantan. This Lata Keding was commercialised and open for public estimated around in the early of 2019. Since Lata Keding is situated nearby to University Malaysia Kelantan, Jeli Campus, this place was often visited not only by tourist but also by the UMK students during weekends and holidays. In Lata Keding, there are resort build named as Resort Lata Keding and Lata Keding were also a recreational area that were opened to the public for family and recreational activity.

Lata Turbo situated in Kampung Lawar, Jeli is the third study area chosen for the comparison of NWQS for recreational area as it receives lesser number of visit compared to the other two study area. Lata Turbo are also a recreational area but mostly known among the local, thus it was usually visited by the local communities around Jeli. The water quality for this area was supposed to be cleaner compared to the other two recreational areas which receive higher number of visitors per month.

3.2. Sampling and Preservation of Water Samples

Sampling and data collection was taken at Lata Janggut, Lata Keding and Lata Turbo on the third week every month of July, August, September and November. Three point for water collection was selected at random for each study area and marked for future sampling procedure. A total of 9 water samples from 3 sampling area was collected using polytetrafluoroethylene (PTFE) bottle.

The collected water samples then preserved by using concentrated hydrochloric (HCl) acid, cooled in an ice box and transported to the laboratory for the ex-situ parameters analyses in the laboratory. As for the in-situ parameters, compromising the temperature, pH, and dissolved oxygen will be measured by using the Yellow Spring Instrument (YSI) Multiparameter.

3.3. Water Quality

3.3.1. In-situ Analysis

The water quality index (WQI) parameters of the three study area are analysed for the comparison of water quality of recreational area study. In-situ method comprising of temperature, pH, turbidity, and dissolve oxygen are analysed by using the YSI multiparameter.

3.3.2. Ex-situ Analysis

For the ex-situ parameters which compromise of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS) and ammoniacal nitrogen (AN) are analysed by using appropriate methods in the laboratory to obtain the results for WQI classification.

a) Biological Oxygen Demand (BOD)

BOD test are conducted by using the BOD5 method. BOD is the amount of dissolved oxygen (DO) needed by organisms to break down organic matter in water. High BOD reading indicates the high consumption of oxygen in water samples and reduce DO levels in the collected water samples.

BOD5 test are done by diluting 100ml volumes of water samples with dilution water approximately to 300ml in the BOD bottles. Initial reading of DO was taken before incubating the samples in 20°C incubator for 5 days. The bottles are wrapped with aluminium foil to prevent the samples from being exposed to sunlight which may encourage photosynthesis to occur.

After five days, the DO for each bottle are read and recorded. BOD were calculated by using the following formula:

$$BOD5 = \frac{D_1 - D_2}{P}$$

Where,

D_1 = Initial reading of DO

D_2 = DO reading after five days

P = Fraction of w/w sample to combined volume

b) Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is an analysis to quantify the amount of oxygen consumption and oxidation of organic matter in water. COD is one of the parameters which are important in determining the water quality as it can also use to measures the amount of DO in water (Menegotto, 2017). Higher COD indicates a higher amount of organic matter that can be oxidized in water samples.

COD analysis involves digestion method at high heat for two hours. 2 ml of water samples and 2 ml of deionized water for blank preparation are added to COD low range vial before heated in the reactor block for 2 hours. The reading of COD then was taken by using HACH spectrophotometer.

c) Total Suspended Solid (TSS)

Total Suspended Solid (TSS) is the measurement of solid particles found in water which includes plant and animal decomposition, algae, other organic compound and also includes inorganic compound such as sand and sediments.

Analysis of TSS requires preparation of a blank sample and homogenized water samples. Water samples are homogenized by blending the samples by using blender for 2 minutes. The reading of TSS value was taken by using HACH spectrophotometer in 10ml sample cells.

d) Ammoniacal Nitrogen (AN)

Ammoniacal Nitrogen (AN) analysis is the method to measure the quantity of ammonia found in water samples. Excessive amount of ammonia found in water can cause toxicity which may kill organisms that live underwater and in its surroundings. Analysis of AN is done by preparing blank and pH neutralized water sample in 10 ml sample cell. Water samples are required to be neutralized because the samples are preserved by using acids. Ammonia Salicylate and Ammonia Cynurate are added to blank and water samples. The prepared samples for analysis are allowed to rest for 3 minutes and 15 minutes respectively. Value of AN were analysed by using 385 N, Ammonia, Salic program in HACH spectrophotometer.

3.4. Data Analysis

Result obtained from in-situ and ex-situ analyses were compared with the guidelines of NWQS provided by the DOE in order to identify the water quality and classes. The identification of water quality and classes are important to ensure water in Lata Janggut, Lata Keding and Lata Turbo are safe to be used to come in contact with human and safe to be commercialised as recreational area.

CHAPTER 4

RESULT AND DISCUSSION

4.1. Physical Parameters

4.1.1. pH

Based on the DOE water quality index classification, pH level of water more than 7 shows classification of water in class I, pH reading between 6 to 7 is in class II, pH reading between 5 to 6 is in class III and pH reading more than 5 is in class IV while reading of pH lower than 5 would be classified into class V.

From the result obtained during sampling in four months which is in July, August, September and November, pH reading in the month of July, August and September shows that water in Lata Janggut, Lata Keding and Lata Turbo is more than 7. This shows that water in the three sampling area can be classified into class I. Unfortunately, pH reading for the samples collected in November of three sampling areas reduced to pH 5. Changing in pH of a river is caused by pollution or other environmental factor. Reduction of pH level in November is might cause by rainy seasons. This due to the sampling activity which was collected on November during rainy days where water flow increases compared on normal days. Large water flows might cause wash out of minerals from river sediments into the water. The washed out minerals can alter the pH level of water as it may transform into organic acid and alkaline (Tribe, 2017).

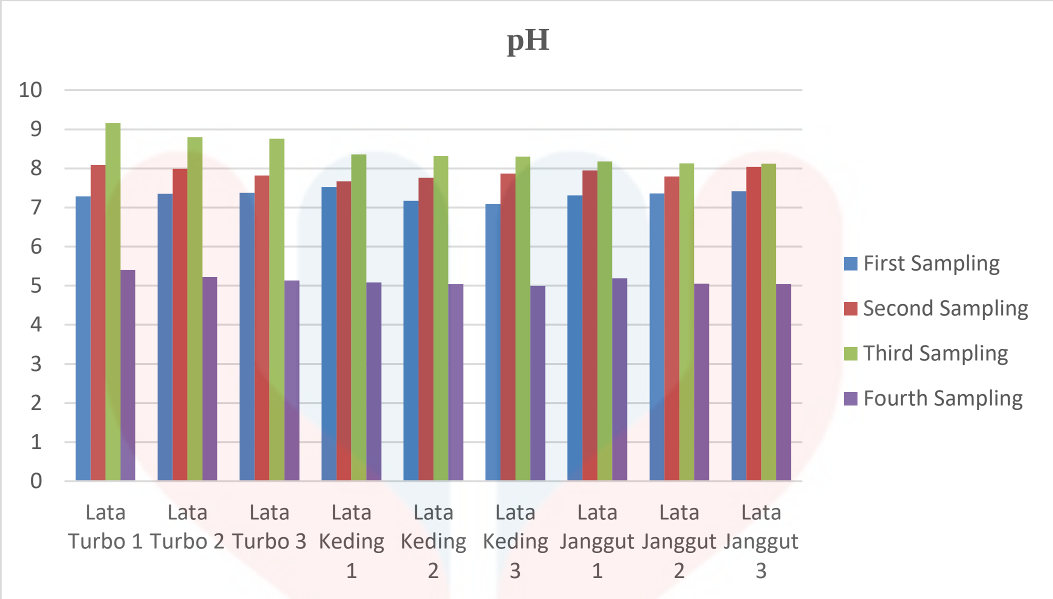

Figure 4.1: pH reading of Lata Janggut, Lata Turbo and Lata Keding for every month

4.1.2. Temperature

Temperature reading are recorded from YSI multiparameters is taken in-situ or on-site. The range of temperature of water in Lata Janggut, Lata Keding and Lata Turbo are in between 28° to 24°C. Cold water temperature is because sampling is done in morning where water temperature is still low as the water in all three study area is not heated by the sun rays. Sampling data in November shows lower temperature because of rainy day during sampling and data collection.

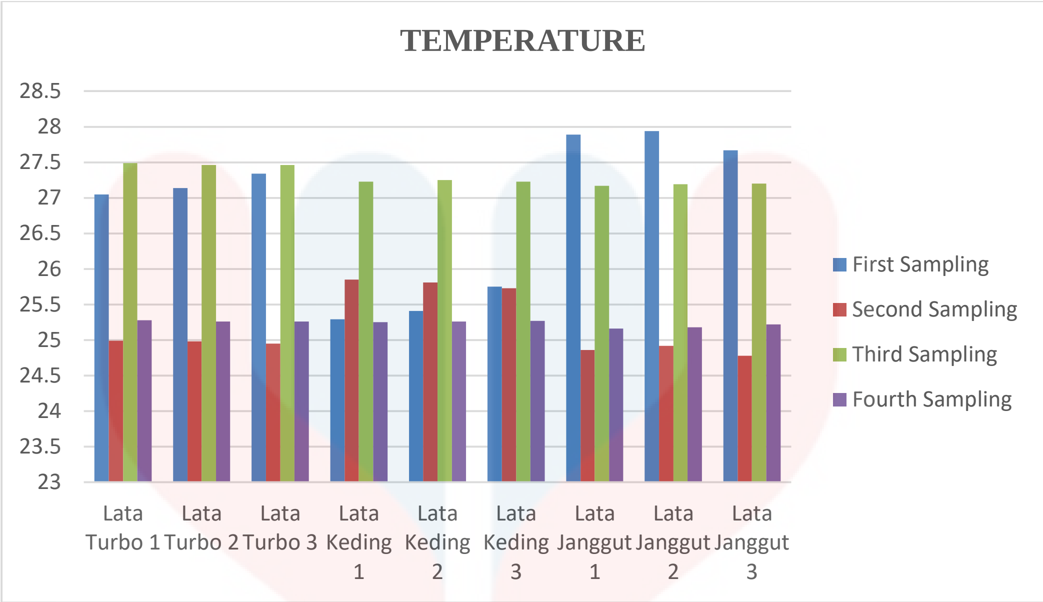

Figure 4.2: Water temperature reading of Lata Janggut, Lata Turbo and Lata Keding for every month

4.1.3. Turbidity

Turbidity is the measurement of water clarity and the measurement of the amount of scattered light passing by compounds found in water of study area. High turbidity is the result of high amount of light scattered. Usually, the particles that caused cloudy water are coloured organic compound that were dissolved in water, inorganic compound such as sediments and clay, and other (ND, 2019).

On July and August, it shows that the reading of turbidity for Lata Turbo and Lata Janggut is high. During the sampling day, it is obvious that the water in Lata Turbo and Lata Janggut are cloudy compared to the clarity of water in Lata Keding. The cloudiness of water in Lata Turbo is because of the high speed of the stream flows at sampling point which cause sediments to float in water. However, the turbidity result of Lata Janggut were influenced by small construction nearby the sampling point in July and August. Water runoff from land might transport sand and other building materials from the construction activity nearby and these materials may end up in the water thus, affecting the water clarity and increase the turbidity reading of the month. Lata Keding seems to be clearer which resulted in a lower reading or turbidity.

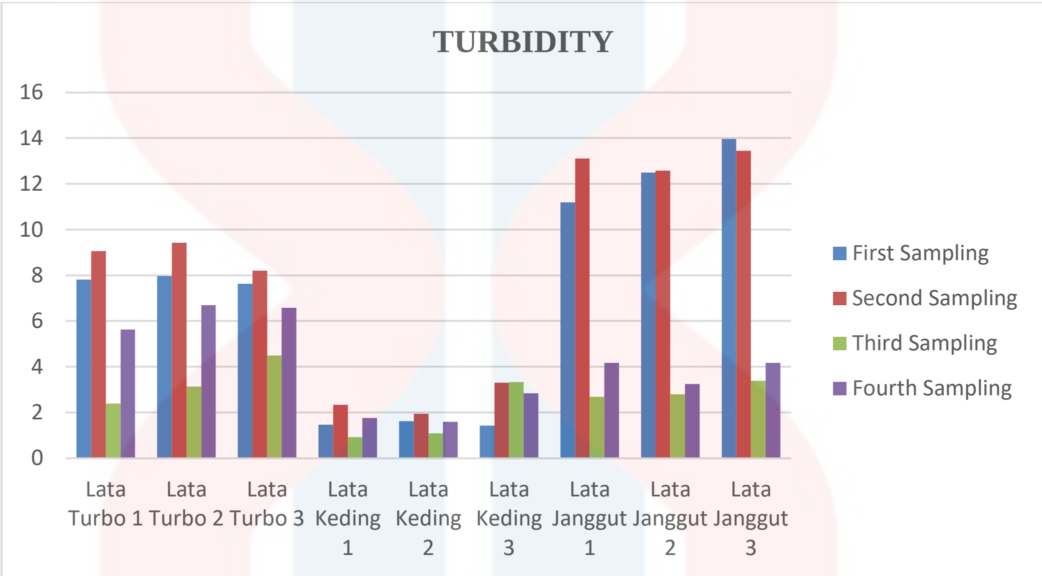

Figure 4.3: Turbidity reading of Lata Janggut, Lata Turbo and Lata Keding for every month

4.1.4. Total Suspended Solid

TSS refers to the amount of suspended particles floating in water of the three study area. Even though TSS also can be used to measure water clarity but it actually measures the quantity of suspended solid found in water samples. Turbidity is an in-situ parameter while TSS is an ex-situ parameter which requires lab work in obtaining the result (Westlab, 2015). TSS shows the reading of suspended solid in collected water samples from the three study area while turbidity only shows the water clarity.

July and August shows a high reading of TSS, corresponding to turbidity reading of the same month in Figure 4.3. Since TSS are related with turbidity, high reading of turbidity will also result in high reading of TSS. High reading of turbidity and TSS is the reason why water in the study area seems cloudy during the sampling day.

WQI classification based on TSS parameters shows that all three study area are classified into class I. TSS values for to be classified into class I is lower than 25 mg/l. Since all the result obtained are lower than 25 mg/l, Lata Turbo, Lata Keding and Lata Janggus can be classified into class I.

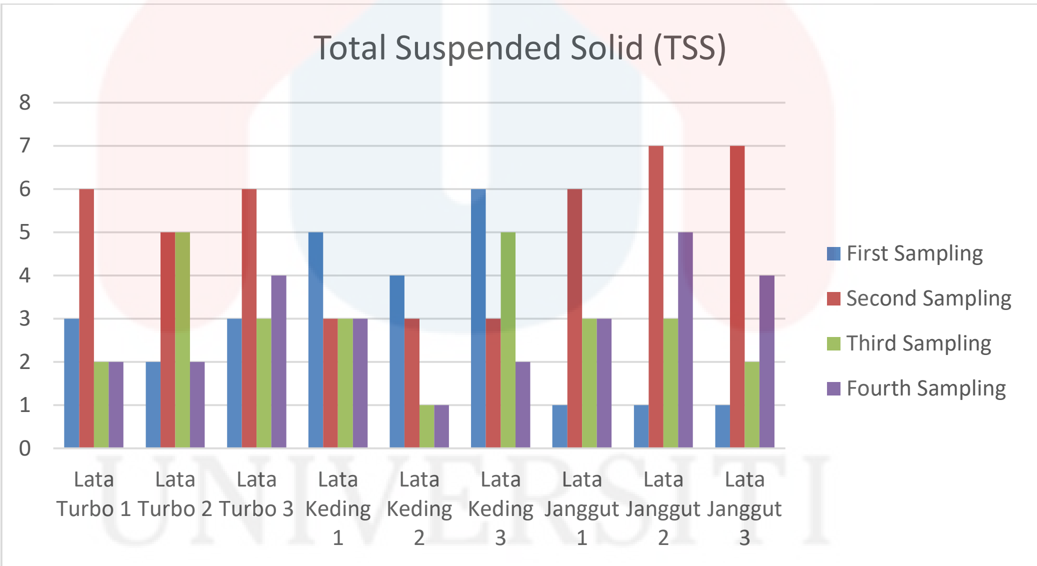

Figure 4.4: Total Suspended Solid reading of Lata Janggut, Lata Turbo and Lata Keding for every month

4.1.5. Dissolved Oxygen

The DO levels in water vary based on the environment factor like pH, temperature and sampling area. The pH level of water influences the reading of DO level in water. Lower pH, results in lower DO level. Reduction in DO levels when pH level decrease is due to the reaction of hydrogen ions and oxygen with water (Bailee Hyslope, 2015). Water with lower temperature tend to have higher reading of DO compared to water with higher temperature.

Other than that, factors that influence DO levels are the condition of the sampling area. DO in rivers changes along with the movement of water down the river (EPA, 2010). Lata Turbo, Lata Keding and Lata Janggut are a type of river that consist small streams which produces high stream flow especially in Lata Keding. Water that has lower temperature and high stream flow tends to hold more oxygen thus this will produce higher reading of DO.

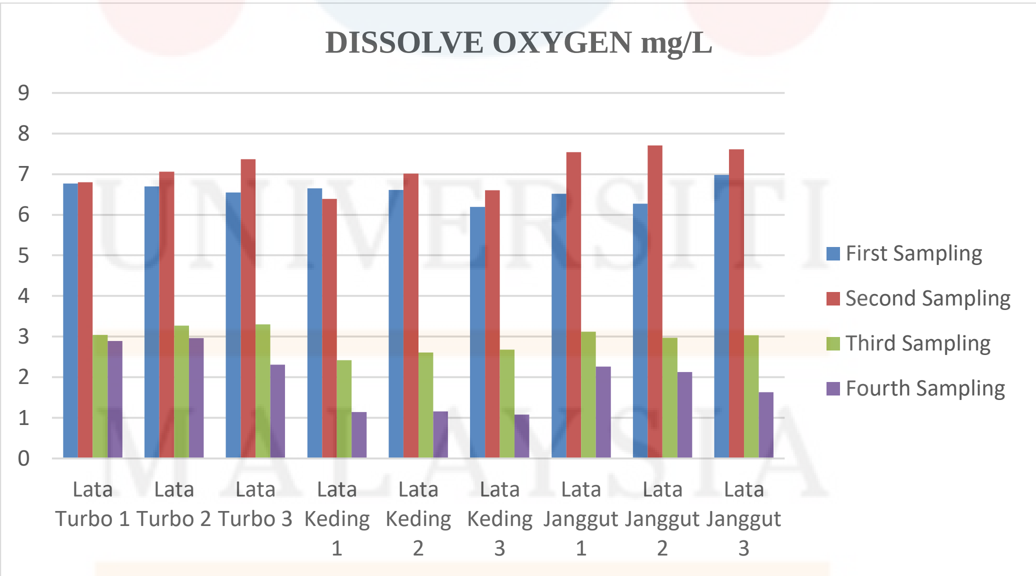

Figure 4.5: Dissolve Oxygen (mg/L) reading of Lata Janggut, Lata Turbo and Lata Keding for every month

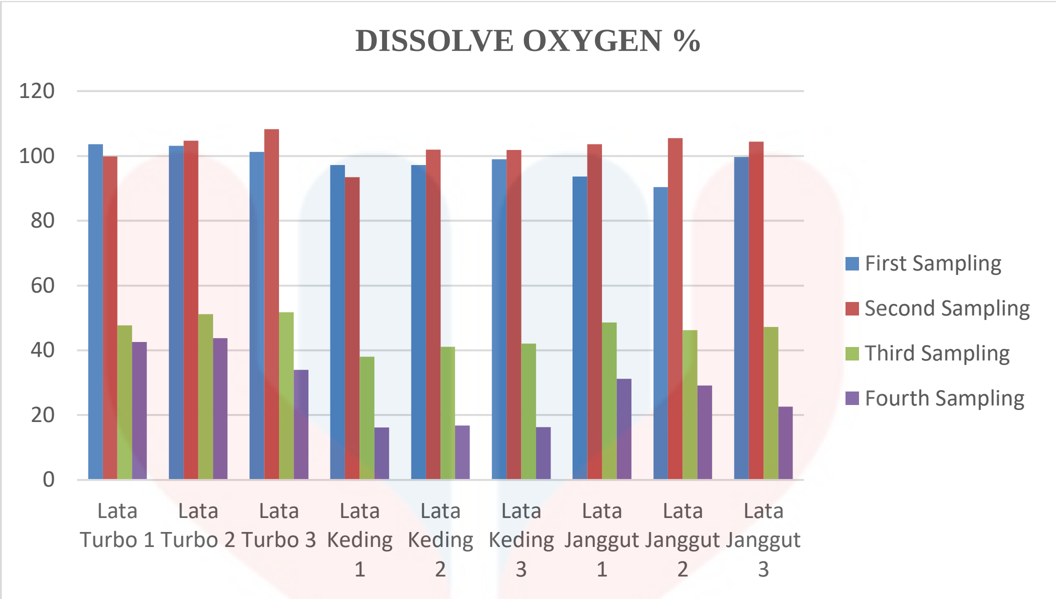

Figure 4.6: Dissolve Oxygen % reading of Lata Janggut, Lata Turbo and Lata Keding for every month

In July and August, Figure 4.6 shows high reading of DO in all three study area. Since the temperature reading of water in the study area during that month is around 28°C to 24°C which is cold temperature, water in Lata Turbo, Lata Keding and Lata Janggut are able to hold more dissolved oxygen thus causing the reading of DO to be high.

While for the month of September and November, the reading of DO reduced due to lower pH reading on that month. pH recorded in September and November is slightly acidic (pH 5) which are caused by rainy seasons. Even though the temperature of water is lower, the amount of DO levels in water also influenced by pH. Classification of water quality based on the WQI shows that in the month of July and August is in class I which reading of DO levels are more than 7, while due to other environmental factors, the low DO levels lead to the river water at Lata Turbo, Lata Keding and Lata Janggut to falls in class V which reading recorded are lower than 5.

4.2. Chemical Parameters

4.2.1. Biochemical Oxygen Demand

BOD indicated the amount of oxygen used to decompose organic compound by organisms in water. Lower reading of BOD values shows a low consumption of DO in water samples thus indicates a good quality of water while higher reading of BOD values shows a polluted water as it has higher rate of oxygen consumption in collected water samples from study area. (Mocuba, 2010)

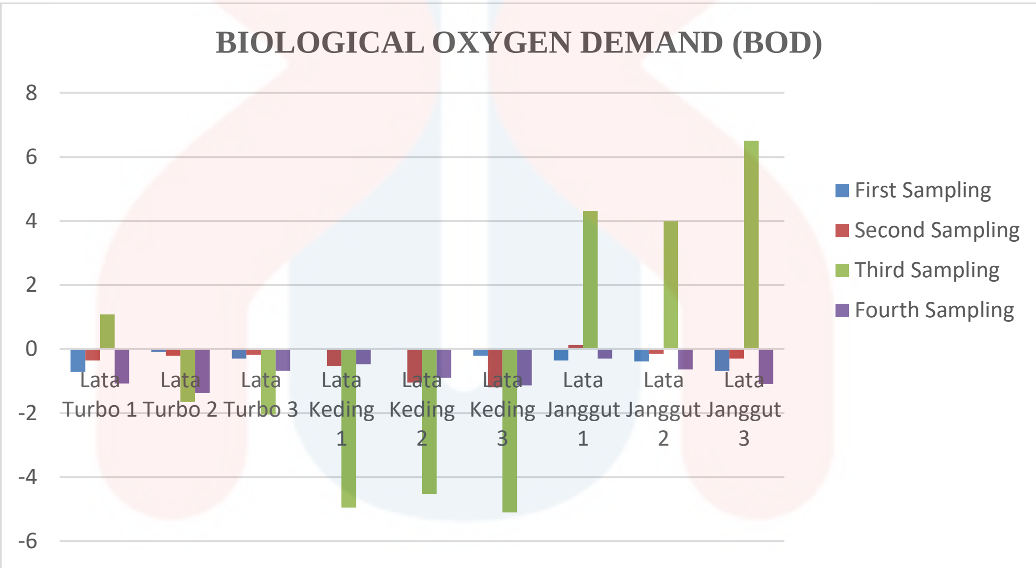

Figure 4.7: Biological Oxygen Demand reading of Lata Janggut, Lata Turbo and Lata Keding for every month

Based on the graph of BOD analysis of Lata Janggut, Lata Turbo and Lata Keding, it shows that the BOD levels are very low, which includes the negative values. Classification of water quality of BOD parameters that is lower than 1 is classified in class I.

Generally, when the BOD values are higher, the DO levels in water would decrease but since the DO levels of water in all three study area are high, the BOD values should be low. This type of result produced may happen when there is less amount organic compound available for decomposition of organic compounds by the organism in water. This cause lower consumption of oxygen in water, resulting higher DO and lower BOD values.

Unfortunately, it is understandable of the negative result are obtained due to several errors. The negative reading of BOD is may cause by the present of micro sized bubble. This micro sized bubbles are not visible on the first day of sample preparation but it will fully dissolve in the fifth day which will result in incorrect DO final reading for BOD analysis (HACH, 2019).

4.2.2. Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is the type of analysis to analyse the amount of oxygen needed to undergo chemical oxidation of the organic matter in water. Water analysis for COD parameter for WQI which result in a high reading indicates a low quality water or polluted water.

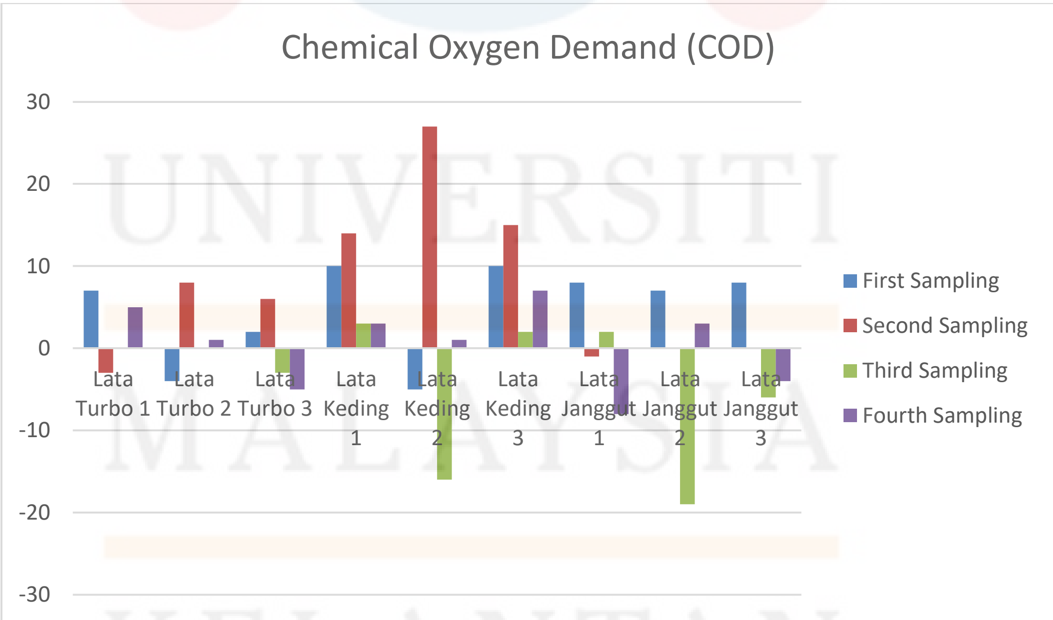

Figure 4.8: Chemical Oxygen Demand reading of Lata Janggut, Lata Turbo and Lata Keding for every month

COD reading for all four months in the study area shows that an average reading of below 10 mg/l, except for Lata Keding reading in August which shows a higher reading of 14 mg/l for point 1, 27 mg/l for point 2 and 15 mg/l for point 3. On an average of all four months, it can be classified that water in the three sampling area can be classified into class I which reading are below 10 mg/l as stated in the DOE guidelines of WQI classification.

The negative reading of COD is due to the type of vial used which is a low range COD vials. The low range COD vial are unable to provide accurate COD reading of Lata Janggut, Lata Turbo and Lata Keding because the stream flow of these study area are slow. Thus, it is recommended to use ultralow range COD vials instead of low range COD vials.

4.2.3. Ammoniacal Nitrogen

Excessive amount of Ammoniacal Nitrogen (AN) in water can cause serious problems to the environment and the ecosystem. High reading of AN values can lead to eutrophication and cause ammonia toxicity to the organisms living in water.

The reading of AN analysis of Lata Janggut, Lata Turbo and Lata Keding for the month of July, August, September and November is in the range of 0.01 to 0.13. The highest reading of AN is in the August at point 2 of Lata Janggut. The AN values that ranged in between 0.01 to 0.13 shows that water in these three study area can be classified into class II.

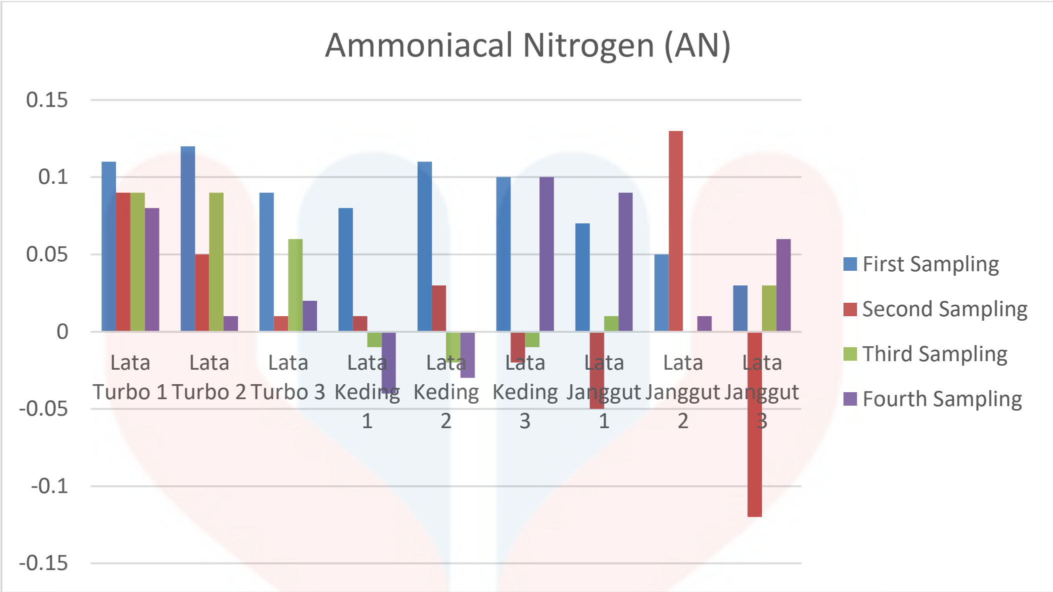

Figure 4.9: Ammoniacal Nitrogen reading of Lata Janggut, Lata Turbo and Lata Keding for every month

4.3. WQI Analysis

WQI analysis is a standard that were used to evaluate the water quality of river. WQI is a guidelines provided by DOE to determine water quality of Malaysia. The average of six parameters was used in calculating the WQI. The parameters and classification of WQI are stated below;

Table 4.1: The tested parameters and WQI classification of Lata Turbo, Lata Janggut and Lata Keding in July.

Parameters	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	100	100	100
BOD	mg/L	101.97	100.7	102.43
COD	mg/L	96.88	92.45	88.90
AN	mg/L	89.27	90.32	95.25
SS	mg/L	95.89	94.51	96.89
pH	-	97.87	98.34	97.72
WQI	-	97.35 (class 1)	96.40 (class 1)	97.20 (class 1)

Table 4.2: The tested parameters and WQI classification of Lata Turbo, Lata Janggut and Lata Keding in August.

Parameters	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	100	100	100
BOD	mg/L	101.46	104.33	100.87
COD	mg/L	94.22	74.27	99.54
AN	mg/L	95.25	99.77	101.87
SS	mg/L	94.12	95.69	93.54
pH	-	91.47	94.03	92.02
WQI	-	96.68 (class 1)	95.27 (class 1)	98.38 (class 1)

Table 4.3: The tested parameters and WQI classification of Lata Turbo, Lata Janggut and Lata Keding in September.

Parameters	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	49.90	35.38	45.61
BOD	mg/L	104.08	120.96	79.50
COD	mg/L	100.43	103.97	109.3
AN	mg/L	92.1	101.87	99.14
SS	mg/L	95.49	95.69	95.89
pH	-	69.12	85.64	88.82
WQI	-	84.21 (class 2)	88.27 (class 2)	83.5 (class 2)

Table 4.4: The tested parameters and WQI classification of Lata Turbo, Lata Janggut and Lata Keding in November.

Parameters	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	34.95	6.82	18.29
BOD	mg/L	104.83	103.95	103.28
COD	mg/L	98.66	94.22	103.09
AN	mg/L	96.62	99.45	94.90
SS	mg/L	95.89	96.29	95.1
pH	-	65.08	57.75	59.63
WQI	-	81.04 (class 2)	73.58 (class 3)	76.75 (class 2)

From the result of the water monitoring in July, August, September and November of Lata Janggut, Lata Keding and Lata Turbo, it was found that water quality had reduced from class I to class II and class III. Lata Turbo and Lata Janggut are classified in class II while Lata Keding is in class III. The WQI values of each month for the three study area are stated in table 4.1, 4.2, 4.3 and 4.4. Depletion of water quality in Lata Turbo and Lata Janggut are basically caused by the environmental factor. In September and November, sampling was conducted during rainy day. The changes in weather in November had changed and altered the assessed parameters.

Since Lata Turbo and Lata Janggut does not receive high amount of visitors per month, the depletion of water quality is not significance. Lata Keding water quality depletion would cause by the increasing number of visitors in this area. As Lata Keding were recently commercialised to the public as a recreational area where visitors can do outdoor water activities in the streams. The increasing amount of visitors cause increase in the amount of polluting which causing decrease in water quality of the study area.

4.4. Summary

Summary from the water monitoring in July, August, September and November of Lata Turbo, Lata Keding and Lata Janggut, it shows depletion of water quality in the study areas. In July and August, WQI classification of assessed parameters of study areas is in Class I. But in September and November, it shows classification of WQI in class II for Lata Turbo and Lata Janggut, class III for Lata Keding. Based on the guidelines and suggested uses of water based on the assessed parameters, water quality of class II which is Lata Turbo and Lata Janggut are safe to come in contact with human skin and can be used for recreational purposes but it will require conventional treatment to become a water supply for the communities living in the nearby area. While for Lata Keding, the depletion in water quality is due to the result of increasing number of visitors to the area. The person in charge or the management of Lata Keding is suggested to do monthly water quality monitoring. Hence, proper mitigation from future problems can be avoided. It is important to maintain the water quality because polluted water source will require extensive treatment which is very expensive and costly.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

In conclusion, recreational centre which involves freshwater sources such as rivers, lakes, streams and waterfalls will require a monthly monitoring. The water quality monitoring and assessment are important to ensure the quality of this water sources can be maintained in excellent condition for future use. Recreational centre that involves water source usually receives high rates of visitors. The rate of visitors per month effects the water quality and increase the pollution of the area. Visitors who visit the recreational area may leave unwanted waste like food waste nearby the streams and rivers. The waste left at the area contributes in depletion of water quality.

This study is conducted in July, August, September and November to analyse and monitor the water quality of Lata Janggut, Lata Keding and Lata Turbo based on parameters and guidelines provided by the DOE. Result obtained from the study shows a decrease in water quality of the three study areas. The WQI values in the most recent month which is November shows that classification of water quality is in class II for Lata Turbo and Lata Janggut, class III for Lata Keding compared to the previous month which water quality of the study areas are in class I.

5.2. Recommendations

For research that can be done in the future, it is suggested that the method in analysing the parameters of COD to use suitable vial in measuring the COD value of water sample. It is recommended to use ultralow range vials for COD reading in small streams in order get a more accurate data. Lastly, for analysing BOD parameters to ensure preparation of BOD samples were done with proper handling to avoid errors for example final reading errors due to formation of micro sized bubbles inside the water sample. This micro sized bubbled alter the final data after it is fully dissolved in the water samples. If this research would be conducted in the future, it is also suggested to gain monthly data of the number of visitors who visited the study area, so that the increasing number of visitors which cause increase of recreational water pollution can be proven.

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APPENDIX A

Figure A.1: YSI Multiparamater, PTFE bottle, BOD bottle and Centrifuge Tube.

Figure A.2: Water sampling on site.

APPENDIX B

Laboratory Test

50ml and 100ml of water sample are placed in two different BOD bottle for each sampling point.

⇩

The samples were mixed with buffer solution which were prepared a day earlier until full.

⇩

Read initial DO for each water samples.

⇩

Wrap the BOD bottles with aluminium foil and keep in the incubator at 20°C.

⇩

After 5 days, read and record the DO for each sample.

⇩

Calculate the BOD5 by minus the reading of initial DO with final DO and divide with the fraction of sample to combined volume.

Figure B.1: Biological Oxygen Demand 5 (BOD5) Method

Prepare blank by adding 2ml of deionized water into the COD low range vial.

↓

Blend 100ml of water sample for 30 seconds to homogenized.

↓

Add 2ml of homogenized sample into COD low range vial. Preheat reactor to 150°C.

↓

Heat sample and blank in the digital reactor block for 2 hours.

↓

Read and record COD value by using HACH Spectrophotometer.

Figure B.2: Chemical Oxygen Demand (COD) Method

Blend 100ml of water sample for 2minutes to homogenized.

↓

Prepare blank sample by adding 10ml of deionized water into the sample cell.

↓

Add 10ml of homogenized sample into 10ml sample cells.

↓

Using UV/VIS spectrophotometer, record the value to TSS of the water sample.

Figure B.3: Total Suspended Solid (TSS) Method

Prepare a blank sample by adding deionized water into 10ml sample cell.

↓

10ml of pH neutralised water sample were add into 10ml sample cell.

↓

Add Ammonia Salicylate powder pillow to blank and sample, let rest for 3 minutes.

↓

Add Ammonia Cyanurate powder pillow to blank and sample, let rest for 15 minutes.

↓

Read and record values of ammonia by using UV/VIS Spectrophotometer

Figure B.4: Ammoniacal Nitrogen (AN) Method

APPENDIX C

WQI Calculation

Parameter	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	102.667	97.8	94.6
BOD	mg/l	-0.37	-0.07	-0.48
COD	mg/l	1.667	5	7.667
AN	mg/l	0.107	0.097	0.05
SS	mg/l	2.667	5	1
pH	-	7.34	7.26	7.363

Table C.1: The average value of parameters to calculate WQI in July.

<u>WQI calculation for Lata Turbo in July:</u>

I. Subindex for Dissolve Oxygen, DO (in percentage):

=100 , for $x \leq 92$

II. Subindex for Biological Oxygen Demand, BOD:

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(-0.37)$

= 101.97 mg/L

III. Subindex for Chemical Oxygen Demand, COD:

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(1.667) + 99.1$

= 96.88 mg/L

IV. Subindex for Ammoniacal Nitrogen, AN:

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.107)$

= 89.27 mg/L

V. **Subindex for Suspended Solid, SS:**

$= 97.5e^{-0.00676x} + 0.05x$, for x ≤ 100

$= 97.5e^{-0.00676(2.667)} + 0.05(2.667)$

= 95.89 mg/L

VI. **Subindex for pH:**

$= -181 + 82.4x - 6.05x^2$, for 7 ≤ x < 8.75

$= -181 + 82.4(7.34) - 6.05(7.34)^2$

= 97.87

Water Quality Index:

= (0.22× 100) + (0.19×101.97) + (0.16×96.88) + (0.15×89.27) + (0.16 ×95.89) + (0.12 × 97.87)

= 97.35 (class 1)

<u>WQI calculation for Lata Keding in July:</u>

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

=100 , for x ≤ 92

II. **Subindex for Biological Oxygen Demand, BOD:**

= 100.4 – 4.23x , for x ≤ 5

= 100.4 – 4.23(-0.07)

= 100.7 mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

= –1.33x + 99.1 , for x ≤ 20

= –1.33(5) + 99.1

= 92.45 mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

= 100.5 – 105x , for $x \leq 0.3$

= 100.5 – 105(0.097)

= 90.32 mg/L

V. **Subindex for Suspended Solid, SS:**

= $97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

= $97.5e^{-0.00676(5)} + 0.05(5)$

= 94.51 mg/L

VI. **Subindex for pH:**

= $-181 + 82.4x - 6.05x^2$, for $7 \leq x < 8.75$

= $-181 + 82.4(7.26) - 6.05(7.26)^2$

= 98.34

Water Quality Index:

= (0.22× 100) + (0.19×100.7) + (0.16×92.45) + (0.15×90.32) + (0.16 ×94.51) + (0.12 × 98.34)

= 96.40 (class 1)

<u>WQI calculation for Lata Janggut in July:</u>

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

=100 , for $x \leq 92$

II. **Subindex for Biological Oxygen Demand, BOD:**

= 100.4 – 4.23x , for $x \leq 5$

= 100.4 – 4.23(-0.48)

= 102.43 mg/L

III. Subindex for Chemical Oxygen Demand, COD:

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(7.667) + 99.1$

$= 88.90$ mg/L

IV. Subindex for Ammoniacal Nitrogen, AN:

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.05)$

$= 95.25$ mg/L

V. Subindex for Suspended Solid, SS:

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(1)} + 0.05(1)$

$= 96.89$ mg/L

VI. Subindex for pH:

$= -181 + 82.4x - 6.05x^2$, for $7 \leq x < 8.75$

$= -181 + 82.4(7.363) - 6.05(7.363)^2$

$= 97.72$

Water Quality Index:

$= (0.22\times 100) + (0.19\times 102.43) + (0.16\times 88.90) + (0.15\times 95.25) + (0.16\times 96.89) + (0.12\times 97.72)$

$= 97.20$ (class 1)

I. Parameter	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	104.3	99.133	104.5
BOD	mg/l	-0.25	-0.93	-0.11
COD	mg/l	3.667	18.667	-0.333
AN	mg/l	0.05	0.007	-0.013
SS	mg/l	5.667	3	6.667
pH	-	7.967	7.767	7.927

Table C.2: The average value of parameters to calculate WQI in August.

<u>WQI calculation for Lata Turbo in August:</u>

I. Subindex for Dissolve Oxygen, DO (in percentage):

=100 , for $x \leq 92$

II. Subindex for Biological Oxygen Demand, BOD:

= 100.4 – 4.23x , for $x \leq 5$

= 100.4 – 4.23(-0.25)

=101.46 mg/L

III. Subindex for Chemical Oxygen Demand, COD:

= –1.33x + 99.1 , for $x \leq 20$

= –1.33(3.667) + 99.1

= 94.22 mg/L

IV. Subindex for Ammoniacal Nitrogen, AN:

= 100.5 – 105x , for $x \leq 0.3$

= 100.5 – 105(0.05)

= 95.25 mg/L

V. Subindex for Suspended Solid, SS:

= $97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

= $97.5e^{-0.00676(5.667)} + 0.05(5.667)$

= 94.12 mg/L

VI. **Subindex for pH:**

$= -181 + 82.4x - 6.05x^2$, for $7 \leq x < 8.75$

$= -181 + 82.4(7.967) - 6.05(7.967)^2$

$= 91.47$

Water Quality Index:

$= (0.22\times 100) + (0.19\times101.46) + (0.16\times94.22) + (0.15\times95.25) + (0.16 \times94.12) + (0.12 \times 91.47)$

$= 96.68$ (class 1)

<u>WQI calculation for Lata Keding in August:</u>

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

$=100$, for $x \leq 92$

II. **Subindex for Biological Oxygen Demand, BOD:**

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(-0.93)$

$= 104.33$ mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(18.667) + 99.1$

$= 74.27$ mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.007)$

$= 99.77$ mg/L

V. **Subindex for Suspended Solid, SS:**

$= 97.5e^{-0.00676x} + 0.05x$, for x ≤ 100

$= 97.5e^{-0.00676(3)} + 0.05(3)$

= 95.69 mg/L

VI. **Subindex for pH:**

$= -181 + 82.4x - 6.05x^2$, for 7 ≤ x < 8.75

$= -181 + 82.4(7.767) - 6.05(7.767)^2$

= 94.03

Water Quality Index:

= (0.22× 100) + (0.19×104.33) + (0.16×74.27) + (0.15×99.77) + (0.16 ×95.69) + (0.12 × 94.03)

= 95.27 (class 1)

WQI calculation for Lata Janggut in August:

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

=100 , for x ≤ 92

II. **Subindex for Biological Oxygen Demand, BOD:**

= 100.4 – 4.23x , for x ≤ 5

= 100.4 – 4.23(-0.11)

= 100.87 mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

= –1.33x + 99.1 , for x ≤ 20

= –1.33(-0.333) + 99.1

= 99.54 mg/L

IV. Subindex for Ammoniacal Nitrogen, AN:

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(-0.013)$

= 101.87 mg/L

V. Subindex for Suspended Solid, SS:

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(6.667)} + 0.05(6.667)$

= 93.54 mg/L

VI. Subindex for pH:

$= -181 + 82.4x - 6.05x^2$, for $7 \leq x < 8.75$

$= -181 + 82.4(7.927) - 6.05(7.927)^2$

= 92.02

Water Quality Index:

$= (0.22\times 100) + (0.19\times100.87) + (0.16\times99.54) + (0.15\times101.87) + (0.16\times93.54) + (0.12\times 92.02)$

= 98.38 (class 1)

Parameter	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	50.2	40.4	47.333
BOD	mg/l	-0.87	-4.86	4.94
COD	mg/l	-1	-3.66	-7.667
AN	mg/l	0.08	-0.013	0.013
SS	mg/l	3.333	3	2.667
pH	-	8.907	8.327	8.143

Table C.3: The average value of parameters to calculate WQI in September.

WQI calculation for Lata Turbo in September:

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

$= -0.395 + 0.030x^2 - 0.00020x^3$,for $8 < x < 92$

$= -0.395 + 0.030(50.2)^2 - 0.00020(50.2)^3$

$= 49.90$

II. **Subindex for Biological Oxygen Demand, BOD:**

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(-0.87)$

$= 104.08$ mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(-1) + 99.1$

$= 100.43$ mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.08)$

$= 92.1$ mg/L

V. **Subindex for Suspended Solid, SS:**

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(3.333)} + 0.05(3.333)$

= 95.49 mg/L

VI. **Subindex for pH:**

$= 536 - 77.0x + 2.76x^2$, for $x \geq 8.75$

$= 536 - 77.0(8.907) + 2.76(8.907)^2$

= 69.12

Water Quality Index:

$= (0.22\times 49.90) + (0.19\times104.08) + (0.16\times100.43) + (0.15\times92.1) + (0.16 \times95.49) + (0.12 \times 69.12)$

= 84.21 (class 2)

WQI calculation for Lata Keding in September:

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

$= -0.395 + 0.030x^2 - 0.00020x^3$,for $8 < x < 92$

$= -0.395 + 0.030(40.4)^2 - 0.00020(40.4)^3$

= 35.38

II. **Subindex for Biological Oxygen Demand, BOD:**

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(-4.86)$

= 120.96 mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(-3.66) + 99.1$

= 103.97 mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(-0.013)$

$= 101.87$ mg/L

V. **Subindex for Suspended Solid, SS:**

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(3)} + 0.05(3)$

$= 95.69$ mg/L

VI. **Subindex for pH:**

$= -181 + 82.4x - 6.05x^2$, for $7 \leq x < 8.75$

$= -181 + 82.4(8.327) - 6.05(8.327)^2$

$= 85.64$

Water Quality Index:

$= (0.22\times 35.38) + (0.19\times 120.96) + (0.16\times 103.97) + (0.15\times 101.87) + (0.16 \times 95.69) + (0.12 \times 85.64)$

$= 88.27$ (class 2)

<u>WQI calculation for Lata Janggut in September:</u>

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

$= -0.395 + 0.030x^2 - 0.00020x^3$,for $8 < x < 92$

$= -0.395 + 0.030(47.333)^2 - 0.00020(47.333)^3$

$= 45.61$

II. **Subindex for Biological Oxygen Demand, BOD:**

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(4.94)$

$= 79.50$ mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(-7.667) + 99.1$

$= 109.3$ mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.013)$

$= 99.14$ mg/L

V. **Subindex for Suspended Solid, SS:**

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(2.667)} + 0.05(2.667)$

$= 95.89$ mg/L

VI. **Subindex for pH:**

$= -181 + 82.4x - 6.05x^2$, for $7 \leq x < 8.75$

$= -181 + 82.4(8.143) - 6.05(8.143)^2$

$= 88.82$

Water Quality Index:

$= (0.22\times 45.61) + (0.19\times 79.50) + (0.16\times 109.3) + (0.15\times 99.14) + (0.16\times 95.89) + (0.12\times 88.82)$

$= 83.5$ (class 2)

Parameter	Unit	Lata Turbo	Lata Keding	Lata Janggut
DO	%	40.1	16.433	27.633
BOD	mg/l	-1.047	-0.84	-0.68
COD	mg/l	0.333	3.667	-3
AN	mg/l	0.037	0.01	0.0533
SS	mg/l	2.667	2	4
pH	-	5.25	5.037	5.093

Table C.4: The average value of parameters to calculate WQI in November.

<u>WQI calculation for Lata Turbo in November:</u>

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

$= -0.395 + 0.030x^2 - 0.00020x^3$,for $8 < x < 92$

$= -0.395 + 0.030(40.1)^2 - 0.00020(40.1)^3$

$= 34.95$

II. **Subindex for Biological Oxygen Demand, BOD:**

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(-1.047)$

$= 104.83$ mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(0.333) + 99.1$

$= 98.66$ mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.037)$

$= 96.62$ mg/L

V. Subindex for Suspended Solid, SS:

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(2.667)} + 0.05(2.667)$

= 95.89 mg/L

VI. Subindex for pH:

$= 17.02 - 17.2x + 5.02x^2$, for $x < 5.5$

$= 17.02 - 17.2(5.25) + 5.02(5.25)^2$

= 65.08

Water Quality Index:

= (0.22× 34.95) + (0.19×104.83) + (0.16×98.66) + (0.15×96.62) + (0.16 ×95.89) + (0.12 × 65.08)

= 81.04 (class 2)

<u>WQI calculation for Lata Keding in November:</u>

I. Subindex for Dissolve Oxygen, DO (in percentage):

$= -0.395 + 0.030x^2 - 0.00020x^3$,for $8 < x < 92$

$= -0.395 + 0.030(16.433)^2 - 0.00020(16.433)^3$

= 6.82

II. Subindex for Biological Oxygen Demand, BOD:

$= 100.4 - 4.23x$, for $x \leq 5$

$= 100.4 - 4.23(-0.84)$

= 103.95 mg/L

III. Subindex for Chemical Oxygen Demand, COD:

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(3.667) + 99.1$

= 94.22 mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

= 100.5 – 105x , for $x \leq 0.3$

= 100.5 – 105(0.01)

= 99.45 mg/L

V. **Subindex for Suspended Solid, SS:**

= $97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

= $97.5e^{-0.00676(2)} + 0.05(2)$

= 96.29 mg/L

VI. **Subindex for pH:**

= $17.02 - 17.2x + 5.02x^2$, for $x < 5.5$

= $17.02 - 17.2(5.037) + 5.02(5.037)^2$

= 57.75

Water Quality Index:

= $(0.22\times 6.82) + (0.19\times103.95) + (0.16\times94.22) + (0.15\times99.45) + (0.16\times96.29) + (0.12\times57.75)$

= 73.58 (class 3)

<u>WQI calculation for Lata Janggut in November:</u>

I. **Subindex for Dissolve Oxygen, DO (in percentage):**

= $-0.395 + 0.030x^2 - 0.00020x^3$,for $8 < x < 92$

= $-0.395 + 0.030(27.633)^2 - 0.00020(27.633)^3$

= 18.29

II. **Subindex for Biological Oxygen Demand, BOD:**

= 100.4 – 4.23x , for $x \leq 5$

= 100.4 – 4.23(-0.68)

= 103.28 mg/L

III. **Subindex for Chemical Oxygen Demand, COD:**

$= -1.33x + 99.1$, for $x \leq 20$

$= -1.33(-3) + 99.1$

$= 103.09$ mg/L

IV. **Subindex for Ammoniacal Nitrogen, AN:**

$= 100.5 - 105x$, for $x \leq 0.3$

$= 100.5 - 105(0.0533)$

$= 94.90$ mg/L

V. **Subindex for Suspended Solid, SS:**

$= 97.5e^{-0.00676x} + 0.05x$, for $x \leq 100$

$= 97.5e^{-0.00676(4)} + 0.05(4)$

$= 95.1$ mg/L

VI. **Subindex for pH:**

$= 17.02 - 17.2x + 5.02x^2$, for $x < 5.5$

$= 17.02 - 17.2(5.093) + 5.02(5.093)^2$

$= 59.63$

Water Quality Index:

$= (0.22\times \text{SIDO}) + (0.19\times\text{SIBOD}) + (0.16\times\text{SICOD}) + (0.15\times\text{SIAN}) + (0.16\times\text{SISS}) + (0.12\times\text{SIpH})$

$= (0.22\times 18.29) + (0.19\times103.28) + (0.16\times103.09) + (0.15\times94.90) + (0.16\times95.1) + (0.12\times 59.63)$

$= 76.75$ (class 2)