COMPARISON OF WATER QUALITY AND HEAVY METALS CONCENTRATION BETWEEN LATA JANGGUT AND LATA KEDING, JELI, KELANTAN

by

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DECLARATION

I declare that this thesis entitled "Comparison of Water Quality and Heavy Metals Concentration between Lata Janggut and Lata Keding, Jeli, Kelantan "is the result of my own research except as cited in the reference. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of my other degree.

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Comparisons of Water Quality and Heavy Metals Concentration between Lata Janggut and Lata Keding, Jeli, Kelantan

ABSTRACT

Water quality becomes a concern issues because low water quality can affect to organisms and ecosystem Therefore, a study was conducted at two sites which are Lata Janggut and Lata Keding that being attraction to community at Jeli District. The main objective of this study was to determine water quality index and classification at the cascades, also to determine physical parameters which are pH, Total Dissolved Solids (TDS), Salinity, Dissolved Oxygen (DO), and Electric Conductivity (EC) by using Multiparameter (YSI), while for chemical parameters are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH3N), and Total Suspended Solids (TSS) by using HACH DR6000 UV-VIS Spectrophotometer, same goes to selected heavy metals; zinc, copper and iron. This research provides information about water quality data at Lata Janggut and Lata Keding, as a future reference for any agencies and community uses. 12 samples were collected from each of two points; flowing water and stagnant water area for two times sampling (July and August). Water Quality Index (WQI) of Lata Janggut was analyzed with 69.07 (Class III), and Lata Keding with 71.75 (Class III), according to the WQI value suggested by DOE of Malaysia. Therefore, Lata Janggut and Lata Keding was still in good conditions, but further monitoring is needed to avoid any environmental issues occur.

Perbandingan Kualiti Air dan Kepekatan Logam Berat di antara Lata Janggut dan Lata Keding, Jeli, Kelantan

ABSTRAK

Kualiti air menjadi masalah yang membimbangkan kerana kualiti air yang rendah akan mempengaruhi organisma dan ekosistem. Oleh itu, satu kajian dilakukan di dua lokasi iaitu Lata Janggut dan Lata Keding, yang merupakan daya tarikan masyarakat di Daerah Jeli. Tujuan utama kajian ini adalah untuk menentukan indeks kualiti air dan klasifikasi di lata tersebut, serta menentukan parameter fizikal iaitu pH, Jumlah Pepejal Terlarut (TDS), Kemasinan, Oksigen Terlarut (DO), dan Konduktiviti Elektrik (EC) oleh Malti-parameter (YSI), manakala bagi parameter kimia ialah Permintaan Oksigen Biokimia (BOD), Permintaan Oksigen Kimia (COD), Amonia Nitrogen (NH3N), dan Jumlah Pepejal Terampai (TSS) dengan menggunakan Spektrofotometer UV-VIS HACH DR6000; zink, tembaga dan besi. Penyelidikan ini memberikan maklumat tentang data kualiti air di Lata Janggut dan Lata Keding, sebagai rujukan masa depan kepada mana-mana agensi serta untuk kegunaan masyarakat. 12 sampel dikumpulkan dari setiap dua titik kawasan air; air mengalir dan kawasan air bertakung, sebanyak dua kali pensampelan sahaja (Julai dan Ogos). Indeks Kualiti Air (WQI) untuk Lata Janggut adalah 69.07 (Kelas III), dan Lata Keding dengan 71.75 (Kelas III), dengan berpandukan nilai WQI yang dicadangkan oleh DOE Malaysia. Demikian itu, Lata Janggut dan Lata Keding masih dalam keadaan baik, tetapi pemantauan lanjut diperlukan untuk menghindari masalah-masalah alam berlaku.

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etc.	Et Cetera
DOE	Department of Environment
EIA	Environmental Impact Assessment
NQWS	National Water Quality Standards for Malaysia
pH	Potential Hydrogen
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
AAS	Atomic Absorption Spectroscopy
µm	Micrometer
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
mg/L	Milligram per Liter
N	North
E	East
Km	Kilometer
mL	Milliliter
Zn	Zinc
Cu	Copper
Fe	Iron

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The body of the water is the most fundamental source of human civilization. Freshwater are comprising rivers, wetlands waterfall, springs, aquifer, and others. Freshwater ecosystem cannot be denied as the important of life support systems on Earth. Each of the freshwater body has the physical and chemical properties which are determined primarily by climatic, geomorphological and geochemical conditions (Meybeck et al,1996). Clean, safe and adequate freshwater is essential for the survival of all living organism and for the smooth functioning of ecosystems, communities and economics. Poor water quality will become global issues once industrial and agricultural activities expand, a human population growth and climate change threatens that causing major changes to the hydrological cycle (WHO, 2011).

Bad water quality had direct impact on the quantity of water in several ways. Contaminated water that cannot be used for drinking, bathing, industry or agriculture will effectively reduce the amount of water that can be used in certain areas. About 700 million people today in 43 countries are experiencing the lack of water, in which there is adequate water resources to meet long term needs(Enderlein et al, 1996). By 2025, 1.8 billion people will be live in countries or regions with absolute water shortages, and two-thirds of the world's population can live under water pressure. With the current climate changes scenario, almost half of the world's population will live in high pressure area by

2030, including between 75 million people in 250 million in Africa (WHO, 2011).

Sanitation investments and water drinks have a high rate of return for the costs of avoiding, saving, reducing illness and healthcare expenses, healthier working days, better education and productivity improvement. Through the Millennium Development Goals, the international community has committed to reducing the half-population without access to clean water and basic sanitation by 2015 as a key element in eliminating poverty and increasing billions of people worldwide. Access to safe and clean water for human consumption is declared as human rights by the United Nations General Assembly in 2010- and water quality is essential to realize the rights (Boylan, 2008)

In addition, Malaysia commonly used in producing agricultural products, aquatic inland reserves, Malaysia also serve as habitat for wildlife, including endemic and endangered species (Hendry et al, 2006). Moreover, some efforts have been undertaken by the Department of Environment to maintain a reasonable standard of water quality despite the rapid urbanization of the reservoir catchment area. The DOE uses the Water Quality Index (WQI) to assess the quality status of water bodies in Malaysia which is the basis for Environmental Impact Assessment (EIA), from any waterways, pollutant load categories and usage classifications used under the National Water Quality Standards for Malaysia (NWQS) (Report, 2015)

1.2 Problem statement

Kelantan is one of the states that have been blessed with natural beauty, heritage and cultural strength, unique food paradise and the beauty of arts and crafts. Kelantan has many interesting natural attractions and unique geological. One of 10 Kelantan districts is, state of Jeli, whereas many places that not been discovered yet by people but are blessed with beautiful geological and landscapes, unique geological phenomena and precious earth materials, including hills, caves, rivers, waterfall, the hot spring and gold deposits (Adriansyah et al, 2015).

Water quality can change times by times, as it can cause by indirectly or directly sources such as human activities, uncontrolled sewage, or heavy metals and sediments. Meanwhile, Lata Janggut is one of the famous ecotourism places in Jeli, Kelantan. People tend to come to Lata Janggut during their leisure time, and doing recreational activities such as swimming, jungle trekking, camping, and barbeques. Literally, Lata Janggut would crowd with visitor during school holidays or weekend. Therefore, the water quality might be affect due to the overcrowding and increase of human activities such as fishing and barbeque. Therefore, this condition is very serious issues as it can probably cause the water quality gets polluted, if there is no essential measure to control the entry of the sewage, manage the quality of water and the sediments from river, and utilize water for various purposes.

Same goes to the Lata Keding, which is one of the new attractions places that have been discovered recently by community of Jeli. Lata Keding was a small waterfall in front of UMK Jeli. As Lata Keding is a new attraction places, people was overwhelmed with the accommodations that have been provided by Jeli Council such as chalet, small café, toilet, etc. Almost every weekend Lata Keding was crowded with people. Most of them tend to do recreational activities such as camping, picnic, bathing and trekking. Therefore, Lata Keding also might get affected from any factors such as human activities, as monitoring measure was needed to avoid any contaminant and pollution occur.

1.3 Objectives

The objectives of the study are as follow:

1. To determine the water quality index and classification of Lata Janggut and Lata Keding, Jeli, Kelantan.
2. To compare the physico-chemical parameters and selected heavy metals between Lata Janggut and Lata Keding, Jeli, Kelantan.

1.4 Significant of study

Based on this study, it will provide information about water quality data that could be serve as reference for any government agencies especially for Jeli District Council to assess any future changes in water quality at Lata Janggut and Lata Keding. Apart from that, based on this study, it can provide information to the Ministry of Tourism in Kelantan regarding the Lata Janggut's water quality, as well as introduce the beauty of Lata Janggut as a tourist destination then can increases the number of tourists to come to Kelantan. Meanwhile, Lata Keding is still developing as a new recreational place for the tourism, thus this research is a good platform to promote the Lata Keding as a recreational place with good water quality. Besides, through this study, it will give extra information or input to the local community of Jeli about the water quality for both of the cascades. Thus, they can avoid any consequences to occur during their visit at the cascades. Furthermore, by doing this research, any directly factors can be find out whether any sedimentation and heavy metals level had in that cascades, which is can show that the water either polluted or not and not suitable for recreational activities. If there is any contaminant at Lata Janggut or Lata Keding, this research is one of the mitigation measures to avoid any consequences occur.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Quality Parameters

Having good water quality is essential for a healthy river and ecosystem. Some basic needs must be met for aquatic life to thrive in the water. When this is not optimal, aquatic life will be stressful. When the condition becomes weak, the organism might die. Therefore, various water quality parameters need to be measured to determine the river's health to be safe for any purpose. As to develop water quality index or river index, there is several parameters need to consider.

2.1.1 The Physical Parameters of Water Quality

There are many types of physical parameters such as pH, temperature, turbidity, dissolved solids, and dissolved oxygen that are used for water quality assessment. Each of parameter has a significant effect on the water quality.

i. pH

Water contains hydrogen ions, H+ and hydroxide ions, OH-. Relative concentrations these two ions determine the pH 7 which has the same concentration two ions and considered neutral solutions. On scale of pH 0 to 14, the value of 0 is the most acidic and 14 is the most basic. Once change from pH 7 to pH 8 on the lake or river representing a tenfold increase in OH- ion concentration.

Measurement of water pH is very important as water quality indicator, because of the sensitivity of aquatic organisms to pH around. Small changes in pH can damage a variety of plants and animals, for example, trout and various types of nymph can only survive in water between pH 7 and pH 9. If the pH of water they live away, they may not live nor reproduce. pH change may also be due to algae, industrial processes that produce base or acid discharges, or oxidation of sulphide that containing sediment (Quality, n.d.).

ii. Dissolved Oxygen (DO)

Oxygen is a clear, colorless, odorless and tasteless gas dissolved in water. Small but important amounts are dissolved in water. The plants and animals were depended on dissolved oxygen for survival. Aquatic life can easily face death or leave the area for lack of dissolved oxygen. Oxygen levels can up and down widely throughout the day and year. Sadly, fish and other organism have to live and breathe in that water all year along (WAV, 2006). Excessive amount of organic matter such as sewage, manure, or leaves that wash into streams can reducing the dissolved oxygen level. Besides, dissolved oxygen also can reducing from arm water that been released from industrial outlets, flowages, or storm sewers (WAV, 2006).

iii. Total Dissolved Solids (TDS)

Total Dissolved Oxygen (TDS) is an inorganic and small amount of organic matter that presents in the water. TDS usually sources from natural sources, sewage, urban and agricultural activities, and also industrial wastewater (WAV, 2006). The presence of synthetic organic chemicals-fuels, detergents, paints and solvents would give effects to aquatic plants and fish, even they present in low concentrations (Fulazzaky, Seong, & Masirin, 2010).

iv. Salinity (Sal)

Salinity categorized into two types – dryland and irrigation salinity. The impact of salinity to the environment is widely, as people might plants by salt-tolerant species, meanwhile organism could lost their source of food, then lead to changes of ecosystems (Karmabunny, 2018). Nevertheless, high saline in groundwater can seep into rivers then affected water quality, in fact increasing salinity can leads to decreasing of biodiversity and an increasing in the prevalence of more salt tolerant species (Karmabunny, 2018).

v. Electric Conductivity (EC)

Conductivity is the measure ability's water to conduct electricity, depend on the concentration of dissolved ions in the water. Conductivity usually measured using special equipment and express in unit (μS/cm). Conductivity measures can be easy and fast, as to estimate the amount of total dissolved solids (TDS) in natural waters (Quality & Guide, n.d.). Municipal water supply is monitored for conductivity, as the increase in soluble solids in water supply can produce hard water, increase the pipe expansion and change the water's taste (Quality & Guide, n.d.). In addition, conductivity analysis is important for aquariums and fish spawning habitats, as many species are sensitive to sudden changes in their environment salinity (Quality & Guide, n.d.).

2.1.2 The Chemical Parameters of Water Quality

Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen and Total Suspended Solid (TSS) are the examples of chemical parameters used to determine the water quality.

i. Biochemical Oxygen Demand (BOD)

BOD is essential to determine the potential of pollutants in term of oxygen required to stabilize domestic and industrial wastes. For oxidation of organic matter to occur at a minimum of 2 to 7 mg/L the DO level shall be maintained at laboratory trials or available in natural waters (Fulazzaky et al., 2010). BOD also measures the amount of food especially organic for bacteria that found in the water. The BOD test gives a rough idea on how much biodegradable residual in the water (WEPA, 2016).

ii. Chemical Oxygen Demand (COD)

COD test, is commonly used to indirectly use to measure the amount of organic in water. Most COD applications determine the amount of organic pollutants in surface of water or wastewater, making COD a useful measure of water quality. It expressed in mg/L which indicates the mass of oxygen used per liter of the solution (Nordin et al, 2013).

iii. Total Suspended Solid (TSS)

Total Suspended Solids (TSS) in water that can capture by the filter, it can cover various types of materials such as mud, plant and animals, industrial waste and sewage. High concentrations of suspended solids can cause many problems for health and current aquatic life (Rafiuddin, Ruslan, & Arman, 2015). High concentrations of suspended solids can be solved in rivers or lakes bottom and closure of aquatic organisms, eggs, or macro-invertebrate larvae. This coating can be avoiding adequate oxygen transfer and resulting in death of buried organisms. Suspended solitary depth reduces the effectiveness of drinking disinfect water by allowing "hidden" microorganisms from disinfection of the body solid aggregates. This is one of the reasons TSS, or turbidity, is issued in drinking water treatment facilities (R, 1993).

iv. Ammoniacal Nitrogen (NH3N)

Ammonium ion, NH4 is an important member of the group of nitrogen contained compounds that act as nutrients for aquatic plants and algae. This fact allowed, regarding the concentration of all nitrogen in the form of ammonia and ammonium combined, commonly called nitrogen ammonia, by measuring only concentrations ammonium ion (Mr. Brian Oram, 2014). Ammonium-nitrogen levels are usually quite low in moving surface waters. This is because there is little decaying organic matter collecting on the bottom. If there is a high level of ammonium nitrogen in a moving stream, it may be an indication of pollution of some kind entering the water. Meanwhile, for Ponds and swamps usually have a higher ammonium nitrogen level than fast-flowing water. Because the sources of ammonia in fish ponds is the decomposition of fish wastes and the remains of fish feeds, which can produce ammonia gas in water. As the ammonia accumulates in pond water, it can be toxic for fish.

2.1.3 The Heavy Metals Properties of Water Quality

Metals naturally occur and become integrated into aquatic organisms through food and water. Metal channels such as copper, selenium, and zinc are important metabolic components at low concentrations. However, metals tend to accumulate bio in tissue and prolonged exposure or exposure to higher concentrations can lead to ailments. High metal concentrations can have a negative impact on wildlife and humans. Human activities such as mining and heavy industries can cause heavy metal concentrations higher than those found naturally in the rivers (Shah, 2017).

i. Copper (Cu)

Copper is a stable transition metal in its metal state and form monovalent cation (cuprous) and divalent (cupric). Copper is usually found on the surface of water, underground water, sea waters and drinking water, but it is mainly found in complexes or as particulate matter (Florio, 1997). For aquatic life, fish and shellfish are exposed to copper through their gills and the water and sediments in which they live. The impact of copper on aquatic life might be able to be directly and indirectly sources. The higher toxicity of copper towards fish gills, could effecting the normal functioning of the cardiovascular and nervous system (Shah, 2017). Meanwhile, human is exposed to copper through inhalation of particulate matter, drinking copper contaminated water and eating copper-contaminated food. In fact, when a person was exposing to the copper level above the highlighted levels needed for good health, the liver and kidney produce (Ramchander et al., 2015).

ii. Zinc (Zn)

Zinc is a metal element form, which is bluish-white metal. Zinc naturally found at low concentrations in many rocks and soils, which are act as sulphide ores and to lower level as carbonates. Zinc was entering water naturally by erosion of minerals from rocks and soil. Most of the zinc was enter the water by artificial pathways such as from steel production or coal-fired power stations, or burning of waste materials. Zinc is also used in some fertilizers underground water. The older galvanized metals pipe and coating shades have been coated with zinc that can be dissolved by soft and acidic waters. Zinc is important for body development but if high level of zinc had in drinking-water, it could lead to stomach cramps, nausea and vomiting (Salem, 1995).

iii. Iron (Fe)

Iron primarily found in soil, sediments and underground water and also can be found most f rocks. Iron is important roles in maintaining of energy metabolism and the prevention of iron deficiency anemia. Iron literally can be found in food – eggs, lean red meat, bean, peas, and other legumes. Basically iron naturally exists in river, lakes, and groundwater. However, some of iron was released from natural deposits, industrial wastes and corrosion of iron that contained metals. Iron is a good nutrient content to health; however the greater consumption of iron in body might damage blood vessels, cause bloody vomit, and damage the liver and also kidney if generally expose to a high concentration of iron (Andromeda Ricky, 2016)

2.2 Water Quality Index (WQI)

Most countries practice the Water Quality Index (WQI) method which is similar to the existing DOE index which stated water quality through one digit by combining selected parameters of physical, chemical, biological and radioactive parameter (Ibrahim, 2016). In general, WQI is a unit of less number that varies between 0 and 100. Higher index values represent good water quality. Therefore, the numerical index is used as a management tool in water quality assessment (Fulazzaky et al., 2010).

In general, WQI is a unit of less number that varies between 0 and 100. Higher index value represents good water quality. This index reflects the water quality status in lakes, rivers, rivers and reservoirs. The WQI concept is based on the comparison of water quality parameters with their respective regulatory standards (Zati & Salmah, 2008). The water quality index combines several important water quality parameters which provide a total water quality index for specific uses. Pollutants and different factors are needed for index development. The simplest WQI reflects several water quality parameters such as dissolved oxygen, soluble solvent volume, pH, and possibly some nutrients. Measurement of each of these parameters is taken and compared to the classification table, where water is recognized as being very good, good, fair, poor or very poor (Ezekiel, Abowei, & Ezekiel, 2011)

Table 2.1: Water Use Classes in the National Water Quality Standards

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: DOE Water Quality Classification Based on Water Quality Index

Sub Index & Water Quality Index	Index Range		
	Clean	Slightly Polluted	Polluted
Biochemical Oxygen Demand(BOD)	91 - 100	80 – 90	0 - 79
Ammoniacal Nitrogen(NH3-N)	92 - 100	71 – 91	0 - 70
Suspended Solids(SS)	76 - 100	70 – 75	0 - 69
Water Quality Index(WQI)	81 - 100	60 – 80	0 - 59

Table 2.3: 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 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

2.3 Statistical Analysis

Statistical analysis is science of collecting, exploring and presenting large amounts of data to discover underlying patterns and trends. Statistics basically was applied almost every day, in research, industry and government, as to become more scientific about decisions that need to be made. Statistical analysis has a lot of concept and way to analyze a data. For example; descriptive analysis, numerical data analysis, design experiment – ANOVA, categorical data analysis – Chi Square Test and qualitative data analysis, Linear regression, Non-linear regression and Multivariate analysis (Ahmad et al, 2017).

2.3.1 Non-Parametric Test

Non-parametric test are frequently used in place of their parametric counterparts when assumptions about the underlying population are questionable such as normality assumption or when observation may be measured on an ordinal scale (Ahmad et al., 2017).

i. Mann-Whitney U Test

The Mann-Whitney U Test or also called as the Mann-Whitney –Wilcoxon (MWW), is an alternative test to the t-test. It is a non-parametric test that is used to compare two population means originated from the same population, and to test the equality between two population’s means. The Mann-Whitney U Test is applied for equal same size, and is used to test the median of two populations. This test is usually used when the data are ordinal. The Mann-Whitney U Test can be applied for the unknown data distributions, the random samples drawn from the population and the samples do not need to be normally distributed (Ahmad et al., 2017)

ii. Spearman's Correlation

Correlation is one of the most common and useful statistics, which is a statistical measurement of the relationship between two variables. Correlation coefficients can range from -1.00 to +1.00. A zero correlation indicates that there is no relationship between the variables. A correlation of -1 indicates a perfect negative correlation, meaning that as one variable goes up, the other lead down. A correlation of +1 shows a perfect positive correlation, meaning that both variables move together in the same direction (Ahmad et al., 2017).

Hence, in this studies, Spearman's correlation is the non-parametric version of the Pearson product moment correlation. Spearman's correlation determines the strength and direction of the monotonic relationship between two variables rather than the strength and direction of the linear between two variables, which is what Pearson's correlation determines (Fu & Wang, 2012)

CHAPTER 3

MATERIALS AND METHOD

3.1 Study area

3.1.1 Lata Janggut

The research will be conducted at Lata Janggut in Jeli, Kelantan. Lata Janggut is selected as study area because its known as a famous ecotourism place, in which had potential to get poor water quality due to the amounts of people come to the cascades compare to other places in Jeli, Kelantan. The coordinate of study area is between N 5’40’0” to N 5’42’30” and E 101’44’00” to E 101’47’00”. The distance located 12 kilometer southwest of Jeli and approximately seven kilometer from the Jeli town (Adriansyah et al, 2015). While from UMK Jeli Campus, it is about 10-15 km. The study area becoming the attraction to the people around the district of Jeli for recreational activities such as swimming, camping, jungle trekking, and barbeques as be mentioned before. The Lata Janggut is part of the Long River, a tributary of Pergau River, and situated within the Gunung Basor Forest Reserve (Adriansyah et al, 2015).

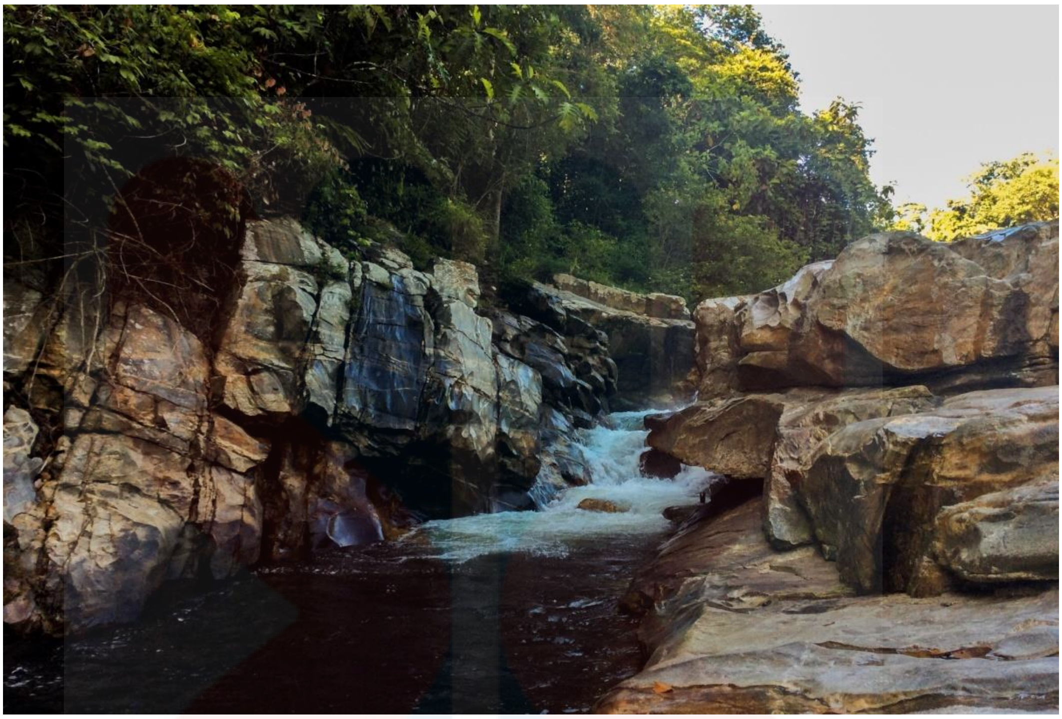


Figure 3.1: Lata Janggut – taken on 29 July 2018

Figure 3.2: Lata Janggut

3.1.2 Lata Keding

This study also had been conducted at Lata Keding, in Jeli, Kelantan. Lata Keding was chosen as the research area because it is a new developed recreational area compared to the Lata Janggut. Literally Lata Keding, has been around for a long time ago, but not very well known as it only serves as bath and picnic area for the locals. Before the Jeli Council takes action to promote the Lata Keding publicly and provide a proper accommodation there, the pathway to go there was quite difficult and dangerous as it is surrounded by long bushes. But after promoting openly to the community, the cascade was gaining more attention and more visitors day by day. The coordinate of study area is between N 5’44’48.1” TO N 5’44’48.4” and E 101’50’53.7” to E 101’50’53.6”. The distance was located seven kilometers from Jeli town, and take 8-minute driving from Jeli town. But only take 2-minute driving from UMK Jeli Campus. The study area become more attraction for people not only their recreational activities but also equipped with chalet, dormitory, campsite, restaurant, toilet and mini zoo.

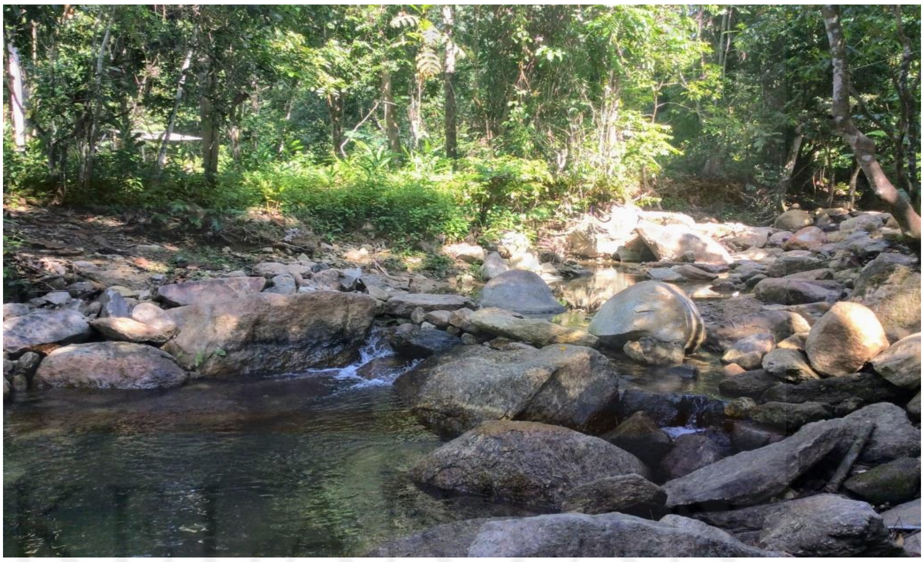


Figure 3.3: View at Lata Keding – taken on 29 July 2018

3.2 Data Collection

A total of 24 samples; 12 bottles of samples for the first sampling and another 12 bottles of samples for the second sampling, have been analyzed for the selected nutrients, physical and chemical parameters. Samples of water have been collected from two different cascades which is Lata Janggut and Lata Keding at Jeli area, Kelantan. The first sampling has been done on 29^{th} of July 2018 meanwhile for the second sampling have been done on 12^{th} of August 2018. For each places, the water samples were collected from two different areas which is, from flowing water area and stagnant water area. The timing of sampling may not statistically relate as there are limitations in usage of laboratory instruments.

The water samples were collected according to each parameter sampling procedures. The sampling bottles were from plastic and after collect the water samples; it was being put into icebox that filled in with ice – to give cold temperature to the water samples. After that, water samples were transferred into chiller by 4° C before doing the laboratory test, whereas to preserve the content of the sample and to lengthen holding time.

3.2.1 Sampling Method

In the study area, the equipment or tool that being used to collect and monitored the water samples is YSI MPS (Multiprobe System).

YSI 556 MPS (Multiprobe System) is a handheld multipara meter that meter provides extreme flexibility for the measurement of a variety of combinations for dissolved oxygen, salinity; total dissolved solid (TDS), pH, and temperature.

During the sampling, all the information included general environmental conditions such as nature of the surrounding landscape, the state of the tide or water flow, weather conditions, and general water conditions such as color, water temperature, etc. also had been considered to reduce any future problems.

3.3 Chemical Parameters Analysis

In this analysis, the collected water sample were analyzed for the chemical parameters which were Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammoniacal Nitrogen (NH3N) and Total Suspended Solid (TSS). The collected water samples are undergoing several analytical procedures, by using APHA Spectrophotometer method. The water quality at Lata Janggut and Lata Keding were analyzed from the chemical parameters above.

3.3.1 Biochemical Oxygen Demand (BOD)

The water samples were collected in plastic bottles. The bottle was filled in to exclude air means that to prevent bubbles from forming. As the sample may degrade during storage, thus the reduction is able to be minimizing through analyses the sample promptly or cool it near to freezing temperature during storage. The maximum holding time recommended between collection and analysis was 48 hours. Before starting the analysis, the sample needs to be warm in chiller to 20-27 ± 3°C.

The method used in texting the BOD was Dilution Method (Method 8043), adapted from Standard Methods for the Examination of Water and Wastewater. First of all, sample dilution water was prepared using a BOD Nutrient Buffer Pillow (reagent). A serological pipette is used to measure a graduated series of five portions of well-mixed sample and transfer to separate, glass-stoppered, 300 mL BOD bottles. After that, the bottle was stopper without any trap of air bubbles then invert several times to mix. Then, the bottle was filled in dilution water to just below the lip. For blank preparation, the BOD bottle was filled in with dilution water only. The initial dissolved oxygen value was determined using probe meter (HQ40d). After enough dilution water is added to the lip of the BOD bottle to make a water seal. A plastic over cap is placed over the lip of each bottle and bottle is placed in an incubator at 21°C. The bottle is incubated in the dark for five days. When the five days' incubation period is complete, the dissolved oxygen content is determined in each bottle. The results are in (mg/L DO remaining). Then after five days, the remaining DO concentration in each bottle is measured.

3.3.2 Chemical Oxygen Demand (COD)

The sample was collected with glass bottle. The method that is used in testing COD is Reactor Digestion Method (Method 8000) (HACH, 2014). First of all, the reactor is turned on and preheats to 150°C. The cap of a COD Digestion Reagent Vial is removed for the appropriate range. After that, the 2.0 mL of sample is carefully pipetted into the vial. Then, the vial is placed in the preheated DRB200 Reactor. The protective lid is closed. After that, the reactor is turned off and waits until the vial to cool to 120°C or less for about 20 minutes. The vial is inverted in several times while still hot. The vial is placed into a rack to cool to room temperature. Then, a calorimetric determination was used to measure the COD mg/L.

3.3.3 Ammoniacal Nitrogen (NH3N)

The sample was collected by using polyethylene bottle. The method that is used on testing the ammoniacal nitrogen is Salicylate Method (Method 8155) (Hach Company, 2015) that usually for water, wastewater and seawater.

Firstly, for the sample preparation, a square sample cell is filled to the 10mL mark with sample. The contents are added of one to each cell. The contents is closed and shaken well to dissolve the reagent. By using an instrument timer, a three-minute reaction period will begin. When the timer expires, the contents will be added with one Ammonia Cyanurate Reagent Powder Pillow to each cell. The contents is closed and shaken well to dissolve the reagent. A 15-minute reaction period is beginning until a green color develops if ammonia-nitrogen is present. The prepare sample is inserted into the cell holder and the result will show in mg/L.

3.3.4 Total Suspended Solids (TSS)

The samples were collected by using polyethylene bottle. The container is filled to exclude the air. The method that is used is Photometric Method (8006) that is adapted from Sewage and Industrial Wastes (1959). First of all, 10 mL of water sample is poured into a sample cell. The gas bubbles are removed in the water by swirling or tapping the bottom of the cell on a table. The blank is inserted into the cell holder with the fill line facing right. The prepared sample is swirled to remove any gas bubbles and uniformly suspend any residue. The results will show in mg/L.

3.4 The Heavy Metals Analysis of Water Sample

For the selected heavy metals analysis which are Copper, Zinc and Iron analysis, a DR 6000 UV-VIS Spectrophotometer was used for determine the concentration heavy metals in water samples. The selected heavy metals were measured using powder pillows method for characterization of the samples.

3.4.1 Copper (Cu)

By using Method 8506, the 10ml of water sample was filled into samples cell. Next, a Cuver 1 Copper Reagent powder pillow was added into the sample cell, then immediately swirled to mix. A 2-minute timer was set up to see the any color changes. Next, within 30 minute after the time out, insert the blank cell first then put the prepared samples into the holder of DR 6000 UV-VIS Spectrophotometer. Then, the reading value was taken in mg/L.

3.4.2 Zinc (Zn)

By using Method 8009 (Method, 1980), 20ml of sample was filled into the 25ml graduated mixing cylinder. After that, one contents of ZincoVer 5 Reagent Powder Pillow were added into the mixing cylinder. Shake the cylinder vigorously to dissolve the powder completely. Then, wait for few seconds to see any color changes, after that use a plastic dropper to add 0.5ml of cyclohexanone to the solution in the mixing cylinder. Next, within the 30 seconds reaction, close the mixing cylinder and shake vigorously the prepared sample to see the color changes – reddish-orange, brown or blue in which depend on zinc concentration, then wait another 3-minute reaction. After time expires, the prepared sample was inserting into the cell holder and the reading was taken in mg/L.

3.4.3 Iron (Fe)

By using Method 8008 (HACH, 1980), 10ml of sample was filled in with water samples, after that a one FerroVer Iron Reagent Powder Pillow was added into the sample cell. Next, swirl the sample cell to mix. Start the instrument timer with 3-minute reaction to see any orange color that show iron present in the samples. Then, the blank sample was cleaned and put into the cell holder after time expires and after that put the prepared samples. The reading was taken in mg/L.

3.5 Data Analysis

The data obtained from the water sampling, therefore based on the data collection and after processing, it was recorded into the SPSS software for further analysis.

In the physical parameters analysis, weathers conditions which act as meteorological parameters such as flowing water area and stagnant water area were used as independent variable. Meanwhile, for the Dissolved Oxygen (DO), pH, Salinity, and Total Dissolved Oxygen (TDS) were used as the dependent variable as using Mann-Whitney U Test and Spearman's Correlation as statistical analysis.

For the chemical parameters analysis, weathers conditions such as flowing water area and stagnant water area were also used as independent variable. Dependent variables in chemical analysis were BOD, COD, TSS, and NH3N. Same as physical parameters, Mann-Whitney U Test and Spearman's Correlation also used as statistical analysis.

As to analyze relationship between physical and chemical parameters at Lata Janggut and Lata Keding, correlation analysis was used. Meanwhile, the Mann-Whitney U Test was used to compare mean between flowing water area and stagnant water area for physical and chemical parameters.

The presence of heavy metals in the study area was also being taken into consideration to determine the characteristics of water at Lata Janggut and Lata Keding. Thus, for heavy metals characterization, the mean concentration of heavy metals that found out through DR 6000 UV-VIS Spectrophotometer was considered as dependent variable. Meanwhile, the element of heavy metals such as copper, iron and zinc was counted as independent variable. All those of heavy metals was analyzed by using descriptive analysis through SPSS software.

3.5.1 Correlation Analysis

The correlation coefficient measures the degree of association that exists between two variables, that one taken as dependent variable. Direct correlation exists when increase or decrease in the value of one parameter is associated with a corresponding increase or decrease in the value of other parameter (Campbell et al., 2007). Thus, in this study coefficient of correlation was worked out to understand the relationship between the parameters of water sample. By using Spearman's correlation method, relationship among the physical and chemical parameter against weather conditions which is flowing water area and stagnant water area are identified.

3.5.2 Mann-Whitney U Test

The Mann-Whitney U Test is used to compare two population means originated from the same population, and to test equality between two population means. The parameters of physical and chemical parameters of water in the research were analyzed by using IBM SPSS Statistics Version 20.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Data Analysis

A total of 24 samples; 12 bottles of samples for the first sampling and another 12 bottles of samples for the second sampling, have been analyzed for the selected nutrients, physical and chemical parameters. Samples of water have been collected from two different cascades which is Lata Janggut and Lata Keding at Jeli area, Kelantan. The first sampling has been done on 29th of July 2018 meanwhile for the second sampling have been done on 12th of August 2018. For each places, the water samples were collected from two different areas which is, from flowing water area and stagnant water area. The timing of sampling may not statistically relate as there are limitations in usage of laboratory instruments.

Values and concentrations of selected parameters were tabulated in Table 4.1 to. The result was reported for each analysis of triplicate samples for more accurate values. The differences between data for the first sampling and second sampling can be observed through the tabulated data. For each table data, it shown two different places of cascades in Jeli area, based on two different points of area – flowing water area and stagnant water area.

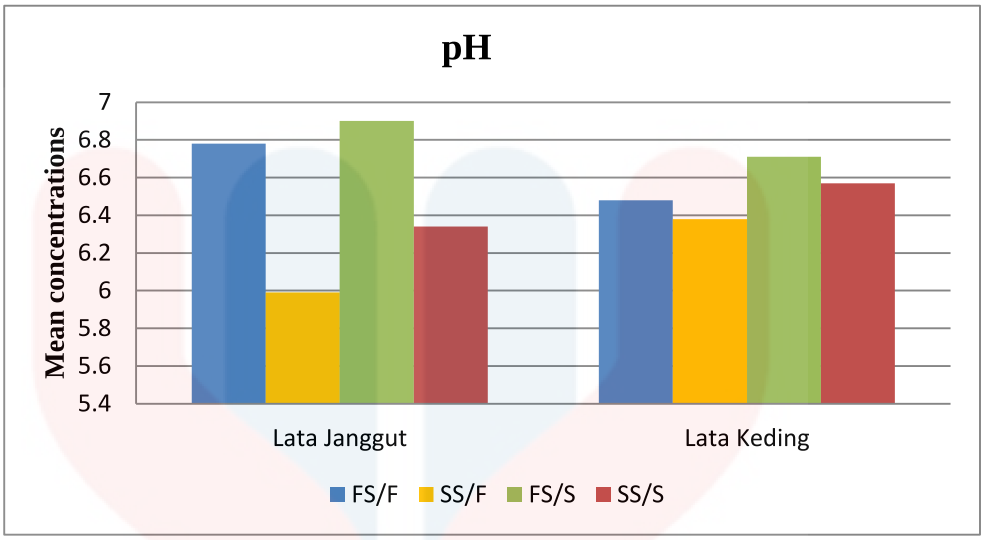
4.2 Physical and Chemical Properties for Water Samples

The variety of physical and chemical properties of water samples which are pH, dissolved oxygen (DO), salinity, total dissolved solids were measured as physical parameters, meanwhile BOD, COD, NH3N, TSS and selected heavy metals such as Copper, Zinc, and Iron were measured as chemical parameters.

4.2.1 The Physical Properties of Water Quality

i. pH

The mean concentrations of pH at flowing water area for first sampling at Lata Janggut is 6.78. Meanwhile, for the second sampling, the mean concentrations of pH at flowing water area at Lata Janggut is 5.99. From the observation, the trend of pH from flowing water area at Lata Janggut was decrease from the first sampling to the second sampling (Figure 4.1). The mean concentrations of pH at flowing water area for first sampling at Lata Keding is 6.48. However, unlike at the flowing water area, the pH at stagnant water area slightly high for the first and second sampling at Lata Janggut and Lata Keding, with mean concentration of 6.9, 6.34 (Lata Janggut) and 6.71, 6.57 (Lata Keding) respectively.



*FS; first sampling; SS; second sampling; F; flowing water area; S; stagnant water area

Figure 4.1: The comparison of flowing water area and stagnant water area between Lata Janggut and Lata Keding

ii. Dissolved Oxygen (DO)

As for dissolved oxygen (DO), its concentration of flowing water at Lata Janggut area is 8.29 for first sampling. While, the second sampling, flowing water area have recorded reading with mean 4.67. Figure 4.2 showed that the DO reading for the stagnant water area had huge gap between Lata Janggut and Lata Keding on with 8.02 and 4.66 respectively. There was huge gap and variation between two cascades; Lata Janggut and Lata Keding within first and second sampling. Lata Keding had balanced mean concentration of dissolved oxygen compare to the average value of Lata Janggut for both water areas. From the bar chart plotted (Figure 4.2), it can be seen that the pattern for the Lata Janggut is higher than Lata Keding values.

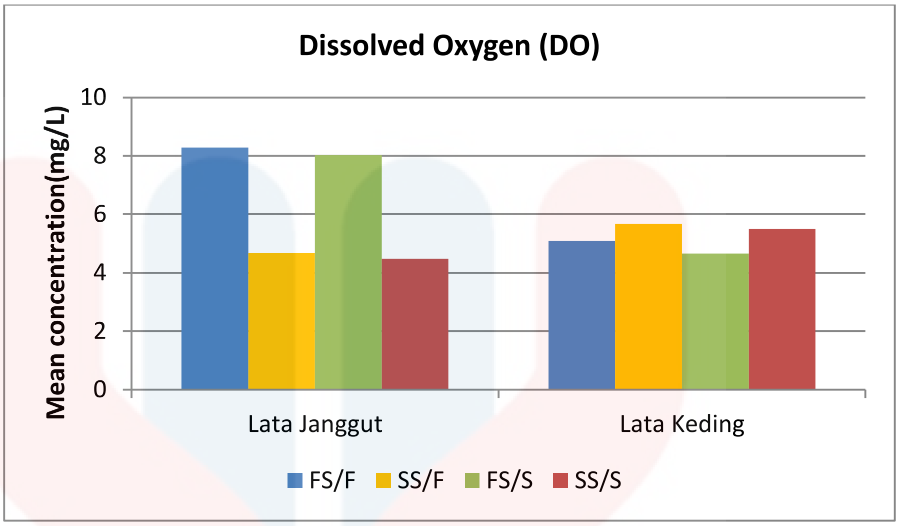


Figure 4.2: Mean concentration between Lata Janggut and Lata Keding on dissolved oxygen (DO) for first and second sampling

The main factor that control dissolved oxygen concentration is biological activity such as photosynthesis that producing oxygen while respiration and nitrification consumes oxygen (Yap.C.K, 2011). The high organic enrichment and turbulence nature of waterfall has become the possible reason responsible for low oxygen values in certain period. The water in Lata Keding may lack aquatic plants which produced oxygen through respirations as well as having decomposing activities organic compounds by aerobic organism which consumed oxygen thus resulting in low DO (Ya *et al.*, 2011).

iii. Salinity

There was no big variation could be seen between Lata Janggut and Lata Keding for flowing water and stagnant water area. However, on first sampling for Lata Janggut, at stagnant water area had lower mean with 0.01 mean concentrations compared to the Lata Keding values. Basically, there is not much gap between both of the area, besides Lata Keding has consistent mean values with 0.02 for two times sampling and for both water areas.

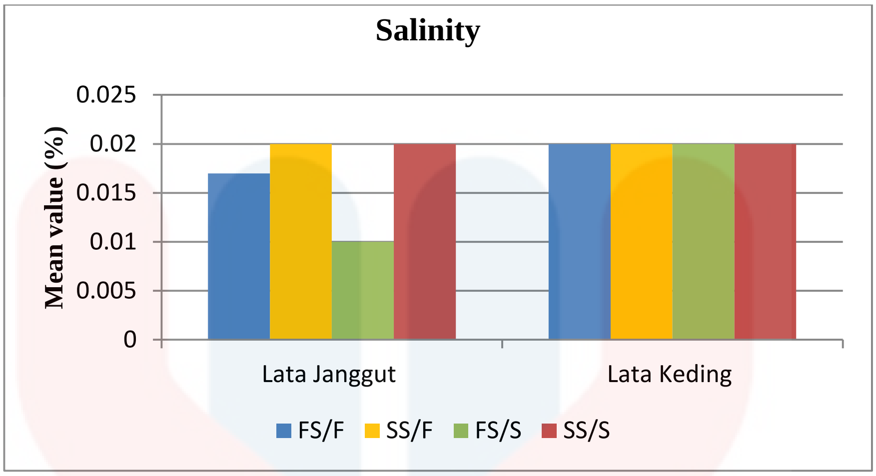


Figure 4.3: Mean concentration between cascades on Salinity for first sampling and second sampling.

iv. Total Dissolved Solids (TDS)

For the value of TDS in the first sampling, Figure 4.4 shows that for both cascades does not have much different mean concentrations with 0.023 mg/L for Lata Janggut while 0.02 mg/L for Lata Keding. The highest values of total dissolved solids (TDS) came from second sampling at Lata Keding at stagnant water area, with 0.04 mg/L mean concentration. From the results, it is observed that the total dissolved solid for Lata Janggut in two times sampling were not much different, as for flowing water area and stagnant water area – between 0.023 mg/L to 0.02 mg/L. Meanwhile, for Lata Keding, total dissolved oxygen was recorded between 0.028 mg/L to 0.04 mg/L.

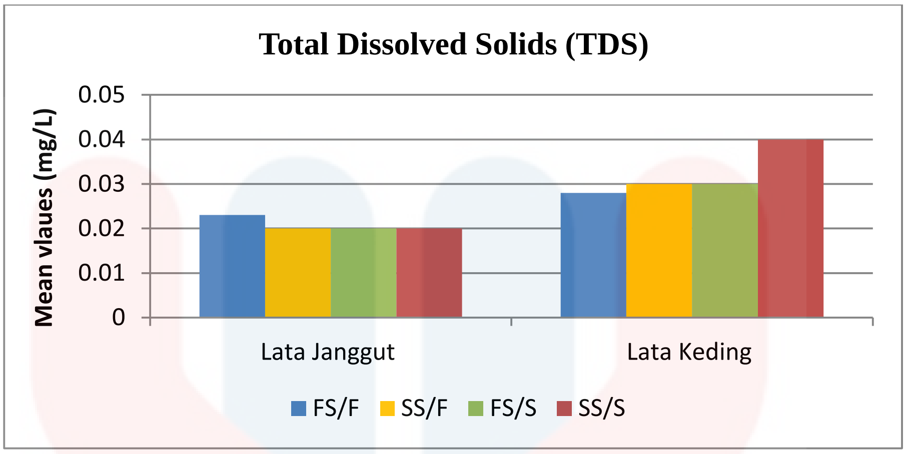


Figure 4.4: Mean concentrations of TDS between Lata Janggut and Lata Keding at the two different points

v. Electric Conductivity (EC)

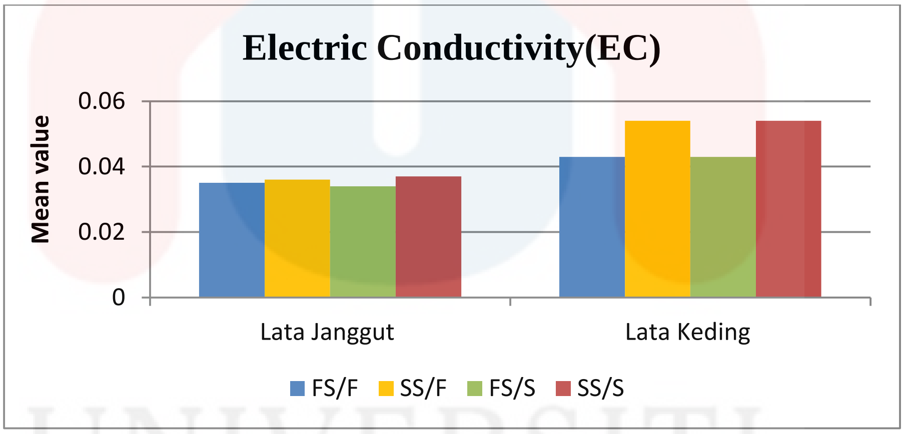


Figure 4.5: Mean concentrations of EC between Lata Janggut and Lata Keding at the two different points

Figure 4.5 show that, Lata Keding has higher value of electric conductivity compared to the Lata Janggut, in which during second sampling, for both water area 0.054 µS/cm had recorded as highest value compared to others. If the conductivity of the water increases, therefore, it's indicate there is must be a source of dissolved ion in the vicinity, in which electric conductivity measurements can be an effective way to allocate any potential water quality problems (Prommi, 2015).

Table 4.1: Mean Values of Physical Water Quality Parameters for Twice Sampling

Report

Places		pH	Dissolved Oxygen (mg/L)	Salinity (%)	Total Dissolved Solids (mg/L)	Conductivity (µS/cm)
Lata Janggut	N	12	12	12	12	12
	Mean	6.5042	6.3650	.0167	.0235	.0356
	Std. Deviation	.38249	1.87685	.00492	.00117	.00178
Lata Keding	N	12	12	12	12	12
	Mean	6.5370	5.2317	.0200	.0314	.0486
	Std. Deviation	.13126	.42458	.00000	.00358	.00550
Total	N	24	24	24	24	24
	Mean	6.5206	5.7983	.0183	.0275	.0421
	Std. Deviation	.28016	1.45121	.00381	.00481	.00775

4.2.1 The Chemical Properties of Water Quality

i. Biochemical Oxygen Demand (BOD)

BOD is a major water quality parameter because it giving big influences the concentration of DO that will be in the water, as the higher the BOD, the lower the water quality. The mean concentration of BOD is 0.882 mg/L as a flowing water area for both cascades – Lata Janggut and Lata Keding. Meanwhile, at the stagnant water area, the mean concentration was found as 1.105 mg/L, in which slightly higher than flowing water area (Table 4.3). But for the mean concentration of Lata Janggut for both areas is 1.18 mg/L, while for Lata Keding, the mean concentration 0.803 mg/L which is had lower BOD compared to the Lata Janggut (Table 4.2). According to the National Water Quality Standards of Malaysia, the BOD value must around 3 mg/L to categorize as good conditions. If any effluent with high BOD levels is enter into cascades, it will accelerate bacterial growth and consume the oxygen levels in the water.

ii. Chemical Oxygen Demand (COD)

COD is measurement of the oxygen required to oxidize soluble and particulate organic matter in water. COD is the main water quality parameter, such as BOD; it provides an index for assessing the effect of waste water in the receiving environment. The higher level of COD, indicate the greater amounts of oxidized organic matter in the sample, which is reduces the degree of dissolved oxygen (DO).

According to Department of Environment (DOE), the standard value for COD in Class II is 10-25 mg/L. The mean concentration of flowing water area for Lata Janggut and Lata Keding is 7.45 mg/L, while for mean value of stagnant water is 9.05 mg/L, which is slightly higher compared to flowing water (Table 4.3). But total mean concentration for Lata Janggut is 10.85 mg/L, meanwhile for Lata Keding is 5.65, which is a little bit lower compared to Lata Janggut (Table 4.2). Therefore, based on DOE standards, COD in Lata Janggut is still in range standards compared to Lata Keding that a way from standards.

iii. Total Suspended Solids (TSS)

Total Suspended Solid is a water quality parameter used, that can be trapped by a filter. High concentrations of suspended solids can cause many problems for stream health and aquatic life (Sheila, n.d.). Total suspended solids is an important factor in observing water clarity, as more solids are present in water, less the clarity of water (Environmental Fondriest, 2014).

Based on DOE standards, the mean concentration of flowing water area at Lata Janggut and Lata Keding, is 21.033 mg/L, while for stagnant water area, the mean concentration is 6.9 mg/L (Table 4.3). Total mean concentration of total suspended solids for Lata Janggut is 25.7667 mg/L, meanwhile for Lata Keding mean value is 2.1667 mg/L (Table 4.3). Therefore, it showed that flowing water is more near most value to DOE standards compared to the stagnant water. Same goes to the Lata Janggut, which is still in range of DOE standards compared of Lata Keding that had lower value of TSS.

iv. Ammoniacal Nitrogen (NH3N)

NH3N is a form of toxic ammonia. Once toxicity increases, pH will increase and as temperature increases. Ammonia levels that exceed the recommended limits can endanger the aquatic life (Environmental Fondriest, 2014).

According to DOE standards, NH3N must range from 0.1 – 0.3 mg/L. But once the toxicity of ammonia at higher level, it can relatively lead to skin, eye and gills damage for aquatic life. (Mr. Brian Oram, 2014). The mean concentration of NH3N for flowing water area is 0.1458 mg/L, while mean value of stagnant water for both the cascades is 0.1208 mg/L (Table 4.3). Here it showed that both of the water areas are still in range DOE standards. Next, for total mean concentration of Lata Janggut is 0.167 mg/L, and for mean value of Lata Keding is 0.1 mg/L (Table 4.2), even though Lata Janggut had high value of ammonia compared to the Lata Keding, but both of the cascades are still in range of DOE standards.

Table 4.2: Mean Value of Chemical Water Quality Parameters between Lata Janggut and Lata Keding

Places		**BOD**	**COD**	**TSS**	**NH3N**
	N	12	12	12	12
Lata Janggut	Mean	1.1845	10.8500	25.7667	.1667
	Std. Deviation	.97135	5.85530	33.31261	.05466
	N	12	12	12	12
Lata Keding	Mean	.8027	5.6500	2.1667	.1000
	Std. Deviation	.65423	4.04441	1.75361	.03668
	N	24	24	24	24
Total	Mean	.9936	8.2500	13.9667	.1333
	Std. Deviation	.83306	5.59231	26.02892	.05685

Table 4.3: Mean Value of Chemical Water Quality Parameters for Flowing Water and Stagnant Water

Area		**BOD**	**COD**	**TSS**	**NH3N**
Flowing water	N	12	12	12	12
	Mean	.8818	7.4500	21.0333	.1458
	Std. Deviation	.48637	6.91461	35.38842	.07192
Stagnant water	N	12	12	12	12
	Mean	1.1053	9.0500	6.9000	.1208
	Std. Deviation	1.08961	4.02278	7.43676	.03528
Total	N	24	24	24	24
	Mean	.9936	8.2500	13.9667	.1333
	Std. Deviation	.83306	5.59231	26.02892	.05685

4.2.2 The Heavy Metals Properties of Water Samples

The selected heavy metals such as copper, zinc, and iron were analyzed by using DR6000 UV-VIS Spectrophotometer.

i. Copper (Cu)

Based on Figure 4.2, the average value of Cu for Lata Janggut is 0.384 mg/L, while for Lata Keding is 0.064 mg/L, in which Lata Janggut had higher amount of copper compared to the Lata Keding. In this case, the concentrations of Cu for both cascades are below the standard either from WHO or USEPA water quality standard.

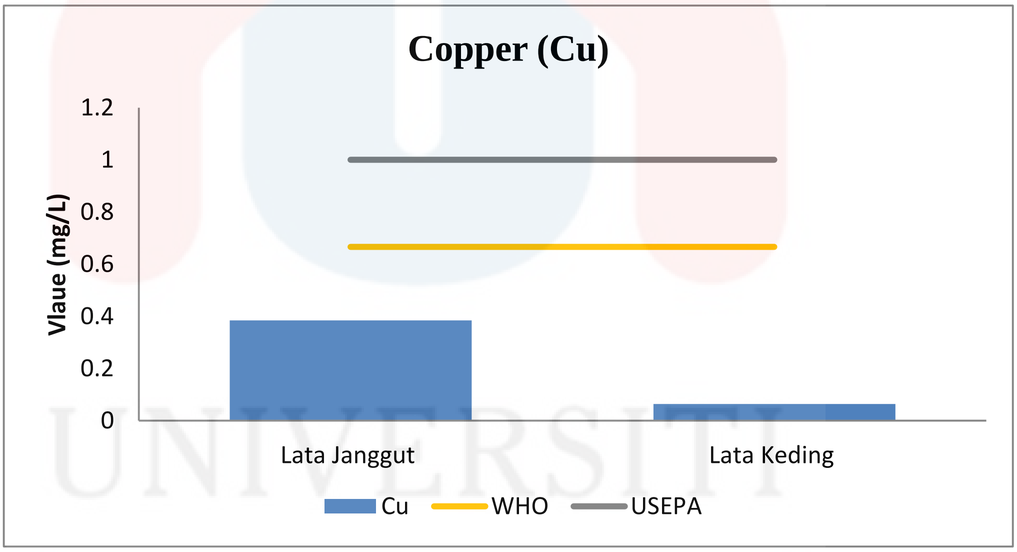


Figure 4.2: Mean Value of Copper for Lata Janggut and Lata Keding (mg/L)

In this study, copper is an important nutrient at low level, but it bad and toxic to aquatic organisms at higher concentrations, because it can give bad effect such as death and chronic exposure which is lead to abnormal growth, retard reproduction and changes in brain function, enzyme activity, blood chemistry and metabolism (EPA, 2012).

ii. Zinc (Zn)

In the Figure 4.3, the mean value of Zn can be seen at Lata Janggut with the value 0.4 mg/L while Lata Keding with lower value ,0.2 mg/L. Here, it showed that at Lata Janggut, had the highest amount of Zn compared to Lata Keding. Luckily, both of the cascades was still below the WHO and USEPA standard, which is 5 mg/L respectively (Balentine, 1995).

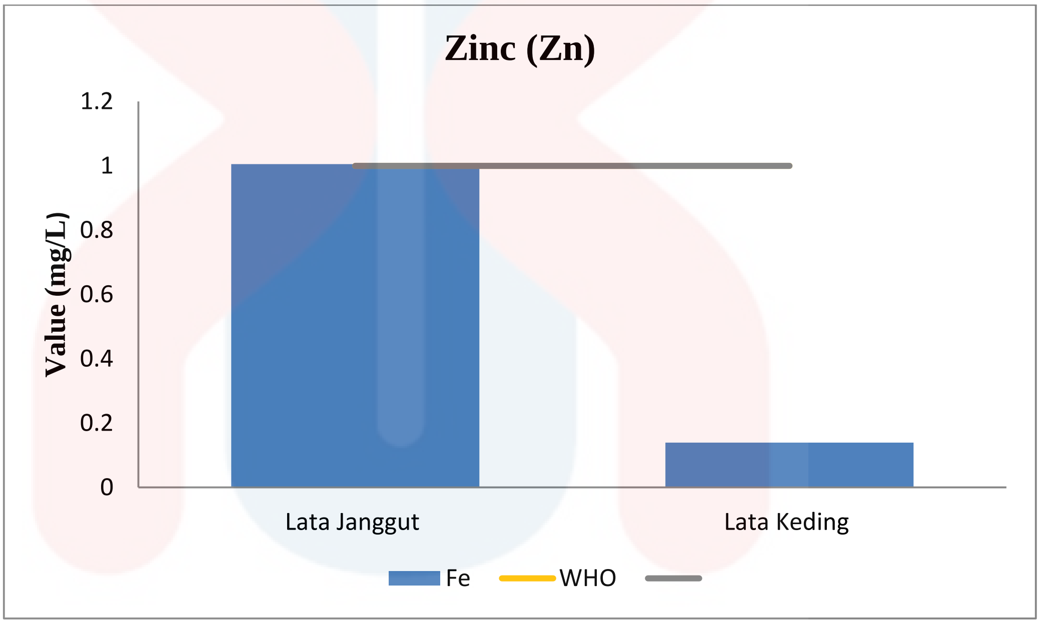


Figure 4.3: Mean Value of Zinc for Lata Janggut and Lata Keding (mg/L)

In this case, zinc also an essential trace elements metal but it becomes toxic when the amount is excessive. Probably, the amounts of zinc at Lata Janggut and Lata Keding are contributed from activities of people like burning of waste, the rest of zinc might release by natural processes. Probably, zinc concentrations are discharge from drainage pipes due to corrosion, therefore it can accumulating in aquatic life and other organisms (Shah, 2017).

iii. Iron (Fe)

The value of Fe is range from 0.12 – 0.74 mg/L. According to the Figure 4.4, the mean concentration of iron at Lata Janggut is achieving 1 mg/L, too high compared to the Lata Keding, which is 0.14 mg/L. It can be seen that the mean value for both cascades is slightly difference and way too far from each other.

The iron comes in several forms in the water. When unusually amounts of iron occur in water, it is due to pollution associated with construction or iron mining. At normal levels, iron does not kill aquatic organisms, but at higher levels when iron is insoluble in water, fish and other creatures cannot process all the iron they take, in the form of water or their food (Andromeda Ricky, 2016). The values of concentration of Fe for Lata Keding is below the limit of guidelines from WHO (Figure 4.4), but Lata Janggut is actually near most towards WHO standards. Therefore, this element is important to be checked in order to know the concentration of it, in the water.

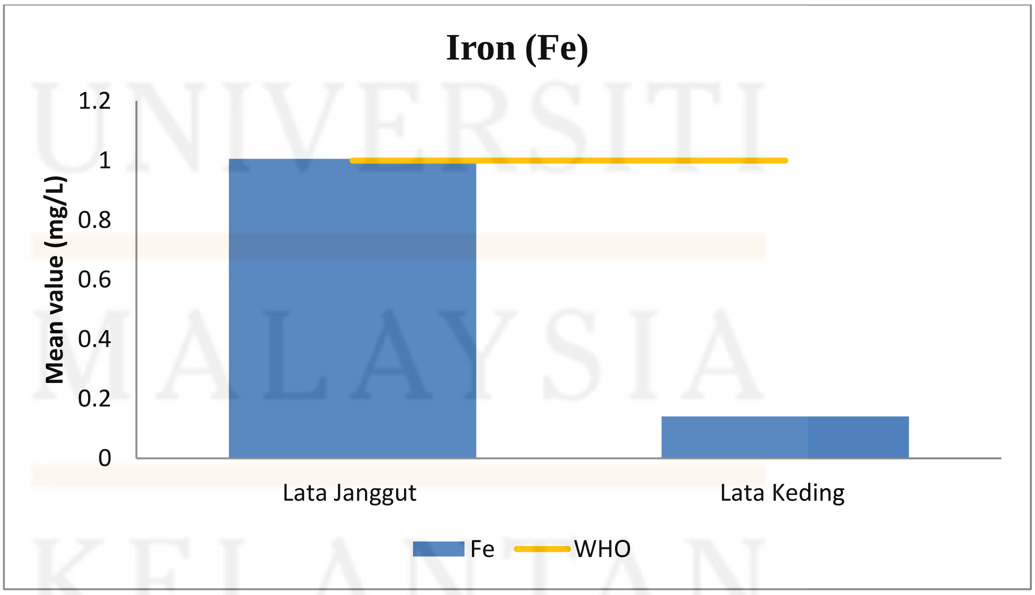


Figure 4.4: Mean Value of Iron for Lata Janggut and Lata Keding (mg/L)

4.2.4 The Mann-Whitney U Test

In this study, Mann-Whitney U Test was conducted to compare two groups means originated from the same variables, and to test the equality between two population means. Therefore, by using IBM Statistics Analysis, Mann-Whitney U Test was carried out between Lata Janggut and Lata Keding.

i. pH

Based on the Table 4.4, it shown that pH of the Lata Janggut and Lata Keding were no differing significantly. As p = 0.885 > 0.05, there is not enough evidence to conclude that there is significance different between for both cascades. Because in mean rank Lata Janggut (12.71) had higher pH compared to Lata Keding (12.29).

Table 4.4: Results of pH by using Mann-Whitney U Test

Test Statistics[a]

	Ph
Mann-Whitney U	69.500
Wilcoxon W	147.500
Z	-.144
Asymp. Sig. (2-tailed)	.885
Exact Sig. [2*(1-tailed Sig.)]	.887[b]

a. Grouping Variable: Places

b. Not corrected for ties.

ii. Dissolved Oxygen (DO)

According to the Table 4.5, it shown that DO of the Lata Janggut (12.29) had not significant different compared to DO of Lata Keding (12.04), as p = 0.751 > 0.05, so there is not enough evidence to conclude that there is no significance different between both cascades.

Table 4.5: Results of DO by using Mann-Whitney U Test

Test Statistics[a]

	DO
Mann-Whitney U	66.500
Wilcoxon W	144.500
Z	-.318
Asymp. Sig. (2-tailed)	.751
Exact Sig. [2*(1-tailed Sig.)]	.755[b]

a. Grouping Variable: Places

b. Not corrected for ties.

iii. Salinity

According to the Table 4.5, it shown that p = 0.032 < 0.05, so there is enough evidence to conclude that there is significance different between both cascades.

Table 4.5: Results of salinity by using Mann-Whitney U Test

Test Statistics[a]

	Salinity
Mann-Whitney U	48.000
Wilcoxon W	126.000
Z	-2.145
Asymp. Sig. (2-tailed)	.032
Exact Sig. [2*(1-tailed Sig.)]	.178[b]

a. Grouping Variable: Places

b. Not corrected for ties.

iv. Total Dissolved Solids (TDS)

Based on the Table 4.6, it shown that, TDS of the Lata Janggut (6.50) had lower value than TDS of Lata Keding (18.50) as were strong different significantly. As $p = 0.000 < 0.05$, there is enough evidence to conclude that there is a significance different between for both cascades.

Table 4.6: Results of TDS by using Mann-Whitney U Test

Test Statistics[a]

	TDS
Mann-Whitney U	.000
Wilcoxon W	78.000
Z	-4.231
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000[b]

a. Grouping Variable: Places

b. Not corrected for ties.

v. Electric Conductivity (EC)

In Table 4.7, EC of Lata Jangut (6.50) had lower value than value of EC at Lata Keding (18.50), then both of it had shown that highly significant difference. As $p = 0.000 < 0.05$, therefore, there is enough evidence to conclude that there is a significance different between for Lata Janggut and Lata Keding.

Table 4.7: Results of EC by using Mann-Whitney U Test

Test Statistics[a]

	EC
Mann-Whitney U	.000
Wilcoxon W	78.000
Z	-4.198
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000[b]

a. Grouping Variable: Places

b. Not corrected for ties.

vi. Biochemical Oxygen Demand (BOD)

According to Table 4.8, the chemical parameters – BOD of Lata Janggut and Lata Keding was shown that there is no significance different between BOD for both cascades. As p = 0.371 > 0.05, there is enough evidence to conclude that there is no different value of BOD in both cascades.

Table 4.8: Results of BOD by using Mann-Whitney U Test

Test Statistics[a]

	BOD
Mann-Whitney U	56.500
Wilcoxon W	134.500
Z	-.895
Asymp. Sig. (2-tailed)	.371
Exact Sig. [2*(1-tailed Sig.)]	.378[b]

a. Grouping Variable: Places

b. Not corrected for ties.

vii. Chemical Oxygen Demand (COD)

Based on the Table 4.9, the chemical parameters which is COD at Lata Janggut and Lata Keding had strong significance different, as p = 0.016 < 0.05. Therefore, there is enough evidence to conclude that there is significant different for COD between both cascades.

Table 4.9: Results of COD by using Mann-Whitney U Test

Test Statistics[a]

	COD
Mann-Whitney U	30.500
Wilcoxon W	108.500
Z	-2.398
Asymp. Sig. (2-tailed)	.016
Exact Sig. [2*(1-tailed Sig.)]	.014[b]

viii. Total Suspended Solids (TSS)

According to the Table 4.10, the chemical parameters which is TSS at Lata Janggut and Lata Keding had strong significance different, as p = 0.007 < 0.05. Therefore, there is enough evidence to conclude that there is different value of TSS between the both cascades.

Table 4.10: Results of TSS by using Mann-Whitney U Test

Test Statistics[a]

	TSS
Mann-Whitney U	25.000
Wilcoxon W	103.000
Z	-2.720
Asymp. Sig. (2-tailed)	.007
Exact Sig. [2*(1-tailed Sig.)]	.006[b]

a. Grouping Variable: Places

b. Not corrected for ties.

ix. Ammoniacal Nitrogen (NH3N)

Based on to the Table 4.11, the chemical parameters which is NH3N at Lata Janggut and Lata Keding had high significance different, as p = 0.004 < 0.05. Therefore, there is enough evidence to conclude that there is different value of NH3N between the both cascades.

Table 4.11: Results of NH3N by using Mann-Whitney U Test

Test Statistics[a]

	NH3N
Mann-Whitney U	22.000
Wilcoxon W	100.000
Z	-2.899
Asymp. Sig. (2-tailed)	.004
Exact Sig. [2*(1-tailed Sig.)]	.003[b]

4.2.5 The Correlation Analysis

Correlation is a statistical measurement of the relationship between two variables. Correlation was used in this study to determine whether there is any relationship between physical parameter and chemical parameter, as the affecting the value of variables or not. Correlation analysis were categorized into two correlation between positive correlation and negative correlation, and under correlation were being classified whether the relationship is very weak, weak, moderate correlation, strong, and very strong correlation (Ahmad et al., 2017)

i. The Physical Parameters of Water Sample

According to the Table 4.12, based on the flowing water area, for pH, the strong positive relationship was found between pH and DO (r = 0.746), which is had significant towards each other. Next, the very weak negative correlation was found at between pH and TDS (r = -0.298) and pH; EC (r = -0.29). Meanwhile, there is for moderate positive relationship between salinity; TDS (r = 0.494) and salinity and EC (r = 0.486). The strongest positive relationship that could be found is between TDS and EC (r = 0.984).

Meanwhile for the correlation between physical parameters at the stagnant water area (Table 4.13), for pH, the strong positive correlation was found between pH and DO (r = 0.720), which is nearly significant between pH and DO. Another strong positive relationship was found between salinity and TDS (r= 0.766) and at salinity; EC (r= 0.761). The very weak negative correlation was found at DO and TDS (r= -0.192) and at DO; EC (r= -0.173). All the correlations mentioned were significant at the 99% level, p-value at 0.01.

Table 4.12: Correlation between Physical Parameters at the Flowing water area.

Correlations at Flowing water area

			pH	DO	Salinity	TDS	EC
Spearman's rho	pH	Correlation Coefficient	1.000	.746**	-.393	-.298	-.297
		Sig. (2-tailed)	.	.005	.206	.347	.349
		N	12	12	12	12	12
	DO	Correlation Coefficient	.746**	1.000	-.306	-.083	-.113
		Sig. (2-tailed)	.005	.	.333	.798	.726
		N	12	12	12	12	12
	Salinity	Correlation Coefficient	-.393	-.306	1.000	.494	.486
		Sig. (2-tailed)	.206	.333	.	.103	.110
		N	12	12	12	12	12
	TDS	Correlation Coefficient	-.298	-.083	.494	1.000	.984**
		Sig. (2-tailed)	.347	.798	.103	.	.000
		N	12	12	12	12	12
	EC	Correlation Coefficient	-.297	-.113	.486	.984**	1.000
		Sig. (2-tailed)	.349	.726	.110	.000	.
		N	12	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.13: Correlation between Physical Parameter at Stagnant water area

Correlations at Stagnant water area

			pH	DO	Salinity	TDS	EC
Spearman's rho	Ph	Correlation Coefficient	1.000	.720**	-.753**	-.363	-.378
		Sig. (2-tailed)	.	.008	.005	.246	.226
		N	12	12	12	12	12
	DO	Correlation Coefficient	.720**	1.000	-.753**	-.192	-.173
		Sig. (2-tailed)	.008	.	.005	.550	.590
		N	12	12	12	12	12
	Salinity	Correlation Coefficient	-.753**	-.753**	1.000	.766**	.761**
		Sig. (2-tailed)	.005	.005	.	.004	.004
		N	12	12	12	12	12
	TDS	Correlation Coefficient	-.363	-.192	.766**	1.000	.987**
		Sig. (2-tailed)	.246	.550	.004	.	.000
		N	12	12	12	12	12
	EC	Correlation Coefficient	-.378	-.173	.761**	.987**	1.000
		Sig. (2-tailed)	.226	.590	.004	.000	.
		N	12	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

According to Table 4.14, based on the Lata Janggut area, the physical parameters that been correlate is pH, the strong negative correlation was found between pH and salinity (r= -0.717), meanwhile for negative moderate relationship were found between parameters of pH; TDS (r= -0.641), at pH and EC (r= -0.545), between DO and salinity (r= -0.410), and DO; TDS (r= -0.671). But the strongest relationship positive was found between TDS and EC (r= 0.908), which is mean the relationship very significant.

Based on the Table 4.15, at the Lata Keding; the physical parameters were being correlate, for pH – the weak negative relationship was found between at pH and DO (r= -0.311) and at pH; EC (r= -0.327). The p-value shows that, the variables parameter had no significant, and not dependable into each other. Meanwhile, at Lata Keding, the positive strong correlation was found between DO and TDS (r= 0.789) and between TDS; EC (r= 0.782). But the strongest positive relationship was found between DO and EC (r= 0.952), whereas when DO increases, EC also increases.

. **Table 4.14**: Correlation Analysis Physical Parameters between Lata Janggut

Correlations

			pH	DO	TDS	Salinity	EC
Spearman's rho	pH	Correlation Coefficient	1.000	.592*	-.641*	-.717**	-.545
		Sig. (2-tailed)	.	.043	.025	.009	.067
		N	12	12	12	12	12
	DO	Correlation Coefficient	.592*	1.000	-.671*	-.410	-.724**
		Sig. (2-tailed)	.043	.	.017	.185	.008
		N	12	12	12	12	12
	TDS	Correlation Coefficient	-.641*	-.671*	1.000	.804**	.908**
		Sig. (2-tailed)	.025	.017	.	.002	.000
		N	12	12	12	12	12
	Salinity	Correlation Coefficient	-.717**	-.410	.804**	1.000	.709**
		Sig. (2-tailed)	.009	.185	.002	.	.010
		N	12	12	12	12	12
	EC	Correlation Coefficient	-.545	-.724**	.908**	.709**	1.000
		Sig. (2-tailed)	.067	.008	.000	.010	.
		N	12	12	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.15: Correlation Analysis of Physical Parameters between Lata Keding

Correlations at Lata Keding

			pH	DO	Salinity	TDS	EC
Spearman's rho	pH	Correlation Coefficient	1.000	-.311	.	-.776**	-.327
		Sig. (2-tailed)	.	.325	.	.003	.300
		N	12	12	12	12	12
	DO	Correlation Coefficient	-.311	1.000	.	.789**	.952**
		Sig. (2-tailed)	.325	.	.	.002	.000
		N	12	12	12	12	12
	Salinity	Correlation Coefficient	.	.	.	.	.
		Sig. (2-tailed)	.	.	.	.	.
		N	12	12	12	12	12
	TDS	Correlation Coefficient	-.776**	.789**	.	1.000	.782**
		Sig. (2-tailed)	.003	.002	.	.	.003
		N	12	12	12	12	12
	EC	Correlation Coefficient	-.327	.952**	.	.782**	1.000
		Sig. (2-tailed)	.300	.000	.	.003	.
		N	12	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

ii. The Chemical Parameter of Water Sample

According to Table 4.16, the chemical parameters were conducted correlation analysis at flowing water area. At the flowing water area between BOD and COD (r=0.270) was found as the positive weak relationship, same goes to BOD and NH3N (r=0.291). Meanwhile the strong positive relationship was found between COD; NH3N (r= 0.714) and at TSS; NH3N (r = 0.714). But the strongest positive relationship was found at COD; TSS (r = 0.938).

While, to Table 4.17, correlation underlying was conducted between chemical parameters at stagnant water area. For BOD, the negative weak correlation was found between BOD and COD (r = -0.354), and at BOD; NH3N (r = -0.178) was declared had very weak relationship. Apart from that, the strong positive relationship was found between COD and TSS (r = 0.718) and at COD; NH3N (r = 0.706). All the correlation was significant 99% and p-value = 0.01

Table 4.16: Correlation between The Chemical Parameter at flowing water area

Correlations

			BOD	COD	TSS	NH3N
Spearman's rho	BOD	Correlation Coefficient	1.000	.270	.074	.291
		Sig. (2-tailed)	.	.397	.819	.358
		N	12	12	12	12
	COD	Correlation Coefficient	.270	1.000	.938**	.717**
		Sig. (2-tailed)	.397	.	.000	.009
		N	12	12	12	12
	TSS	Correlation Coefficient	.074	.938**	1.000	.714**
		Sig. (2-tailed)	.819	.000	.	.009
		N	12	12	12	12
	NH3N	Correlation Coefficient	.291	.717**	.714**	1.000
		Sig. (2-tailed)	.358	.009	.009	.
		N	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.17: Correlation between The Chemical Parameter at Stagnant water area

Correlations at Stagnant water area

			BOD	COD	TSS	NH3N
Spearman's rho	BOD	Correlation Coefficient	1.000	-.354	-.504	-.178
		Sig. (2-tailed)	.	.258	.094	.580
		N	12	12	12	12
	COD	Correlation Coefficient	-.354	1.000	.718**	.706*
		Sig. (2-tailed)	.258	.	.009	.010
		N	12	12	12	12
	TSS	Correlation Coefficient	-.504	.718**	1.000	.569
		Sig. (2-tailed)	.094	.009	.	.053
		N	12	12	12	12
	NH3N	Correlation Coefficient	-.178	.706*	.569	1.000
		Sig. (2-tailed)	.580	.010	.053	.
		N	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

According to the Table 4.18, the chemical parameters based on Lata Janggut area was been correlate to determine the relationship between the parameters. As for BOD, the weak negative relationship was found between BOD and COD (r = -0.165) and at BOD; TSS (r = -0.336). But the positive very weak correlation was between BOD and NH3N (r= 0.074) and also between TSS; NH3N (r= 0.032). For the moderate positive relationship was found at COD and TSS (r = 0.648), which is the correlation was near significant and had small relationship involve it.

Based on the Table 4.19, the chemical parameters based on the Lata Keding area, was correlate to determine the chemical parameters and to find out the relationship between it. As for, BOD, the negative weak was found between BOD and NH3N (r = -0.298). The very negative weak relationship was found at BOD and TSS (r=-0.298). But the moderate positive correlation was found between COD and TSS (r=0.530) and at COD; NH3N (r= 0.621), which is both had relationship but in low level.

Table 4.18: Correlation between the Chemical Parameter at Lata Janggut

Correlations

			BOD	COD	TSS	NH3N
Spearman's rho	BOD	Correlation Coefficient	1.000	-.165	-.336	.074
		Sig. (2-tailed)	.	.609	.286	.819
		N	12	12	12	12
	COD	Correlation Coefficient	-.165	1.000	.648*	-.027
		Sig. (2-tailed)	.609	.	.023	.935
		N	12	12	12	12
	TSS	Correlation Coefficient	-.336	.648*	1.000	.032
		Sig. (2-tailed)	.286	.023	.	.922
		N	12	12	12	12
	NH3N	Correlation Coefficient	.074	-.027	.032	1.000
		Sig. (2-tailed)	.819	.935	.922	.
		N	12	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.19: Correlation between the Chemical Parameter at Lata Keding

Correlations

			BOD	COD	TSS	NH3N
Spearman's rho	BOD	Correlation Coefficient	1.000	.280	-.170	-.298
		Sig. (2-tailed)	.	.379	.598	.346
		N	12	12	12	12
	COD	Correlation Coefficient	.280	1.000	.530	.621*
		Sig. (2-tailed)	.379	.	.076	.031
		N	12	12	12	12
	TSS	Correlation Coefficient	-.170	.530	1.000	.754**
		Sig. (2-tailed)	.598	.076	.	.005
		N	12	12	12	12
	NH3N	Correlation Coefficient	-.298	.621*	.754**	1.000
		Sig. (2-tailed)	.346	.031	.005	.
		N	12	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.3 Water Quality Index (WQI) and Classification at Lata Janggut and Lata Keding

Water Quality status classification was determined by using Water Quality Index (WQI). WQI value for flowing water area and stagnant water area of both cascades was calculated by entering the mean values of water quality parameters such as DO, BOD, COD, TSS, NH3N and pH. Then the WQI was deriving from the calculation as below:

$$WQI = (0.22*SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16*SISS) + (0.12*pH)$$

According to the Table 4.20, the WQI value for flowing water area and the stagnant water area were 70.65 and 71.99 respectively. Based on the calculation provided, the quality of water from both of the areas showed that they were classified as slightly polluted (Class III). Based on the Table 4.20, it showed that WQI value for stagnant water area was a little bit high than the flowing water area.

Table 4.20: WQI value and Classification for Flowing water and stagnant water area

Study area	WQI Value	Classification
Flowing water area	70.65	Class III: Slightly polluted
Stagnant water area	71.99	Class III: Slightly Polluted

WQI (Flowing Water Area): (0.22*0) + (0.19*96.67) + (0.16*89.1915) + (0.15*85.191) + (0.16*85.63) + (0.12*96.084)

WQI (Stagnant Water Area): (0.22*0) + (0.19*95.725) + (0.16*87.06) + (0.15*87.816) + (0.16*93.40) + (0.12* 97.97)

Meanwhile, according to Table 4.21, WQI value for Lata Janggut and Lata Keding was calculated by entering the six parameter mean values such BOD, DO, COD, pH, NH3N and TSS. Based on the Table 4.21, the WQI Value of Lata Janggut and Lata Keding were 69.07 and 71.75 respectively which is both of the cascades was slightly polluted (Class III). The WQI values of the both study area was calculated as in the equations below:

WQI (Lata Janggut): (0.22*0) + (0.19*95.39) + (0.16*84.67) + (0.15*82.9965) + (0.16*83.2023) + (0.12*96.98)

WQI (Lata Keding): (0.22*0) + (0.19*97.005) + (0.16*91.5855) + (0.15*90) + (0.16*84.324) + (0.12*97.259)

Table 4.21: WQI value and Classification for Lata Janggut and Lata Keding

Study area	WQI Value	Classification
Lata Janggut	69.07	Class III: Slightly polluted
Lata Keding	71.75	Class III: Slightly Polluted

Table 4.22: Comparison with DOE Water Quality Index and Classification

Parameter	Unit	Class					Present study
		I	II	III	IV	V	
NH3N	mg/L	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7	LJ: 0.1667 LK: 0.1
BOD	mg/L	<1	1-3	3-6	6-12	>12	LJ: 1.1845 LK: 0.8027
COD	mg/L	<10	10-25	25-50	50-100	>100	LJ: 10.85 LK: 5.6
DO	mg/L	<7	5-7	3-5	1-3	<1	LJ: 6.365 LK: 5.2317
pH	mg/L	>7.0	6.0-7.0	5.0-6	<5.0	>5.0	LJ: 6.5042 LK: 6.5370
TSS	mg/L	<25	50	150	300	>300	LJ: 25.7667 LK: 2.1667
WQI		>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0	LJ: 69.07 LK: 71.75

LJ; Lata Janggut, **LK**; Lata Keding

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The present study focused on the assessment of ecological parameters which involves the physical and chemical properties of water sample in order to determine the water quality at Lata Janggut and Lata Keding. Basically, different location of each studied had given different values for each tested parameters.

Based on the data presented in the research, one of the major findings is to find out the value of WQI at the study area. According to WQI and classification provided by Department of Environment (DOE), the mean water quality was calculated in slightly polluted for Lata Janggut and Lata Keding.

Throughout the research, Lata Janggut and Lata Keding had been classified as slightly polluted which is categorized under Class III, as the WQI values for Lata Janggut and Lata Keding is 69.07 and 71.75 respectively. Although there were some parameters shown high values in certain period, but basically for the both cascades, the values were still under control and safe to had body contact with the water.

With the regard, it is clear that the water and sediments for both cascades were safe from contaminated heavy metals. According to the above mentioned points, it’s clear that using the water for recreational purposes, washing, fishing or any activities was detrimental to human health and environment. Therefore, any serious measures and steps were needed to take, for maintaining the water quality from getting polluted in future.

5.2 Recommendation

The present study was involved in determine the water quality for both cascades through physical and chemical parameters in which take two times sampling only (July and August). Therefore, on future work, the research should be done for more weeks to gain data patterns according to the water area. The next project should be involving longer study period that can cover up to the whole year's data of the study area. Thus, the data from this study can be useful information towards the public who love natural activities, and any related department and agencies. A good time management for the sampling process and carried out the laboratory analysis, as well as being alert with the availability of the instrument in the laboratory may improve the way of conducting the experiment.

For the improvement of this research, the study also should add more parameters to be analyzed such as testing microbial activity at the both cascades, and replenish the heavy metals test such as arsenic, lead, cadmium etc.

On the other hand, the usage of advanced laboratory instruments was very helpful in this research, as having high technology instruments for test the water sample may produce more precise result for each parameter and can minimize the errors that may occur during carry out the analysis. Example of instrument such as using the Atomic absorption spectroscopy (AAS) and Scanning Electron Microscopes (SEM) or other types of instrument might give a good result for the research.

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APPENDIX A

RAW DATA

Table A.1: Physical Parameters for First Sampling

	Replication	Physical Water Quality Parameters									
		Dissolved oxygen (mg/L)		pH(°C)		Salinity (%)		Total Dissolved Solids (mg/L)		Oxidation Reduction Potential (mV)	
		Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water
Lata Janggut	1	8.52	7.93	6.75	6.82	0.02	0.01	0.024	0.021	22.4	24.5
	2	8.12	8.18	6.77	6.93	0.01	0.01	0.022	0.023	54.7	34
	3	8.24	7.94	6.83	6.96	0.02	0.02	0.023	0.023	34.6	1.1
Lata Keding	1	4.85	4.68	6.44	6.68	0.02	0.02	0.028	0.028	85.2	89.4
	2	5.06	4.67	6.5	6.72	0.02	0.02	0.028	0.028	92.8	89.8
	3	5.35	4.64	6.51	6.74	0.02	0.02	0.028	0.028	-16.1	91.3

Table A.2: Physical Parameters for Second sampling

	Replication	Physical Water Quality Parameters									
		Dissolved oxygen (mg/L)		pH(°C)		Salinity (%)		Total Dissolved Solids (mg/L)		Oxidation Reduction Potenial (mV)	
		Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water
Lata Janggut	1	4.68	4.51	5.97	6.32	0.02	0.02	0.024	0.024	78.1	53.4
	2	4.67	4.47	5.98	6.34	0.02	0.02	0.024	0.025	87.2	62.5
	3	4.67	4.45	6.01	6.37	0.02	0.02	0.024	0.025	92.2	70
Lata Keding	1	5.76	5.51	6.32	6.56	0.02	0.02	0.034	0.035	73.4	23.8
	2	5.63	5.5	6.39	6.57	0.02	0.02	0.035	0.035	69.9	31.2
	3	5.65	5.48	6.43	6.58	0.02	0.02	0.035	0.035	68.6	37.7

Table A.3: Chemical Parameters for First Sampling

	Replication	Chemical Water Quality Parameters							
		Biochemical Oxygen Demand (mg/L)		Chemical Oxygen Demand (mg/L)		Total Suspended Solids (mg/L)		Ammoniacal Nitrogen (mg/L)	
		Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water
Lata Janggut	1	1.188	-0.36	10.8	11.2	76.2	18.6	0.26	0.13
	2	0.78	0.525	26	19.2	85.4	17	0.23	0.13
	3	0.72	0.74	7.6	9.4	77.2	21	0.13	0.12
Lata Keding	1	0.792	-0.18	2.2	10.8	1.2	5	0.1	0.16
	2	0.285	1.11	6.2	10.2	1.4	5.2	0.13	0.14
	3	1.48	0.1	12.2	2	2.8	4.6	0.12	0.11

Table A.4: Chemical Parameters for Second sampling

	Replication	Chemical Water Quality Parameters							
		Biochemical Oxygen Demand (mg/L)		Chemical Oxygen Demand (mg/L)		Total Suspended Solids (mg/L)		Ammoniacal Nitrogen (mg/L)	
		Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water
Lata Janggut	1	0.516	2.28	7.2	8	2.8	4.4	0.2	0.11
	2	0.735	1.89	7.4	8.6	1.4	2.2	0.16	0.1
	3	2.04	3.16	6.2	8.6	1.2	1.8	0.23	0.2
Lata Keding	1	0.636	0.684	1.2	7.2	1	0.8	0.02	0.1
	2	0.45	1.035	1.4	6.4	1	1.2	0.09	0.07
	3	0.96	2.28	1	7	0.8	1	0.08	0.08

Table A.5: Heavy metals selected for First Sampling

	Replication	Heavy metal value					
		Cu (mg/L)		Zn (mg/L)		Fe (mg/L)	
		Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water
Lata Janggut	1	0.66	0.74	0.42	0.33	1.91	1.95
	2	0.77	0.68	0.48	0.31	2.06	1.69
	3	0.76	0.69	0.42	0.27	1.84	2.02
Lata Keding	1	0.1	0.09	0.19	0.2	0.26	0.21
	2	0.1	0.09	0.16	0.14	0.32	0.19
	3	0.07	0.08	0.17	0.15	0.18	0.16

Table A.6: Heavy metals selected for Second Sampling

	Replication	Heavy metal value					
		Cu (mg/L)		Zn (mg/L)		Fe (mg/L)	
		Flowing water	Stagnant water	Flowing water	Stagnant water	Flowing water	Stagnant water
Lata Janggut	1	0.08	0.03	0.12	0.72	0.09	0.11
	2	0.07	0.04	0.12	0.74	0.1	0.11
	3	0.03	0.06	0.15	0.66	0.1	0.09
Lata Keding	1	0.03	0.04	0.22	0.25	0.07	0.07
	2	0.04	0.05	0.16	0.15	0.02	0.08
	3	0.04	0.04	0.2	0.2	0.05	0.07

APPENDIX B

WQI Formula and Calculation

WQI = (0.22*SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16*SISS) + (0.12*pH)

Where: $0 \leq WQI \leq 100$

SIDO is Sub index DO (% saturation);

SIBOD is Sub index BOD;

SICOD is Sub index COD;

SIAN is Sub index NH3N;

SISS is Sub index SS;

SIpH is Sub index pH.

Best Fit Equations for the Estimation of Various Sub Index Values:

Sub index for DO (% in saturation)

SIDO = 0 for $x \leq 8$

SIDO = 100 for $x \geq 92$

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

Sub index for BOD

SIBOD = 100.4 – 4.23x for $x \leq 5$

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

Sub index for COD

SICOD = -1.33x + 99.1 for x ≤ 20

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

Sub index for NH3N

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

Sub index 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

Sub index 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*

APPENDIX C

Figure C.1: Entrance of Lata Janggut

Figure C.2: Stagnant water area at Lata Janggut

Figure C.3: Water sampling process using YSI Multiparameter

Figure C.4: Flowing water area at Lata Keding

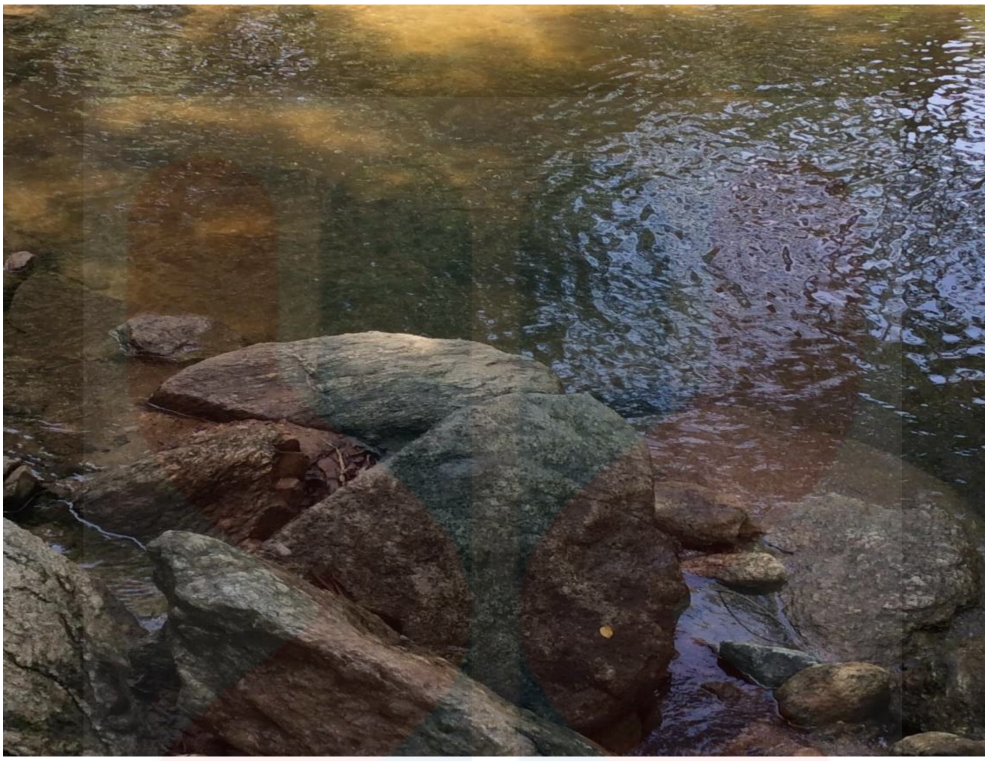

Figure C.5: Stagnant water area at Lata Keding