# DETERMINATION OF WATER QUALITY INDEX (WQI) OF LANAS RIVER, KELANTAN, MALAYSIA

by

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## DECLARATION

I declare that this thesis entitled "Determination of Water Quality Index (WQI) of Lanas River, Kelantan, Malaysia" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

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# Determination of Water Quality Index (WQI) of Lanas River, Kelantan, Malaysia


## ABSTRACT

In consequences of the pollution water, the ecosystems are affected due to water pollution because of human activities like dumping of garbage or sewage directly into the water bodies or use of chemical fertilizers from agricultural activities. Thus, the health of the water sources such as rivers or coastal waters can be determined by using Water Quality Index or WQI and National Water Quality Standard (NWQS) for Malaysia River. In this study, 19 parameters are conducted to determine the water quality and the factors that affecting the Lanas River, Ayer Lanas, Kelantan based on WQI calculation method which are ammoniacal nitrogen ($NH_3$-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, conductivity, salinity, total suspended solid (TSS), temperature, turbidity, fecal coliform counts, total coliform counts, zinc, cadmium, lead, copper, nitrite, nitrate and phosphorus. Three stations were marked as Point 1, Point 2 and Point 3 along the Lanas River, Ayer Lanas, Kelantan. The samples were taken from August until November. The overall WQI in August were calculated as 23.64 for point 1, 23.35 for point 2 and 25.03 for point 3 and was under class V due to heavy rainfall while in September, the level of WQI was under class IV for point 1 and point 2 except for point 3 was under class V. In October, the overall WQI were 34.13, 41.18 and 41.53 under class IV. As for November, all points were classified as class IV in WQI. 51.71 was the WQI for point 1, 38.98 for point 2 while 43.73 for point 3. Lanas River was supposed to be under class IIB which is suitable for recreational uses with body contact but the river was classified under class IV due to the pollution caused by the human activities done nearby.

**Penentuan Indeks Kualti Air (IKA) Sungai Lanas, Kelantan, Malaysia**

## ABSTRAK

Akibat daripada kesan pencemaran air, ekosistem terjejas akibat daripada aktiviti manusia seperti pembuangan sampah atau sisa kumbahan secara terus ke dalam air atau penggunaan baja kimia daripada aktiviti pertanian. Oleh hal yang demikian, kesihatan sumber air seperti sungai, perairan pantai atau tasik boleh ditentukan dengan menggunakan Indeks Kualiti air atau IKA dan Standard Kualiti Air Negara untuk sungai di Malaysia. Melalui kajian ini, 19 parameter telah dijalankan untuk menentukan kualiti air dan faktor-faktor yang mempengaruhi Sungai Lanas, Ayer Lanas, Kelantan berdasarkan kaedah pengiraan WQI iaitu Nitrogen Ammonia (NH3-N), Permintaan Oksigen Biokimia (BOD), Permintaan Oksigen Kimia (COD), Indeks Kealkalian (pH), kekonduksian, saliniti, Jumlah Pepejal Terampai (TSS), suhu, kekeruhan, kiraan koliform tahi, jumlah kiraan koliform, zink, kadmium, plumbum, tembaga, nitrit, nitrat dan fosforus. Tiga stesen ditanda sebagai Titik 1, Titik 2 dan Titik 3 di sepanjang Sungai Lanas, Ayer Lanas, Kelantan. Sampel telah diambil dari bulan Ogos hingga November. WQI keseluruhan ditentukan dalam tempoh empat bulan pada tiga titik di sepanjang sungai Lanas, Kelantan, Malaysia. Keseluruhan WQI pada bulan Ogos dikira sebagai 23.64 pada titik pertama, 23.35 pada titik kedua dan 25.03 pada titik ketiga dan berada di bawah kelas Lima kerana hujan lebat manakala pada bulan September, tahap WQI berada di bawah kelas Empat pada titik 1 dan titik 2 kecuali pada titik 3 berada di bawah kelas Lima. Pada bulan Oktober, keseluruhan WQI adalah 34.13, 41.18 dan 41.53 di bawah kelas Empat. Pada bulan November, kesemua mata dikelaskan sebagai kelas Empat dalam IKA. 51.71 adalah IKA pada titik 1, 38.98 adalah pada titik 2 manakala 43.73 pada titik 3. Sungai Lanas sepatutnya berada di bawah kelas IIB yang sesuai untuk kegunaan riadah bagi kegunaan manusia tetapi sungai ini dikelaskan di bawah kelas IV akibat pencemaran dari aktiviti manusia yang dilakukan berdekatan kawasan sungai tersebut.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AN | Ammoniacal Nitrogen |
| BOD | Biochemical Oxygen Demand |
| COD | Chemical Oxygen Demand |
| DO | Dissolved Oxygen |
| $H_2SO_4$ | Sulfuric acid |
| NaOH | Sodium Hydroxide |
| $NO_2$ | Nitrite |
| $NO_3$ | Nitrate |
| $NH_3$-N | Ammoniacal nitrogen |
| NTU | Nephelometric Turbidity Units |
| NWQS | National Water Quality Standard |
| ppt | part per trillion |
| TNTC | Too Numerous to Count |
| TSS | Total Suspended Solid |
| WQI | Water Quality Index |

## LIST OF SYMBOLS

| | |
|---|---|
| °C | Temperature (degree Celsius) |
| > | Less than |
| < | Greater than |
| ≥ | Greater than or equal to |
| % | Percentage |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of study

River is known to be an important resource which carry water and nutrient for the living things and act as an important element in hydrological cycle especially in channeling the water drainage. It provides humans with fresh water for drinking, cleaning, cooking or washing purposes. Damage to the river system will degrading the water quality and the ability to perform its function, which will lead to loss in the economics sector. The health and condition of a river will show the relationship between human and water sources. Therefore, the assessment of the condition of the river health is an essential to help human to maintain the river in a more sustainable way (Song et al., 2015). Water Quality Index (WQI) is an important tool that is used to conclude and summarize based on several values of analytical determination and signify specific water resources quality (Finotti, Finkler, Susin, & Schneider, 2015). On the other hand, WQI is used as an evaluation to know the river quality status based on selected water quality parameters comprising of dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, total suspended solid (TSS), ammoniacal nitrogen ($NH_3$-N), electrical conductivity, salinity, temperature, turbidity, fecal coliform counts, total coliform counts, zinc, cadmium, lead, copper, nitrite, nitrate and phosphorus (Al-Badaii, Shuhaimi-Othman, & Gasim, 2013b).

## 1.2 Problem Statement

Nowadays, water pollutions are seen as a big problem or negative issue in most of the countries and this can lead to bad consequences to the health of the ecosystem such as human health, aquatic organisms and also the environment. A great amount of domestic, agricultural and transportation wastes that are generated from the development from anthropogenic activities are discharge into the water resources which cause the water to pollute. On the other hand, land use can degrade the quality of river water due to land changing from the anthropogenic activities. For examples, forest clearing, conversion of natural landscape to farmland, building of roads and city development (GreenFacts, 2006). This study was conducted at Lanas River, Kelantan to determine its water quality and the factors that affecting the water quality.

## 1.3 Objectives

i. To determine the level of water quality of Lanas River based on the WQI parameters and additional parameters which are electrical conductivity, salinity, temperature, turbidity, fecal coliform counts, total coliform counts, zinc, cadmium, lead, copper, nitrite, nitrate and phosphorus.

ii. To identify the major factors that influences the water quality of the river at Lanas River, Kelantan.

## 1.4 Scope of study

The scope of study was to identify the water quality level of Lanas River based on selected WQI parameters. The selected study area was at Lanas River, Ayer Lanas, Kelantan and the sampling activity was taken based on three sampling stations refer as Point 1, Point 2 and Point 3. The location for sampling activity was different between each sampling points which was along the Lanas River, Ayer Lanas, Kelantan. The samples were taken every month starting from August until November on every Sunday of the third week of the month. The location for Point 1 was at the river near the residential area of Ayer Lanas, for Point 2, was at the river near the plantation area of lime and also rubber plantation. Lastly at residential area located at Desa Legeh for Point 3.

## 1.5 Significance of study

The finding of this study was important to identify the quality level of the river as river fulfills human activities such as fisheries, agriculture and also drinking. If the quality level of the river was much lower than the safety standard stated, it will lead to many serious consequences but not just to human being but also affect other organisms especially to aquatic organisms. Besides, the effectiveness of water quality index (WQI) as an instrument that can be used to analyse the conditions of the river water quality as to represent the overall information of the water quality in a single term which is helpful to select of the best treatment for the concerned issues that affecting the river (Shah & Joshi, 2017). In other word, WQI are very helpful to identify the major factors that caused the Lanas river water degradation.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 WATER

### 2.1.1 Importance of water

Water which is colorless and odorless is a type of molecule that is made up of an oxygen atom and two hydrogen atoms that are held together by strong covalent bonds. Rivers, streams, and oceans are the liquid form of water while solid form is in ice and water that is in the form of gas or vapor states is when the water is in the atmosphere. All living things need water to survive. Human can live for days or even weeks without consume any food, but human cannot survive without water for few days (Fetter, 2015). Clean water access is essential to human as most of the human body is comprises up to 60 percent of water. Therefore, human needs clean water to assists in many vital functions in the body or otherwise, if human consume or use contaminated or unclean water, it may lead to health risks (Fifield, 2017). Therefore, the need to get access clean water sources is essential as the basic need of life. For some countries, this is a major dilemma such as difficulties to get the access to clean drinking water or water pollution.

### 2.1.2 WATER POLLUTION

Malaysia is a developing country that experiences rapid urbanization and having ascent in the population growth. The population growth will lead to an increased demand for water supply and will affect the levels of water pollution. These impact can cause harm to the water quality in Malaysia. Various sources of waste like domestic waste, industrial waste and transportation waste such as oils will drain into the water supply. Water sources pollution can be a factor towards human health problems (Kenworthy, 2017). The main causes of water pollutions happens because of chemicals or other harmul substances that contaminated or polluted the water sources such as lake, river or oceans which degrades the water quality and leads to toxicity to the living organisms. The sources of contamination that commonly pollute the water is from farming or livestock production like the discharges of the animal wastes from the farm or pesticides from this agricultural sector into the waterways cause the water pollution (Denchak, 2018).

## 2.2 WATER QUALITY

The quality of water remains as a huge major concern in our country till now. Water quality monitoring is really important to help human to aware the condition or to find the best mitigation measures to clean up the water pollution. The condition of the waterways or the water bodies shows the states and the composition of the specific water sources on that area such as streams, rivers, and lakes. (Booth & Wardropper, 2015). The major factor that influence the quality of the water is caused by the anthropogenic or man-made activities through the discharge of municipal or industrial wastewater into the water bodies. Based on a study at Pelus River, Perak, Malaysia, human activities such as construction of hydroelectric dams can change aquatic life ecology for both at the upper and lower part of the river and will affect the river water quality. Poor quality of the river water will lead to disturbance in natural ecosystem, thus affecting the food chain, and can affect the aquatic life and wildlife population (Hasan, Jamil, & Aini, 2015). Therefore, it is really important to aware of the river health within an acceptable level. As for river in Selangor, the most popular state was also facing with the same problem regarding to river water pollution which was contamination due to human activities. This study found that Semenyih River, Selangor was contaminated with ammoniacal nitrogen, total suspended solid, chemical oxygen demand, nitrate and highly polluted with phosphate and faecal coliform. Industrial, agricultural, livestock farming and soil erosion were the sources of the river water contamination (Hanafiah, Yussof, Hasan, Abdulhasan, & Toriman, 2018). The importance of knowing the quality of water is to know the current state and the composition of the water bodies (Booth & Wardropper, 2015). Hence, based on the studies show that the need of water quality monitoring to the river especially to Lanas River as river is an important water sources to the ecosystem health.

### 2.2.1 Physical Parameters

a) pH

The measurement of electrically charged particles in the substances is known as pH as it can be an indicator of acidity and alkalinity of certain substances (Cirino, 2018). The measurement of pH is in the scale from 0 to 14, and pH 7 is considered as neutral. The solution that has pH below than 7 is acidic while solutions that are more than pH 7 until 14 is considered as bases. The pH of water can be different and vary due to the bedrock or composition of soil which the water moves such as limestone it neutralize acid. The limestone contains carbonate, bicarbonate, and hydroxide compounds that can dissolve in water that eventually will raise the level of pH. The water is acidic due to some reasons that come from multiple of sources such as rainfalls are slightly acidic as it contains carbon dioxide in the atmosphere. On the other hand, the decomposition of plant and chemical runoff are also become one of the major contibutor that can reduce pH of water (Water Right Group, 2019). In addition, the discharge of toxic chemicals from domestic or industrial activities into the water bodies may also affect the pH value in the water (Oram, 2014).

b) Temperature

One of the most essential indicator of water quality is water temperature which it regulates a broad scope of biological processes in the water bodies such as river or lake. Temperature mainly affect spawning periods, the growth of rates and the rates of mortality of the aquatic organisms in the river (Harvey, Lye, Khan, & Paterson, 2011). Besides, temperature can give effect to the chemical and biological water component such as it effects level of dissolved oxygen (DO) in the water, the photosynthesis process, metabolic rates and also the sensitivity of the aquatic life towards pollution. Low DO level is caused by the rates of metabolic of the aquatic plants in the water thus rise the water temperature that also increase biochemical oxygen demand (BOD) level (Kreger, 2004).

c) Salinity

Salinization can be refers as the increase or rises as the concentration of total dissolved solid (TDS) in the water sources and can be detected by the increase of chloride in the water (Kaushal et al., 2005). The salt in seawater not just contain sodium chloride but also other elements such as calcium, magnesium, and potassium (Kennedy, 2018). Water from the rainfall seeps into and being stored in the soil. The water is mostly occupied by plants , but some of the water may lost,seeping down past through the root region into the groundwater. Thus, will cause the increase of groundwater levels and mobilising the salts content. When the saline water table increases up to one or two metres of the ground's surface, the water brings salt along and moves through the capillary of the soil surface into the water. Over the time goes, the soil will becomes saline, limit the vegetation growth of the plant.As salinity levels in the water increase, the salt sensitive plant species will prone to die (Victoria State Government, 2017).

d) Turbidity

The particles that are suspend or dissolve in the water absorb or scatter the light which will appear the water looks cloudy is known as the phenomenon of turbidity The particulate matter that include such as sediment, organic and inorganic substances, microbes such as algae are the causes of turbidity (Peterson & Gunderson, 2008). Turbidity show the clearness of the particular water sources in which higher TSS in the water, will make it murkier and increase the reading of turbidity. The major source of turbidity in open water bodies such as river or lakes typically because of phytoplankton, clays and silts from the erosion of shoreline.

e) Total Suspended Solid (TSS)

Total Suspended Solids (TSS) are known as the portion of tiny particulate matter that left over in the water suspension that make the water to appear murkier or can be see as cloudy by naked eyes. The measurement of TSS is almost the same turbidity, but TSS has an actual weight of particulate matter in a given volume of the sample in the unit mg/l while turbidity is in NTU or Nephelometric Turbidity Units.

When the concentrations of TSS is higher it will leads to many problems regarding the health of the water sources and aquatic organisms such as high TSS will cause the blockage of light from reaching the aquatic plant causing the slowdown of photosynthesis process. Lower DO level will be released into the water when photosynthesis rate is decreasing and eventually will cause the plant to die (Murphy, 2007).

f) Dissolved Oxygen

Dissolved oxygen (DO) is known as the quantity of oxygen concentration exist in the water resources and DO is essential for the aquatic ecosystem to undergo biological productivity such as the decomposition of organic materials (Prasad et al., 2014). The atmosphere and the aquatic plants are the sources for the water bodies to get oxygen. Aquatic plants such as kelp, and algae that grow at lower depth surface of water use only a tiny amount of sunlight to undergo photosynthesis to release oxygen into the atmosphere. Photosynthesis undergo by a large amount of plants will cause in extremely increase in level of DO. Uncontrollable plant growth for example algal bloom will cause fertilizer runoff, and also will give effect to the aquaculture activities (Kremer, 2018).

g) Conductivity

Conductivity or also be called as electrical conductance is define as the mathematical measurement of a ability of a material to conduct electricity. The unit of conductivity represented as micromhos per centimeter (µmhos/cm) or siemens per meter (S/m) in SI unit. Pure water is a type of poor electricity conductor but with certain presence of chemicals or elements add up in the water such as sodium, calcium or chloride will turns the water to be a good conductor of electricity. As the water salinity increases, it will also rise the conductivity level too. On the other hand, water that has higher temperature tends to be more conductivity (Reymolds, 2019).

### 2.2.2 Chemical Parameters

a) Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is a measurement of oxygen volume that being occupied by aerobic microbes by oxidizing the organic material such as the decay of vegetation or fallen leaves from the tree. The factors that will also increase the oxygen demand are the urban runoff such as discharge of waste from livestock farming or high nutrients from lawn fertilizer (Shmeis, 2018). BOD value is in the unit of milligrams of oxygen consumed per liter of the sample, mg/L during a certain time of incubation at 20 °C. The BOD test will determine the oxygen molecules that are being used up during a specific timeframe like five days for the biochemical to degrade the organic material and the quantity of oxygen that are need to undergo the oxidization process of the inorganic material.

b) Chemical Oxygen Demand (COD)

Chemical Oxygen Demand(COD) are known as an oxygen measurement that needs to oxidize the soluble and particulate organic matter in the resources of water. COD analyzer can measure COD in real-time that can help to bring efficiency to the process of wastewater control and the efficiency of water treatment plant (Realtech, 2017). COD is closely linked with to BOD but it is difference because BOD test organic material level that can be oxidized biologically. On the other hand, COD test chemically oxidized the amount of the organic substances. The level of COD is usually more than level of BOD due to more organic substances can be oxidized chemically than biologically test.

c) Ammoniacal Nitrogen

Ammonia is a type of nitrogen form that can be found in the water. Ammonia has the ability to brings direct toxic effects to the aquatic organisms unlike any type of nitrogen that can lead to nutrient over enrichment in the water thus increase its concentrations (EPA, 2013) Ammonia can be found in water sources such as runoff from agricultural sectors such as in fertilizer or can be found in underground aquifers because of animal feedlot runoff. One of the drawbacks of ammonia is it is difficult to be remove from the water. It can be removed by exchange of cation resin in the form of hydrogen which need the use of acid as a regenerant (Rozic et al., 2000)

d) Heavy Metals

Heavy metals usually exist in trace amounts in water sources but they are chemically toxic even in very low concentrations. The inclination of the amount of heavy metals in water resources put a great concern, especially when many industries are discharging their effluents that contain toxic heavy metals into the water without any proper treatment. Heavy metals may accumulate in human tissues through consumption of food or water, air or skin absorption in several sectors such as agriculture, manufacturing, pharmaceutical, industrial or residential activities.(Masindi & Muedi, 2018). Chemical precipitation is one of the common used to remove heavy metal from inorganic waste (Barakat, 2011).

### 2.2.3 Biological Parameters

a) Fecal Coliform Counts and Total Coliform Counts

Biological parameters are important factor that can determine water quality. Biological parameters are more important than physical and chemical parameters because it can give direct effect to the human health. Total coliforms by meaning is bacteria colonies that can be found naturally grow in the water which can be found in human waste product such as feces or can be found in animal manure or soil. Therefore, the total coliforms counts can be an indicator for detecting fecal contamination. Fecal coliforms is a subset of total coliform bacteria or more fecal-specific (US EPA, 2012).

## 2.3 WATER QUALITY STANDARD FOR WATER

### 2.3.1 Water Quality Index

The classification of river water quality by the Department of Environment or DOE is based Water Quality Index or WQI in which is a group of water quality determinants and the combination of the parameters into a single number at the same scale in accordance with an appropriate method or computation model (Amneera, Najib, Mohd Yusof, & Ragunathan, 2013). Nineteen parameters including the DO, BOD, COD, pH, total suspended solid (TSS), $NH_3$-N, electrical conductivity, salinity, temperature, turbidity, fecal coliform counts, total coliform counts, zinc, cadmium, lead, copper, nitrite, nitrate and phosphorus are involves in measuring WQI. In addition, WQI can be used to analyse and comparing water quality among different water sources of rivers or waterways (Amneera et al., 2013). The calculation of sub-indexes for each WQI parameters is useful to check the problematic parameters at the river and the best treatment that can be applied (Naubi, Zardari, Shirazi, Ibrahim, & Baloo, 2016b).

### 2.3.2 National Water Quality Standard for Malaysia

The classification of the Malaysian rivers is a guidelines gazette as a reference to the river water quality status in Malaysia by the Department of Environment (DOE). The factors of river pollution can be analyse by comparing and measure the water quality based on recommended sub-indices such as total suspended solids (TSS), pH, temperature (°C), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) and ammoniacal nitrogen (NH3-N) based Table 2.1 (Ahmad, Kutty, Raji, & Saimy, 2015).

**Table 2.1**: National Water Quality Standards for Malaysia (Selected Parameters)

| PARAMETER | CLASSES | | | | |
|---|---|---|---|---|---|
| | **I** | **IIA/IIB** | **III#** | **IV** | **V** |
| Ammoniacal Nitrogen, mg/L | 0.1 | 0.3 | 0.9 | 2.7 | 2.7 |
| $BOD_5$, mg/L | 1 | 3 | 6 | 12 | 12 |
| COD, mg/L | 10 | 25 | 50 | 100 | 100 |
| DO, mg/L | ≥7 | 5-7 | 3-5 | 3-1 | <1 |
| pH | 6.5-8.5 | 6.5-9 | 5-9 | 5-9 | - |
| Electrical Conductivity, µmhos/com | 1000 | 1000 | - | 6000 | - |
| Salinity, ppt | 0.5 | 1 | - | 2 | - |
| Total Suspended Solids, mg/L | 25 | 50 | 150 | 300 | 300 |
| Temperature,°C | - | Normal + 20 oC | Normal + 20 oC | - | - |
| Turbidity, NTU | 5 | 50 | 50 | - | - |
| Fecal Coliforms, counts/100 mL | 10 | 100/400 | 5000 (20000)a | 5000 (20000)a | - |
| Total Coliforms, counts/100 mL | 100 | 5000 | 50000 | 50000 | >50000 |
| Zinc, mg/L | Natural Levels | 5 | 0.4* | 2 | Levels above Class IV |
| Cadmium, mg/L | Natural Levels | 0.01 | 0.01* (0.001) | 0.01 | Levels above Class IV |
| Lead, mg/L | Natural Levels | 0.05 | 0.02* (0.01) | 5 | Levels above Class IV |
| Copper, mg/L | Natural Levels | 0.02 | - | 0.2 | Levels above Class IV |
| Nitrite (NO2) | Natural Levels | 0.4 | 0.4 (0.03) | - | Levels above Class IV |
| Nitrate (NO3) | Natural Levels | 7 | - | 5 | Levels above Class IV |
| Phosphorus, mg/L | Natural Levels | 0.2 | 0.1 | - | Levels above Class IV |

*Note:*

* = At hardness 50 mg/l CaCO3

- = no value

a : Maximum not to be exceeded

Adapted from " National Water Quality Standards For Malaysia" by Department Of Environment (DOE). Retrieved from https://www.doe.gov.my/portalv1/wp-content/uploads/2019/05/Standard-Kualiti-Air-Kebangsaan.pdf

# CHAPTER 3

# MATERIALS AND METHODS

## 3.1 STUDY AREA AND SAMPLING POINT

Sampling point was selected based on the criteria of the utilization of water and significant activities that were done nearby such as development or agricultural. Three stations were marked as Point 1, Point 2 and Point 3 as shown in Figure 3.1, Figure 3.2 and Figure 3.3 along the Lanas River, Ayer Lanas, Kelantan. The samples were taken from August until November. The sampling was started at the third week of August because the weather was still sunny compare to at the end of the year because of the monsoon season. A sunny day with no rainfall for the previous 24 hours are preferred to collect the water samples because it provides a better chance to get water quality tests in normal river flow conditions. However, sampling during rainfall, may not truly represent the river water quality because the river flow is not in normal conditions (Naubi, Zardari, Shirazi, Ibrahim, & Baloo, 2016).


**Figure 3.1**: Three sampling points along the Lanas River.

(Source:Google Map)


**Figure 3.2**: Sampling point for Point 1

(Source: Google Map)


**Figure 3.3**: Sampling point for Point 2.

(Source: Google Map)


**Figure 3.4**: Sampling point for Point 3

. (Source: Google Map)

Latitude and longitude of each point were stated in Table 3.1. The location for point 1 was at the river near the residential and surrounds with shop and food court at Ayer Lanas, for point 2, the water samples was taken near the plantation area which was lime and rubber tree whereas for Point 3 was at near Desa Legeh residential area. The samples were not suitable to be taken when it is raining because rains can contribute to bacterial loading and nutrient contamination by the contributions of surface runoff (Amneera et al., 2013).

**Table 3.1**: Latitude and longitude of point 1, point 2 and point 3

| Location | Latitude | Longitude |
|---|---|---|
| Point 1 | 5°47'05.3"N | 101°53'22.7"E |
| Point 2 | 5°46'00.3"N | 101°53'59.2"E |
| Point 3 | 5°44'59.5"N | 101°54'17.3"E |

### 3.2 Sample Collection

Water samples were collected by using polyethylene bottles during sampling. Three bottles of polyethylene bottles were used and labelled correctly its sampling point and date during the sampling process. The equipment to be used for sampling were needed to be clean properly before using it to prevent contamination. The sample were collected by facing into the direction of the river flow to flow away any potential contamination from substrate disturbance from where the sample is being collected. Rotate the sample container into the direction of flow. Sample bottles were rinsed at least three times with river water. The bottles were filled at least one third of the container volume. The sample bottles were shaken gently and pour the water downstream of the sample collection point. The sample of surface water was collected about 10 cm below the surface water. The samples were preserved immediately by acidifying with 98% concentrated sulphuric acid to pH below 2 to minimize precipitation and adsorption on the container and immediately put it in ice cold storage. The difference parameters of water will be analysed following to the standard procedures. The water samples need to be keep in the laboratory refrigerator at the temperature below 4°C to terminate the microbial activities in the water (Amneera et al., 2013). The sample collection of the water quality parameters was replicated three times to ensure validity and account for error because the repetition of a scientific experiment or trial it is because to obtain a consistent result (Mckubre, 2008).

### 3.2.1 Sampling activity for in situ environmental analysis

In situ analysis gives brief status and information about the water quality bodies encountered. In-situ analysis was using several apparatus that give certain physical properties of water such as pH, electrical conductivity, salinity, temperature, turbidity and dissolved oxygen. Chemicals or materials were used in situ analysis were distilled water and also rubber gloves. YSI Multiparameter and turbidimeter were two of the necessary apparatus needed to be used to monitor in situ water quality parameters. The target locations were identified as Point 1, Point 2 and Point 3 for the water analysis. The YSI Multiparameter was prepared for the water quality determination. The YSI probe was carefully dip into the flowing water and the probe has to be fully submerged under the water. Small amount of water samples needed to be collected into the turbidity water sample bottle for turbidity test and were put into the turbidity meter to record the reading. In addition, the data gained from the YSI Multiparameter for dissolved oxygen, salinity, conductivity, temperature and pH. were recorded for data analysis.

### 3.2.2 BOD and COD Determination

Biochemical oxygen demand or BOD is define as an empirical test to determine the molecular oxygen used during a specified incubation period usually took for five days, for the biochemical degradation of organic matter and the oxygen used to oxidise the inorganic matter (Scholz, 2006). As for chemical oxygen demand (COD) is to measure the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals (The Laboratory People, 2009). The material needed in this test were deionized water, rubber gloves, micropipette, aluminium foil, HACH COD vial and dilution water, while for the apparatus needed were PTFE bottles, 300 ml BOD bottles, Digital Reactor Block, DO meter, HACH DR6000 Spectrophotometer and a blender. For the procedure of BOD and COD determination, samples were collected from the Lanas river by using PTFE bottle for COD analysis and BOD bottle for BOD analysis. The sampling for BOD bottle has to be submerged completely under the water to avoid interruption of atmospheric oxygen and the sample were advisable to be kept immediately in the laboratory for instant analysis for a better result.

a) BOD Test

For BOD test, three sample volumes of 10, 50 and 100 ml were identified to be use in this test. The sample were stirred gently and needed to be transfer respectively into sample volume to three difference BOD bottles. Each bottle was filled with dilution water until full and the bottle was closed carefully using stopper to prevent any air bubbles trapped in the bottle. The bottles were gently inverted to make it mix for several times. Another blank was prepared with 300 ml dilution water. Dissolved Oxygen meter was used to read the initial dissolved oxygen for each bottles. The BOD samples needed to be intubate in a 20℃ incubator for 5 days' time period in still position. The BOD bottles needed to be wrapped in aluminum foil to avoid any photosynthesis process occur in the bottles. After five days, DO meter was used to read the dissolved oxygen for each bottles and the data were recorded. The BOD value are calculated by using the equation below (Equation 3.1).

$$BOD_5 = \frac{(D_1 - D_2)}{P} \tag{3.1}$$

Whereas:

$BOD_5$ is the BOD value for five days' test;

$D_1$ is the dissolved oxygen of diluted sample immediately after the preparation, mg/L;

$D_2$ is the dissolved oxygen of diluted sample after five days of incubation at 20ºC, in mg/L;

P is volume of sample/ volume of sample bottle (300ml)

a) COD Test

For COD test, a blank was prepared by adding 2 ml of deionized water into the vial at 45-degree angle. The vial was inverted for several time to mix. Digital Reactor Block or DRB200 Reactor was turned on and preheat to the temperature of 150 ℃. 100 ml volume of sample was blended in a blender for 30 seconds to make it homogenized and from the previous step, 2 ml of homogenized sample are added into the HACH vial and inverted into several times. After that, the blank and sample vial were placed into the reactor block and needed to be heat for 2 hours. The reactor was turned off after 2 hours of heating and let the vials to be cool to decrease the temperature until 120 ℃ in the reactor before taking the vials out. The vials were inverted several times while it still warm and let it cool in the tube rack until it reaches the room temperature. HACH DR6000 spectrophotometer was used to read the COD value using preset program and the data obtained were recorded.

### 3.2.3 Determination of Ammonical Nitrogen and Total Suspended Solids

Ammoniacal nitrogen is one of the major nitrogen forms in the nitrogen cycle, which consists of ammonia ($NH_3$) and ammonium ($NH_{4+}$) in natural waters (Liang, Yan, Guo, Xu, & Hu, 2016). Ammonia is a forms of nitrogen that can be found in aquatic environments. Unlike any other forms of nitrogen, that can cause eutrophication that cause over-enrichment of nutrient in a water body at elevated concentrations and indirect effects to the aquatic organism, ammonia also can cause direct toxic effects to them. On the other hand, total suspended solids (TSS) can be found in the water column which its particles are larger than 2 microns. Anything that are smaller than 2 microns is considered as a dissolved solid. Most suspended solids such as bacteria and algae are made up of inorganic materials that can contribute to the total solids concentration (Fondriest Environmental, 2014). Chemicals or materials needed in ammoniacal nitrogen and total suspended solid test were deionized water, 1M Sodium Hydroxide, NaOH to use for buffer solution. Then for the apparatus were HACH DR6000 Spectrophotometer, micropipette, 10 ml of sample cell, a blender and pH meter.

**a)** Total Suspended Solid Test

For Total Suspended Solid test, 100 ml of water sample were collected then blend by using a blender for 2 minutes to make it homogenized. Next, a blank sample was prepared by adding 10 ml deionized water into the sample cell. 10 ml of homogenized water sample was added into the sample cell and by using the HACH Spectrophotometer, the TSS value of the sample water can be analyzed.

**b)** Ammoniacal Nitrogen Test

As for ammonial nitrogen test, a blank was prepared with the addition of deionized water into the sample cell. Next, the sample was prepared by adding 10 ml of water sample into the sample cell. If the sample was at pH 2, buffer solution, NaOH needed to be add up to neutralize the pH. The next step was adding the Ammonia Salicylate powder pillow to both blank and sample and shaken it and let it to react for 3 minutes. Ammonia Cyanurate powder pillow was added to both blank and sample cells and being shaken to make it dissolve. The blank and sample were let to be rest for 15 minutes to observe the reaction. The green color showed the presence of ammonia-nitrogen in the samples. Then, the blank and sample cells were analysed by using spectrophotometer for reading using program 385 N, Ammonia, Salic.

### 3.2.4 Determination of heavy metal analysis

Water samples were collected from Point 1, Point 2 and Point 3 of the Lanas River. Samples were collected in good quality screw capped high density pre-sterilized polypropylene bottles of 1 litre capacity. The bottles were labelled properly and analyzed in the laboratory to trace metals by using UV-Vis Spectrophotometer. The analysis of water samples analyzes the selected heavy metals such as zinc, cadmium, lead, copper, nitrite, nitrate and phosphorus. The Ultraviolet-visible (UV-Vis) spectrophotometry is a method when the light absorbance across the ultraviolet and visible range of the electromagnetic spectrum. This spectrophotometer measures the light intensity of the light transmitted through the water sample which was then were compared to a reference measurement of the incident of the light source.

a) Analysis of heavy metal by using UV-Vis Spectrophotometer

UV-Vis Spectrophotometer were set into single wavelength program for reading of the heavy metals absorbance. Next, the series of standard solution of each heavy metals are prepared for zinc, cadmium, lead, copper, nitrate, nitrite and phosphorus. The Table 3.2 below shows the type of stock solution used to make the standard solution for each of heavy metals.

**Table 3.2**: Stock solution for heavy metals

| Heavy metals | Stock solution |
|---|---|
| Zinc | Zinc Stock Solution |
| Cadmium | Cadmium Stock Solution |
| Lead | Lead Stock Solution |
| Copper | Copper(II) Sulfate Stock Solution |
| Nitrate | Potassium Nitrate |
| Nitrite | Sodium Nitrite |
| Phosphorus | Potassium dihydrogen phosphate |

Next, a dilution from 50 mg/L of stock solution are made into 2, 4, 6, 8 and 10 mg/L as the series of each of the stock solution. The dilution of unknown concentration was made from the water sample taken for each month for a ratio of 1:50. The preparation of blank was made by using 10ml of volumetric flask and filled with 1 ml of distilled water with 9 ml of $H_2SO_4$ (0.2M) and added with 0.2 ml of 0.25% (w/v) 1,5-diphenylcarbohydrazide solution. 1 ml of 2 mg/L of the stock solution with 9 ml of $H_2SO_4$ (O.2M) and added with 0.2 ml of 0.25% (w/v) 1,5-diphenylcarbohydrazide solution in 10 ml of volumetric flask. The next step is the mixture is shaken to mix all the solution. The procedure was then repeated with other concentration for 4, 6, 8, 10 mg/L and unknown concentration for water samples.

### 3.2.5 Total Coliform Counts and Fecal Coliform Counts

a) Preparation of nutrient agar and sterilization of apparatus

About 14 g of nutrient agar are weighted and put in the of media bottle. The agar was dissolved in 500 ml of distilled water. The media was then autoclave at a maintain temperature of 121 ºC. Autoclave is operated at high temperature and pressure in order to kill the microorganisms and spores that might stimulate in the growth of microorganisms on the agar. Dilution blanks in capped tubes and in 100 ml of media bottles were also autoclave along with the pipette tips to make it sterilized.

b) Serial Dilution and Spread Plate

The sterile dilution blanks were marked in the following sequence of 100 ml dilution blank is $10^{-2}$ and the next tubes were marked as $10^{-3}$, $10^{-4}$, $10^{-5}$ and $10^{-6}$. The sterile dilution blanks can be made by autoclave the distilled water. 1 ml of water samples were taken from each of the river collected from Point 1, 2 and 3 which then were added to the $10^{-2}$ dilution blank and was shaken vigorously for a minimum of one minute and let set for a short time period. Then. 1 ml was transferred aseptically from the dilution blank into $10^{-3}$ tube and was shaken to mix it through. For each succeeding step, fresh and sterile pipette was used to transfer 1 ml of $10^{-3}$ dilution to the $10^{-4}$ dilution blank, then from the $10^{-4}$ to the $10^{-5}$ and from $10^{-5}$ to the $10^{-6}$. The sample were mixed thoroughly each time it being transferred into the dilution fluids before transferred into the next tube. 0.1 ml of each of the dilution from $10^{-3}$, $10^{-4}$, $10^{-5}$ and $10^{-6}$ were transferred to the agar plate. The glass spreader was sterilized by dipping it into 70% ethanol and flamed it in a Bunsen burner flame. When the glass spreader was cooled, the sample was spread on the entire surface of the agar. The plates were sealed tightly by using parafilms. Lastly, the plates were incubated at 30 ºC in an inverted position. The plates were duplicated each from each dilution that received a particular medium which one for Nutrient Agar and one for Nutrient Agar -7.5 % NaCl. After the incubation, the colonies were counted. The counted plates those with a range of 30-300 colonies were required and recorded. The bacteria concentrations in the original sample were then calculated.

## 3.3 ANALYSIS OF DATA

All nineteen water quality parameters are required to measure the National Water Quality Standards for Malaysia such as BOD, COD, $NH_3$-N, TSS, fecal coliform counts, total coliform counts, zinc, cadmium, lead, copper, nitrite, nitrate and phosphorus will be tested in the laboratory based on the appropriate methods. As for pH, electrical conductivity, salinity, temperature, turbidity and DO parameters will be measure directly at the sampling points by using in-situ method. The results obtained will be compared to National Water Quality Standards for Malaysia stated in Table 2.1 and DOE Water Quality Index Classification stated in Table 4.2 (Amneera et al., 2013). The following WQI (Equation 3.2) were used to calculate the Water Quality Index:

$$WQI = 0.22\,SiDO + 0.19\,SiBOD + 0.16\,SiCOD + 0.15\,SiAN + 0.16\,SiSS + 0.12\,SipH \quad (3.2)$$

The result that will be obtained from physicochemical parameters and laboratory experiments will be tabulated in tables and plotted by using Microsoft Excel.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 PHYSICAL PARAMETERS

a) pH

Figure 4.1 shows the pH reading from August until November 2019. The highest average values of pH in August was obtained at point 3 which was 7.06, whereas the lowest average value was of 6.66 which was obtained at point 2. In September, the highest average value of pH was 8.3 at point 1 and the lowest was 7.91 at point 3. For both months, the average value of pH was recorded as alkaline. Next for October, the highest average value of pH was 5.62 at point 1 and the lowest was at point 3 which was 5.14 which were acidic and for the last month, the highest pH value was at point 3 at 5.27 and the lowest pH is 4.93 at point 1 and also recorded as acidic.

Among the four month of sampling, the highest average value of pH recorded was in September. The highest average value was 8.3 at point 1 and the lowest was at 4.93 on November which was at point 1. However, the results were within the standard range and classified under class I based on National Water Quality Syandard (NWQS) for Malaysian rivers. However, based on NWQS for Malaysian rivers, the results in August and September are within the standard range and are classified under class I. However, for the remaining months of October and November was exceeding the standard range which is Class III and above. For the last two months, the pH was acidic due to the rainfall as rains contribute to bacterial loading and nutrient contamination by the contributions of surface runoff and can disturb the pH reading. Next was point source pollution also a common cause of decreasing of pH value because of chemicals contamination from the housing and plantation area because point 1 and point 3 was near to the residential area whereas for point 2 was near to the plantation area (Environmental, 2013). Overall, the range of pH from 6.5 to 9 in class I is mainly suitable for the aquatic life. Therefore, it is vital to keep or maintain the pH value of the river within the range because high and low pH can be destructive in nature (Al-Badaii et al., 2013).

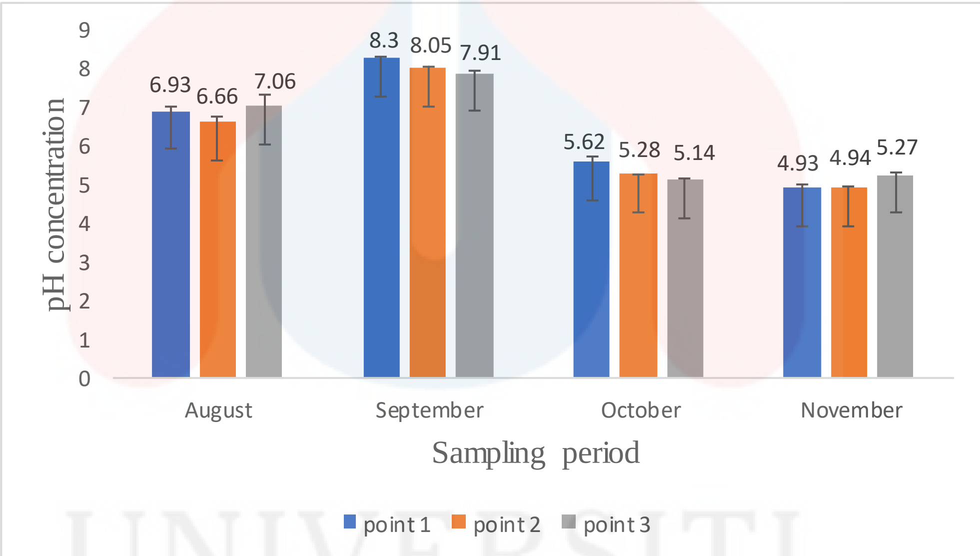


**Figure 4.1**: Mean variation of pH at Lanas River

b) Temperature

Figure 4.2 shows the temperature of the Lanas river from August till November. The average temperature was highest at 25.54 ºC and the lowest was 25.26 ºC in August. As for September, the highest average temperature is 27.46 ºC and the lowest is 27.01 ºC. The highest average reading of temperature in October was 24.46 ºC and the lowest was at 25.44 ºC. Next, the highest average temperature was 25.22 ºC and 25.21 ºC was the lowest temperature in November. The highest average temperature recorded for the overall months was 27.46 ºC and the lowest average temperature was 25.21 ºC. The temperature results are within the standard range of National Water Quality Standard of Malaysia (NWQS). The factor affecting the temperature of water was due to the time of sampling and the condition of weather that gave effect to the increase or decrease of the temperature in the river (Al-Badaii et al., 2013). The sampling time was done in the morning; hence the temperature was not high compared to sampling time in the afternoon.

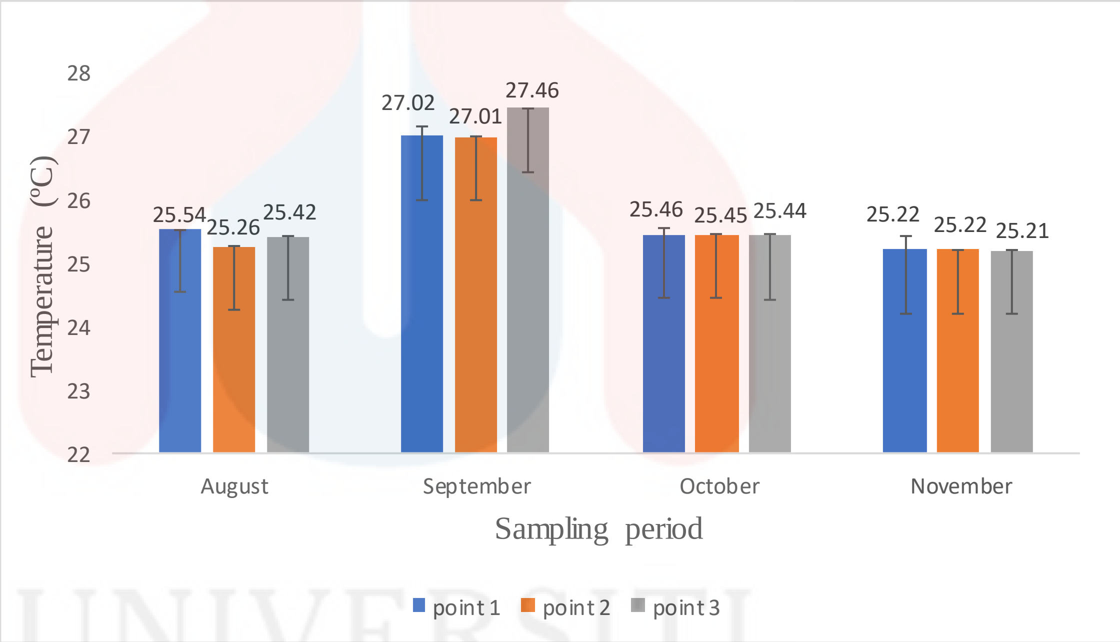


**Figure 4.2**: Mean variation of temperature at Point 1, Point 2 and Point 3 of Lanas River

c) Salinity

Figure 4.3 shows the salinity level in Lanas river for four months in part per trillion (ppt). In August, the highest average salinity level was 0.26 ppt at point 1 and the lowest average salinity level was 0.16 ppt at point 3. The highest average level of salinity in September was 0.33 ppt at point 2 and the lowest was 0.3 ppt at point 3. On the other hand, 0.3 ppt was the highest average salinity reading at point

2 and the lowest average salinity level was at point 3 which was 0.27 ppt. For November, at point 3 was the highest average level of salinity at 0.25 ppt and the lowest average salinity level was at 0.21 ppt at point 2. All the salinity reading for overall months were within the standard range of salinity in NWQS for Malaysia which is below 0.5 ppt in class I. The salinization process or the buildup of salts, was different in each place and salinity may occur naturally because of rainfall. Small amounts of salt like sodium chloride were evaporated from ocean water and are carried in rainclouds and were deposited into the river water or also influenced by human activities through the discharge of waste from agricultural area.

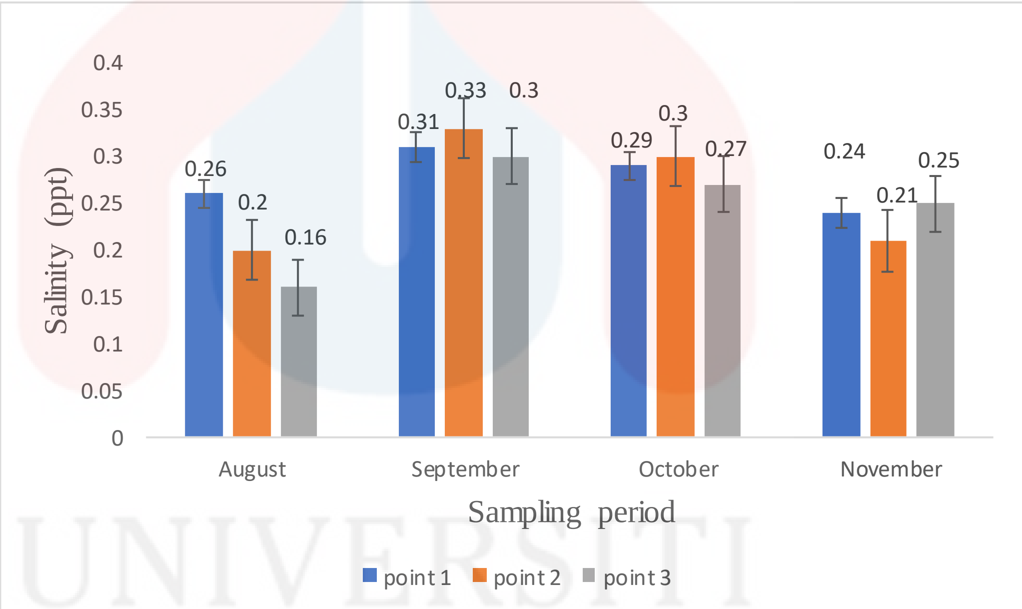


**Figure 4.3**: Mean Variation of salinity of Lanas River

d) Turbidity

Figure 4.4 shows the mean variation of turbidity value of Point 1, Point 2 and Point 3 of Lanas River. The result of turbidity measurement is in Nephelometric Turbidity units or NTU. The average turbidity value in August was the highest at 191 NTU and the lowest at 104 NTU whereas in September the highest average turbidity was at 69.23 NTU and the lowest 42.47 NTU. Next, the highest average turbidity value was at 34.77 NTU while the lowest was at 16.99 NTU in October. As for November, the highest average value was 46.07 NTU and lowest at 38.1 NTU. The highest average reading of turbidity was in August which was 191 NTU and the lowest was in October which was 16.99 NTU.

In addition, the average turbidity level in August and point 3 in September were exceeding the standard limit of NWQS for Malaysia river which was more than 50 NTU. Meanwhile for the other readings were within the range of standard limit of NWQS for Malaysian River. The turbidity value was high in August due to heavy rainfall the day before the sampling time which caused all the sediments discharge or washed off into the river while for September, the average value at point 3 was high due to the human activities such as agriculture. Chemical pollutants such as fertilizers and pesticides were stick to the soil particles and were washed off into the river. These pollutants can cause algal blooms and reduce the concentration of oxygen in the water, threatening the aquatic organism, thus increase the turbidity readings (Horne & Goldman, 1994).

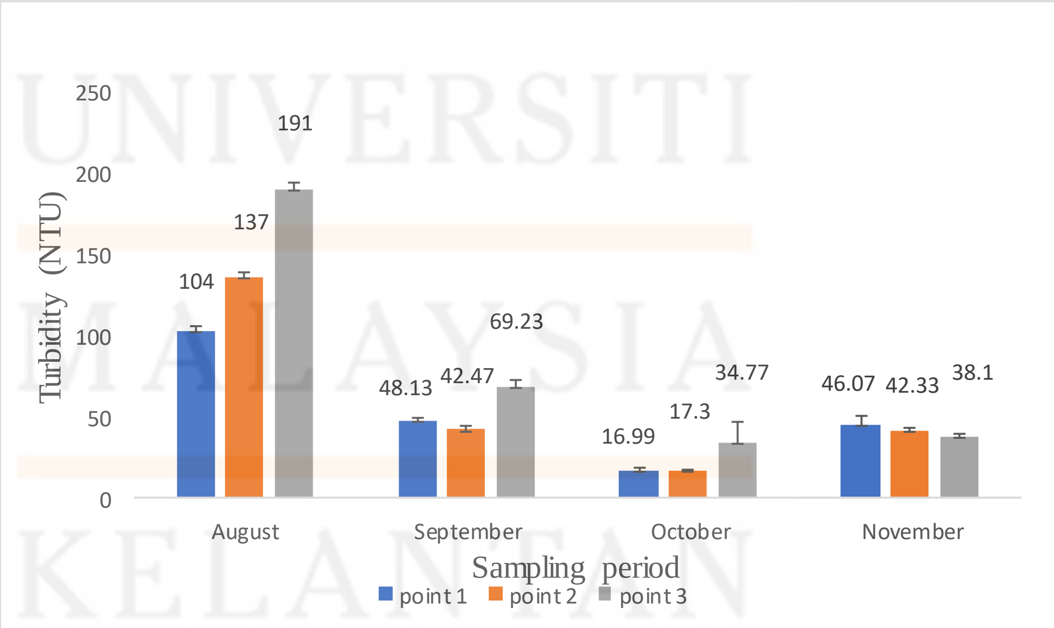


**Figure 4.4**: Mean variation of turbidity of Lanas River

e) Total Suspended Solid (TSS)

Figure 4.5 shows the average value of total suspended solid (TSS) of Lanas river for point 1, point 2 and point 3. As for total suspended value in August, the highest average reading was at 88.33 mg/L at point 1 while the lowest was 51 mg/L at point 3. In September, the highest reading of TSS was 21 mg/L at point 1 and the lowest at point 3 which was 7 mg/L. The highest average of TSS value was 15.33 mg/L at point 1 while at point 3, the lowest average value which was 4.67 mg/L in October. On the other hand, 26 mg/L was the highest average TSS reading at point 1 and the lowest at point 3 which was 14.33 mg/L. All of the TSS results were within the standard range of NWQS of Malaysia river and are classified as class II. The flow rate of the water body is a primary factor in TSS concentrations. Fast running water can carry more particles and larger-sized sediment. Heavy rains can pick up sand, silt, clay, and organic particles such as leaves, soil, tire particles from the top soil land and carry it into surface water. A change in river water flow rate can also affect TSS. High reading of turbidity in August was due to rain because when speed or direction of the water current increases, particulate matter from bottom sediments were resuspended (Murphy, 2007).

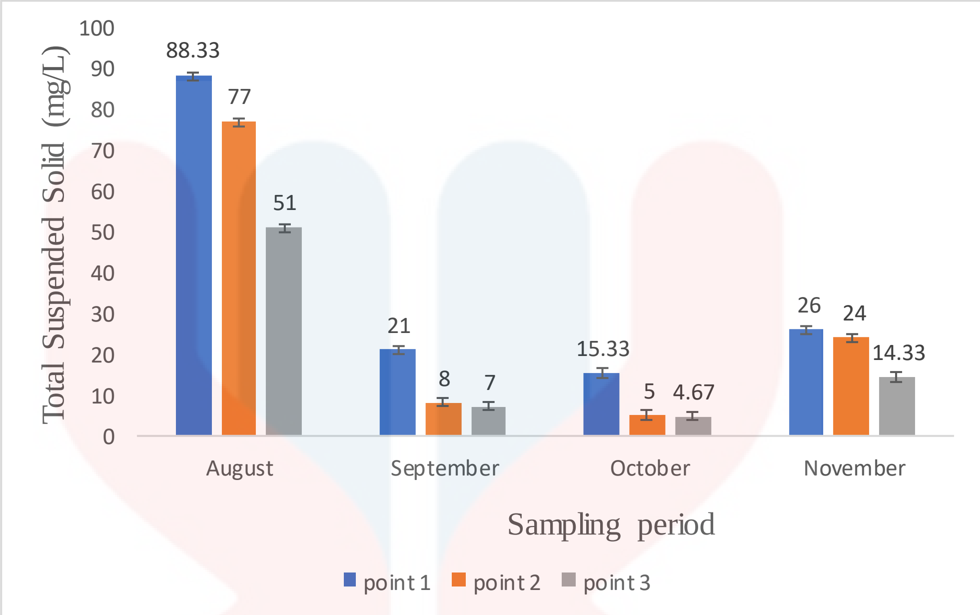


**Figure 4.5**: Mean variation of total suspended solid (TSS) of Lanas River

f) Dissolved Oxygen (DO)

The amount of oxygen that are dissolves in water can be different in term of time which happens daily or seasonal patterns, and decreases due to higher temperature, salinity, and elevation. Same goes to the average dissolved oxygen (DO) reading at Lanas river for three points which was point 1, point 2 and point 3 shown in Figure 4.6. For the first month of sampling, the highest average reading of DO was 6.28 mg/L and the lowest value was 6.07 mg/L while on September, 6.25 mg/L was the highest average reading and the lowest reading was 5.76 mg/L. On October, the highest average reading was 2.81 mg/L and the lowest reading was 1.91 mg/L and as for last month of sampling, 3.41 mg/L was the highest average reading and 2.5mg/L was the lowest average value of DO during that month.

Based on National Water Quality Standard (NWQS) for Malaysia, the acceptable value of DO level is more than 3 mg/L which is categorized under Class III. The safe ranges of DO level at Lanas river was between 6.28 mg/L until 3.4

mg/L while it might rise concern on the average level of DO that was below 3 mg/L on October and also on November for point 1 which was 2.5 mg/L.

The cause of lower dissolved oxygen was caused by weather condition. In between October and November, there was high rainfall distribution happened that contributed to low level of dissolved oxygen levels. The production of oxygen through photosynthesis process is decreased or interrupted on cloudy and windless days because lack of circulation of the water resources and limited surface diffusion of atmospheric oxygen (Sierra Biologist, 2016).

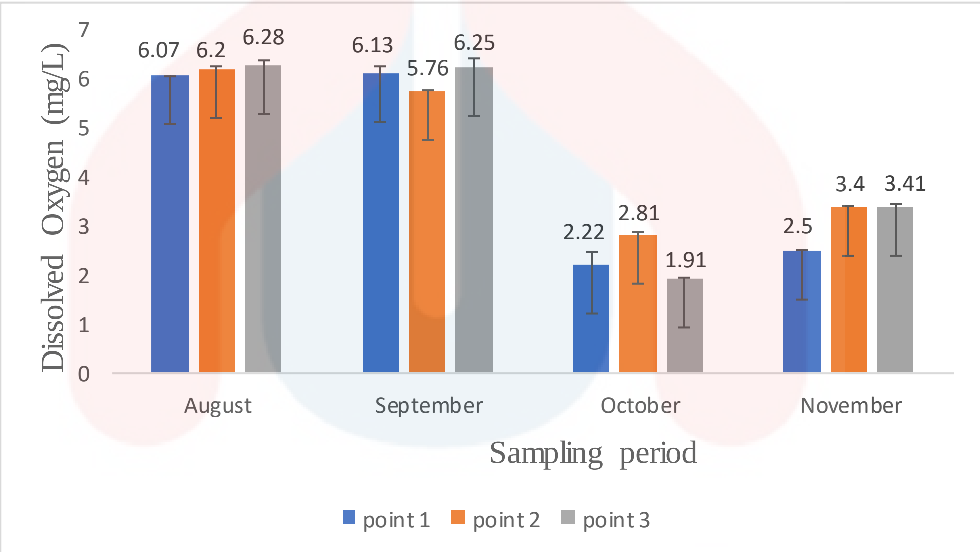


**Figure 4.6**: Mean variation of dissolved oxygen (DO) of Lanas River

g) Conductivity

Conductivity is very useful to measure water quality. Figure 4.7 shows the results of conductivity of Lanas river for three points across the sampling period. In August, the highest average reading of conductivity was 41.51 µmhos/cm at point 1 and the lowest reading was at point 3 which was 30.84 µmhos/cm. The highest reading was 52.05 µmhos/cm, meanwhile the lowest level was 47.99 µmhos/cm in September. The highest average conductivity level was 47.21

µmhos/cm and 41.83 µmhos/cm was the lowest average value in October. In November, 39.69 µmhos/cm was the highest average value of conductivity and the lowest was 34.23 µmhos/cm. So, the range value of conductivity of Lanas river were within the standard range of the NWQS, which is below 1000 µmhos/cm which is below class I.

Conductivity is a measurement of water's capability to pass electrical flow. Conductivity in water is directly related to the concentration of ions in the water. The more ions that are present in the river, the higher results of conductivity of water. Likewise, for Lanas River, the ions that presence were fewer in the water, thus less conductive the river water (Fondriest Environmental, 2010).

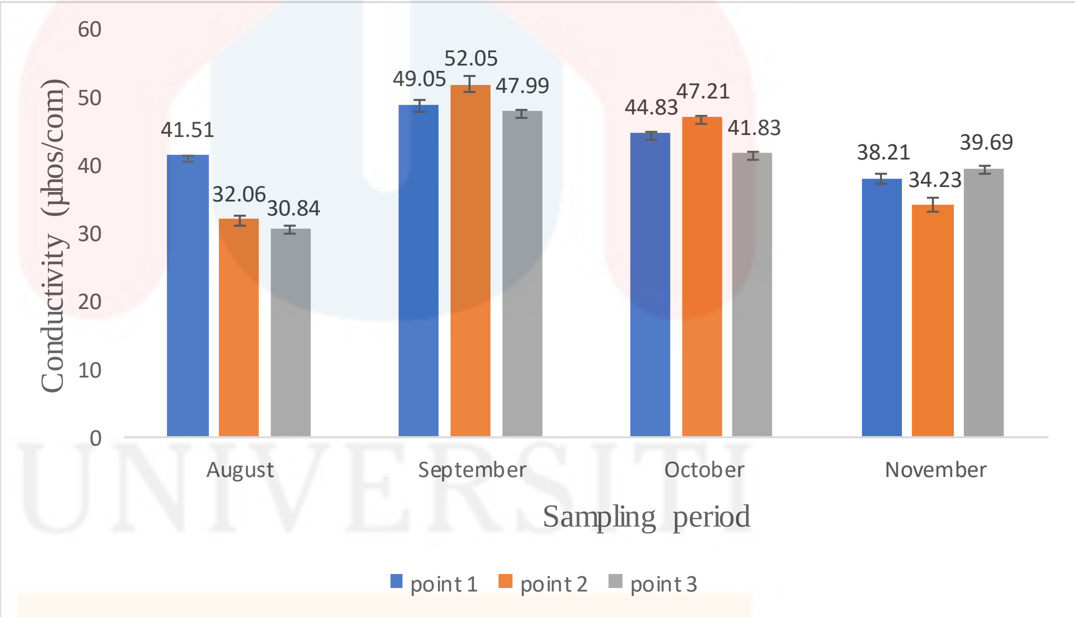


**Figure 4.7**: Mean variation of conductivity of Lanas River

## 4.2 Chemical Parameters

a) Biochemical Oxygen Demand (BOD)

Figure 4.8 shows the reading of biochemical oxygen demand (BOD) in mg/L. In August, the highest average reading of BOD was 13.78 mg/L while the lowest reading was 9.3 mg/L. As for September, the highest average result of BOD was

12.44 mg/L and the lowest BOD level was 5.67 mg/L. On the other hand, the highest average result of BOD in October was 15.54 mg/L and the lowest reading was 5.8 mg/L. In addition, 5.43 mg/L was the highest average BOD level and the lowest BOD level was 2.86 mg/L in November. The average value of BOD for point 2 in August, point 3 in September and point 1 in October were exceeding the range value of BOD level that recommended in NWQS which were more than 12 mg/L.

When the level of BOD is higher, it will cause the decline in dissolved oxygen (DO) level. The reason the BOD level was high was because high oxygen demand by the bacteria and the bacteria was taking the oxygen from the dissolved oxygen in the water. If there is no organic waste exist in the water bodies, there will be not as many bacteria present to decompose it and thus will make the BOD level lower and the increase the DO level. When the level of BOD in the river is higher, macro invertebrates that are tendency to tolerant with lower dissolved oxygen such as leeches and sludge worms may presence and become plenty (Penn et al., 2009). The highest level of BOD was at point 1 was because of the discharges of organic constituents from the untreated sewage in the river water as point 1 was located near the residential area. Direct discharges of sewage contain organic compounds that are decomposed by microorganisms, which use oxygen in the process (Nuruzzaman, Al-Mamun, & Salleh, 2018). Hence, the larger the quantity of organic waste in the river water, the higher the demand for oxygen for bacteria to decompose this waste. Thus, increase the level of BOD in the river water.

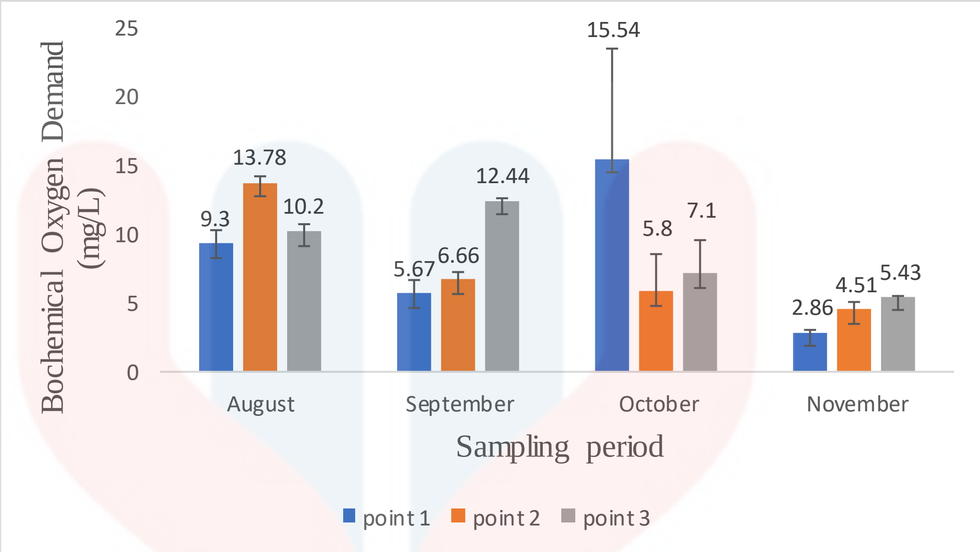


**Figure 4.8**: Mean variation of biochemical oxygen demand (BOD) of Lanas River

b) Chemical Oxygen Demand (COD)

The average chemical oxygen demand (COD) value of Lanas river for four months was shown in Figure 4.9. The average value of COD for August, the highest value was 49.33 mg/L at point 3 while the lowest value was 44.67 mg/L at point 2. On the other hand, for September, the highest average value of COD was 50 mg/L at point 3 while the lowest value was 10 mg/L at point 2 and for October the highest average reading of COD was 26 mg/L while 17.67 mg/L was the lowest reading. As for the last month of sampling, the highest average value of COD was 35.33 mg/L and 15.67 mg/L was the lowest reading of COD value. The highest average reading of COD value is 50 mg/L which was on class III and the lowest reading was 10 mg/L which was on class I. So, the range of COD value of Lanas river for four months were within the standard range of National Water Quality Standards of Malaysia which was below 50 mg/L. Increase of COD value in the river was because of the increase of organic matter and inorganic chemicals due to direct discharge from nearby residential area and also waste from livestock animals such as cows at point 3. Location of point 3 was located near Desa Legeh residential area and also the residents of the village also raised livestock animals nearby the river. Direct discharge of untreated domestic waste into the river was the reason for the high organic and inorganic pollution that lead to high average value of COD at point 3 in September (Usharani, Umarani, Ayyasamy, Shanthi, & Lakshmanaperumalsamy, 2010).

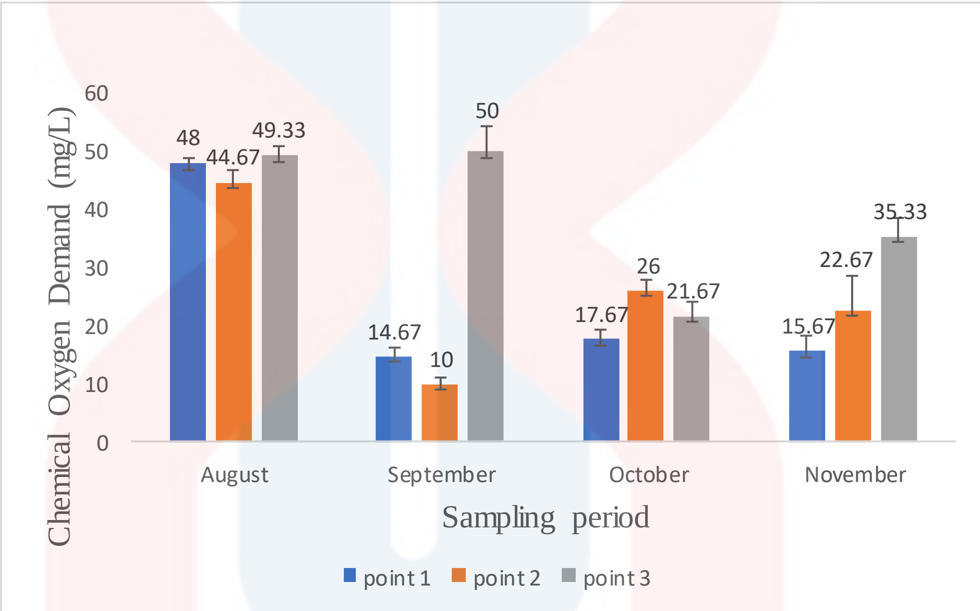


**Figure 4.9:** Mean variation of chemical oxygen demand (COD) of Lanas River

c) Ammoniacal Nitrogen

Figure 4.10 shows the results of ammoniacal nitrogen ($NH_3$-N) for three points at Lanas river. As for the value of ammoniacal nitrogen in August, the highest average value of NH3-N was 0.23 mg/L for both point 1 and point 2 meanwhile the lowest average reading of $NH_3$-N was at point 3 which was 0.12 mg/L. On the other hand, the average result of $NH_3$-N was the highest in September was at point 2 which was 0.22 mg/L and the lowest average value was 0.04 mg/L at point 3 while in October the highest average value of $NH_3$-N was 0.23 mg/L at point 2 and the lowest reading was 0.13 mg/L at point 3. As for November, the last month of sampling, 0.2 mg/L was the highest average reading of $NH_3$-N and the lowest reading of $NH_3$-N was 0.06 mg/L at point 3. The overall range of ammoniacal nitrogen was within the standard range of NWQS which was below 0.3 mg/L which was under class II. Ammonia can be found naturally in the water source and also was produced by human activity. Ammonia is an important source of nitrogen which is needed by plants and animals. Ammonia was use in agriculture which it was applied directly into soil on farm fields, and was used to make fertilizers for farm crops and plants (Effendi, Romanto, & Wardiatno, 2015). On the other hand, ammonia also can be found in many household and industrial cleaners. Thus, the average reading of $NH_3$-N were higher at point 1 and point 2 because point 1 there were many human activities were involved near the river which leads to direct discharges of municipal waste while for point 2 because of the uses of ammonia in fertilizers at the agriculture area.

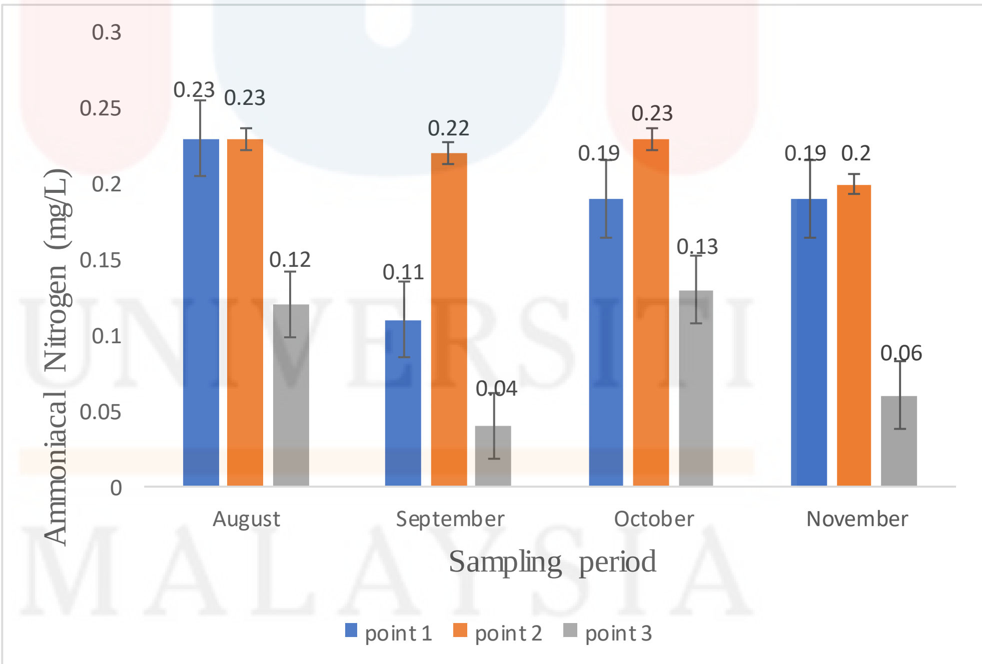


**Figure 4.10**: Mean variation of ammoniacal nitrogen ($NH_3$-N) of Lanas River

d) Heavy metals

The Figure 4.11 and Table 4.1 shows results of the overall type of heavy metals in Lanas river. The types of heavy metals analysed were zinc, cadmium, lead, nitrite, nitrate and phosphorus. As for zinc, the average concentration level of zinc for August, September and November were under class IV which was exceeding the acceptable level of NWQS for Malaysia river as river should be under class IIB that was suitable for recreational uses with body contact. Zinc is one of the important requirement needed in human body, but it is harmful to human if zinc is exceeded as it cause zinc toxicity. As for October, the average concentration level of zinc was within the standard level which was under class I. The contribution to the high level of zinc in the river came from disposal of waste from the residential areas and fertilizer from the agricultural activity at point 2 being discharged into the river(Cheng-Di, Chih-Feng, & Chiu-Wen, 2012).

As for the average concentration of cadmium was the highest at 4.48 mg/L in October and November while the lowest average concentration value of cadmium was 3.97 mg/L in September. The cadmium was exceeding the standard range which was the acceptable range was less than 0.01 mg/L. The use of agricultural chemicals in the agricultural area at point 2 had been indicated as the main anthropogenic source of cadmium pollution in Lanas River.

Next, the highest average concentration of lead was in August which was 6.73 mg/L and the lowest average concentration of lead was 4.78 mg/L in September. The average concentration in August and October were exceeded the NWQS of Malaysia river because the concentration was more than 5 mg/L. The presence of lead in the river water were coming from the domestic waste such as from household food waste and human and animal wastes (Abdel-Shafy & Mansour, 2018).

Besides, for the average concentration of copper, the values were all exceeded within the safe range of NWQS which was more than 0.2 mg/L. The highest average reading of copper was at 4.14 mg/L. Copper can be released into the environment by both natural sources and human activities such as decaying vegetation and phosphate fertilizer production (Lenntech, 2019).

Nitrite was the highest average value of heavy metal in Lanas river which was 16.07 mg/L in November and exceeded the standard range of NWQS due to the use of pesticides from the plantation area. The acceptable range of nitrite is below 0.4 mg/L. The average concentration level of nitrate was only within the standard range for November which was 6.44 mg/L under class II but for the other readings were mostly exceeded. The lowest reading of nitrate was at 0.89 mg/L. Nitrates can be found in river water through the breakdown of human or animal sewage by bacteria in the environment, or by runoff from fertilized land (Effendi et al., 2015). Lastly, for the average concentration of phosphorus were all exceeding the standard range of NWQS for Malaysia river which were above 0.1 mg/L. The highest average concentration of phosphorus was in October which was 5.95 mg/L while the lowest average concentration of was 3.09 mg/L. The presence of phosphorus can be found in agricultural fertilizers, manure, and organic wastes in sewage and domestic effluent which was related to the location of the sampling points (Mainstone & Parr, 2002). Heavy metal pollution and contamination, cause harm to the environment and lead to a serious concern especially on human health and also aquatic life.

**Table 4.1**: The results of the heavy metal of Lanas River

| Heavy metal(mg/L) | August | September | October | November |
|---|---|---|---|---|
| Zinc | 1.92 | 0.38 | 0.00 | 0.38 |
| | 0.38 | 0.38 | 6.92 | 2.69 |
| | 2.69 | 3.46 | 2.69 | 0.38 |
| | 1.66 | 1.41 | 3.20 | 1.15 |
| Cadmium | 3.36 | 5.18 | 4.27 | 4.27 |
| | 5.18 | 4.27 | 1.55 | 8.82 |
| | 5.73 | 2.45 | 8.82 | 1.55 |
| | 4.76 | 3.97 | 4.88 | 4.88 |
| Lead | 4.50 | 7.00 | 7.00 | 4.50 |
| | 6.20 | 4.50 | 2.00 | 9.50 |
| | 9.50 | 2.83 | 9.50 | 1.17 |
| | 6.73 | 4.78 | 6.17 | 5.06 |
| Copper | 2.71 | 4.86 | 3.43 | 2.00 |
| | 4.14 | 3.43 | 1.29 | 8.43 |
| | 5.57 | 2.00 | 7.00 | 1.29 |
| | 4.14 | 3.43 | 3.91 | 3.91 |
| Nitrite | 13.40 | 9.40 | 17.40 | 15.40 |
| | 9.40 | 7.40 | 15.40 | 13.40 |
| | 21.40 | 15.40 | 3.40 | 19.40 |
| | 14.73 | 10.73 | 12.07 | 16.07 |
| Nitrate | 2.56 | 3.67 | 2.56 | 2.00 |
| | 3.11 | 2.56 | 0.89 | 6.44 |
| | 4.22 | 2.00 | 4.78 | 0.89 |
| | 3.30 | 2.74 | 2.74 | 3.11 |
| Phosphorus | 0.00 | 5.00 | 3.57 | 0.71 |
| | 2.14 | 2.14 | 0.71 | 10.71 |
| | 7.86 | 2.14 | 13.57 | 0.71 |
| | 3.33 | 3.09 | 5.95 | 4.04 |

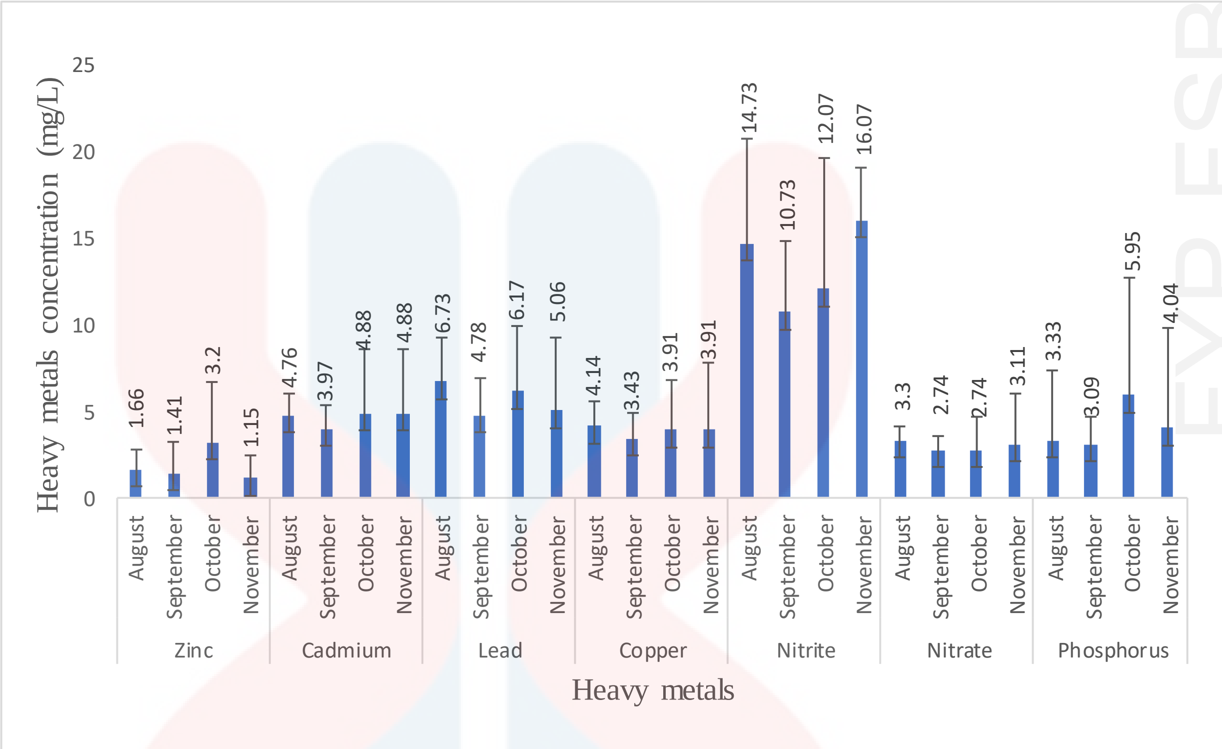


**Figure 4.11**: The concentration of heavy metals in Lanas River

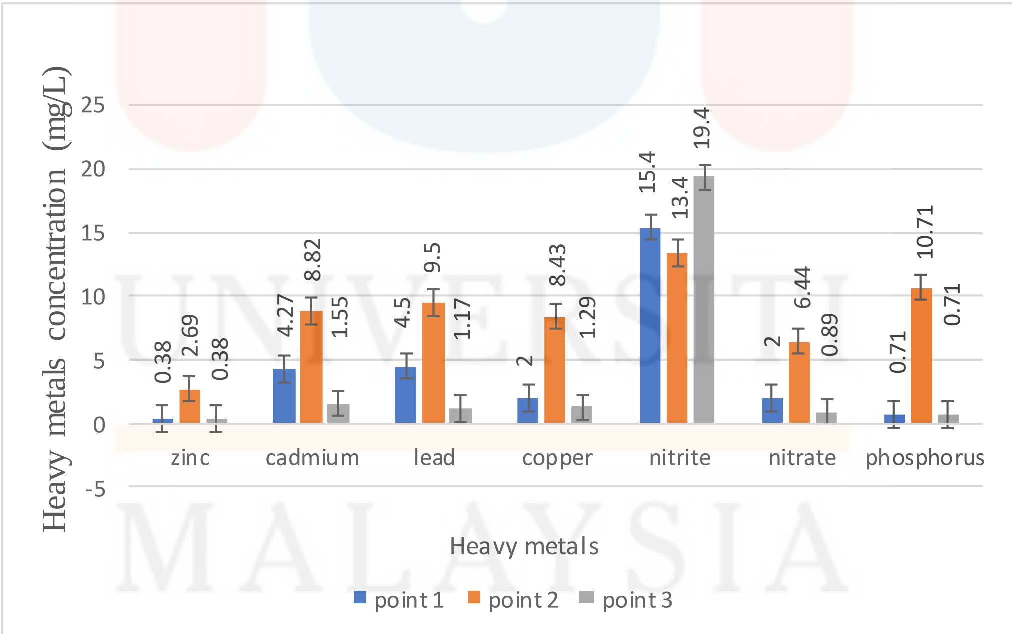


**Figure 4.12**: The heavy metals concentrations in November

The highest value of heavy metal in November was nitrite which was 19.4 mg/L at point 3 and exceeded the standard range of NWQS due to the use of pesticides from the plantation area. Nitrite was the highest reading of heavy metals for all months based on Figure 4.11. In Figure 4.12, the graph was to identify which points have the highest reading of heavy metals which was for nitrite. The highest value of nitrite was the highest at point 3 due to the discharge from point 2 flowed into point 3 and also this river was near to community such as near to residential area, schools and variety of shops that contributes to waste discharge into the water.

## 4.3 Biological Parameters

a) Fecal Coliform Counts and Total Coliform Counts

The results of the fecal coliform counts and total coliforms counts were Too Numerous to Count (TNTC) for all points of point 1, point 2 and point 3 of Lanas River. The serial dilution was made from $10^{-2}$, $10^{-3}$, $10^{-4}$, $10^{-5}$ and $10^{-6}$. The dilution was diluted until $10^{-6}$ but there was no single colony was isolated as the Figure 4.12 below. The reason of the absence of one single colony in the nutrient agar was because of the abundance of microbiota activities in the river caused by the waste discharged from the livestock animals such as chicken and cows (Oram, 2014).

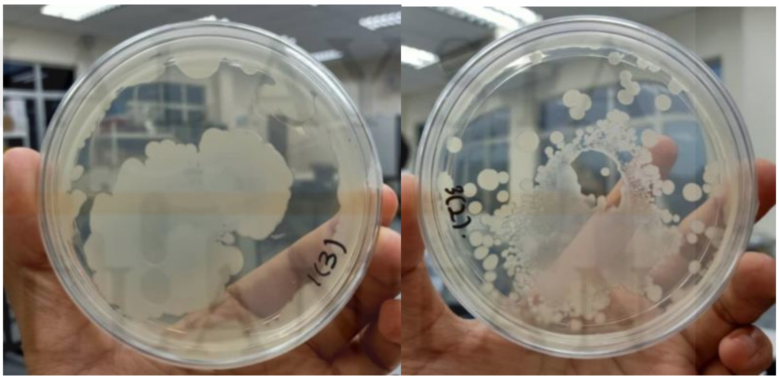


**Figure 4.13**: The agar plates with the abundance of microorganism

### 4.4 Water Quality Index (WQI) Analysis

Water Quality Index or WQI assign quality value to an overall set of the selected parameters. WQI is aiming to summarise or conclude an amount of data from the water quality for a particular river into a simple terms (Zainudin, 2010). The results of the WQI were recorded for each month in Table 4.4, Table 4.5, Table 4.6 and Table 4.7. The selected parameters in the WQI such as ammoniacal nitrogen, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, pH and total suspended solid have its own classification in determining the quality of the water whether it is clean or the water is polluted. DOE Water Quality Index Classification as in Table 4.2 that present the quality class for each of the parameters that can determine the quality of water of a specific river or water bodies. For each range of the selected parameters are very essential to calculate the WQI by following the best fit equations to estimate the various values of sub index as shown in Equation (4.1) (Arif et al., 2018).

**Table 4.2**: The DOE Water Quality Index Classification

| 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 Suspenbed 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 |

**Table 4.3**: Water Classes and Uses

| 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. |

The overall WQI in August were calculated as 23.64 for point 1, 23.35 for point 2 and 25.03 for point 3 and was under class V as shown in the Table 4.4. Heavy downpour a day before the sampling was the main reason for the Lanas river to be classified as class V because the flow of water of the river is not in normal condition. Besides, it is advisable to take the samples, at a minimum of 72 hours after the rain stopped for the river flow to turns normal (Naubi et al., 2016).

**Table 4.4**: The Water Quality Index in August, September, October and November for Point 1, Point 2 and Point 3

| | | Point | | | |
|---|---|---|---|---|---|
| Water Quality Parameters | unit | August | September | October | November |
| Biochemical Oxygen Demand (BOD) | mg/L | 9.3 | 5.33 | 15.3 | 2.88 |
| | | 12.6 | 6.67 | 6 | 4.53 |
| | | 10.2 | 12.33 | 6.90 | 5.41 |
| Chemical Oxygen Demand (COD) | mg/L | 48 | 14.7 | 18 | 16 |
| | | 45 | 10 | 26 | 23 |
| | | 49 | 50 | 22 | 35 |
| Ammoniacal Nitrogen (AN) | mg/L | 0.23 | 0.11 | 0.19 | 0.19 |
| | | 0.23 | 0.22 | 0.23 | 0.20 |
| | | 0.12 | 0.04 | 0.13 | 0.06 |
| Dissolved Oxygen (DO) | mg/L | 6.07 | 6.13 | 2.22 | 2.50 |
| | | 6.20 | 5.76 | 2.81 | 3.40 |
| | | 6.28 | 6.25 | 1.91 | 3.41 |
| pH | | 6.93 | 8.30 | 5.62 | 4.93 |
| | | 6.66 | 8.05 | 5.28 | 4.94 |
| | | 7.06 | 7.91 | 5.14 | 5.27 |
| Total Suspended Solid (TSS) | mg/L | 88 | 21 | 15.3 | 26 |
| | | 77 | 8 | 5 | 24 |
| | | 51 | 7 | 5 | 14.33 |
| Overall WQI And Class Class | | 23.64 (V) | 37.4 (IV) | 34.13 (IV) | 51.71(IV) |
| | | 23.35 (V) | 35.85 (IV) | 41.18 (IV) | 39.98(IV) |
| | | 25.03 (V) | 25.04 (V) | 41.53 (IV) | 43.73(IV) |

In September, the WQI level for point 1 was 37.4, point 2 was 35.85 and 25.04 for point 3. The WQI results were under the class IV which under the uses of irrigation based on Table 4.3 except for point 3 which was under class V.

As for October, all the points were under class IV and the overall WQI were 34.13, 41.18 and 41.53. Based on Table 4.3, class IV was under the use of irrigation for Lanas river but it is supposed to be under class IIB for recreational uses with body contact suitable for its location which is near the community.

For the last month of sampling in November, the WQI were classified as class IV similar with September and also October. 51.71 was the overall WQI for point 1, 38.98 for point 2 and lastly, 43.73 for point 3 shown in Table 4.4.

The overall WQI for Lanas River was supposed to be under class IIB suitable for recreational use body contact because of the sampling location as all points involved human and animal interaction. The source of Lanas river water quality degrading because of discharging of domestic waste from point 1 and point 3 as the location were nearby the residential area and also effluent discharging from the agricultural activities that affect the water quality of the river (Rohani, 2012).

# CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

Based on this research, the level of water quality of Lanas river are determined by using Water Quality parameters such as $NH_3$-N, COD, DO, BOD, TSS and pH while the additional parameters were conductivity, salinity, temperature, turbidity, fecal coliforms and total coliforms counts, zinc, cadmium, lead, copper, nitrite, nitrate and also phosphorus. The additional parameters were used to analysis data including WQI in this study in order to get better assessment on the water quality. Meanwhile, the major factors that influenced the quality of water of Lanas river were also identified at the selected area of point 1, point 2 and point 3 along the river. Nitrite was the highest concentration of heavy metals in Lanas due to the discharge from point 2 flowed into point 3 and also the location that was near to community which contributes to the discharge of waste into the water. The results of the fecal coliform counts and total coliforms counts were Too Numerous to Count (TNTC) for all sampling points because of the abundance of microorganism's activities in the river.

The overall WQI for Lanas river was classified as class IV due to the human activities that are involved there such as the discharge of waste from the household or pesticides from the plantation area as point 1 and point 3 are near to the residential area which are Ayer Lanas and Desa Legeh while point 2 is near the plantation area of lime and rubber tree.

## 5.2 Recommendation

Jeli District Council should do frequent river monitoring in order to prevent water pollution by irresponsible human activities such as discharge of domestic waste directly to the river. Among all of the activities that can contribute to river pollution, dumping of garbage and other waste materials leads to the main cause of river pollution. Materials such as plastics that was being dumping into the river are non-degradable and may affect the aquatic life in the river. Besides, when the water is polluted, people are not advisable to use the water and have to seek for an alternative to find other water sources. In addition, it is recommended that further research is perform on other additional parameters in order to get more and precise assessment on the water quality.

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**APPENDIX A**

**WQI FORMULA AND CALCULATION FORMULA**

WQI = (0.22* SlDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16 * SISS) + (0.12 * SipH)

where; SIDO = Sublndex DO (% saturtlon)

SIBOD = Sublndex BOD

SICOD = Sublndex COD

SIAN = Sublndex NH3–N

SISS = Sublndex SS

SipH = Sublndex pH

$0 \leq WQI \leq 100$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALIES

Sublndex for DO (In % saturatlon)

SIDO = 0 for $x \leq 8$

SIDO = 100 for $x \leq 92$

SIDO = $-0.395 + 0.030x2 - 0.00020x3$ for $8 < x < 92$

Sublndex for BOD

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

SIBOD = 108* exp(–0.055x) – 0.1x for x > 5

Sublndex for COD

SICOD = –1.33x + 99.1 for x ≤ 20

SICOD = 103* exp(–0.0157x) – 0.04x for x > 20

Sublndex for NH3–N

SIAN = 100.5 – 105x for x ≤ 0.3

SIAN = 94* exp(–0.573x) – 5* I x – 2 I for 0.3 < x < 4

SIAN = 0 for x ≥ 4

Sublndex for SS SISS = 97.5* exp(–0.00676x) + 0.05x for x ≤ 100

SISS = 71* exp(–0.0061x) + 0.015x for 100 < x < 1000

SISS = 0 for x ≥ 1000

Sublndex for pH SlpH = 17.02 – 17.2x + 5.02x2 for x < 5.5

SlpH = –242 + 95.5x – 6.67x2 for 5.5 ≤ x < 7

SlpH = –181 + 82.4x – 6.05x2 for 7 ≤ x < 8.75

SlpH = 536 – 77.0x + 2.76x2 for x ≥ 8.75

Note: *means multiply with