ANALYSIS OF WATER QUALITY USING PHYSICO-CHEMICAL PARAMETERS IN SUNGAI GALAS, KELANTAN

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by

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DECLARATION

I declare that this thesis entitled Analysis of Water Quality Using Physico-Chemical Parameters in Sungai Galas, Kelantan 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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LIST OF ABBREVIATION

DO	Dissolved oxygen
FAO	Food and Agriculture Organization
NTU	Nephelometric Turbidity Units
TDS	Total Dissolved Solid
U.S.EPA	United State Environmental Agency Protection
WHO	World Health Organization

LIST OF SYMBOLS

%	Percentage
^{o}C	Degree Celsius
<	Less Than
>	More Than
n	Number of Sample

Analysis of Water Quality Using Physico-Chemical Parameters in Sungai Galas, Kelantan

ABSTRACT

The purpose of this research is to determine the status of water quality in Sungai Galas based on physico-chemical parameter. There were 60 sampling station were selected at two sampling areas and three replication measurement were conducted at each sampling station by using YSI Multiprobe parameter and turbidimeter. In-situ parameters reading taken at the site were water temperature, pH, water conductivity, salinity, dissolved oxygen (DO), total dissolved solid (TDS), and turbidity. This study was done starting from July, August and September 2016. From the obtained results, as most physico-chemical parameters in residential area (downstream) has higher mean value compared to vegetative area (upstream) namely temperature, conductivity, salinity, TDS and turbidity. pH and DO mean values descend as the river water flow from upstream to downstream. The highest pH recorded was in vegetative area, 7.12 ± 0.08 and the lowest, 6.30 ± 0.07 from residential area. The temperature recorded was less varies which within range 26.50 ± 0.18 ^{o}C to 29.55 ± 0.26 ^{o}C. The highest mean concentration of DO recorded was 6.45 ± 0.44 mg/L from vegetative area and the lowest was 2.12 ± 0.29 mg/L from residential area while the conductivity value is highest at residential area which is 90.00 ± 0.01 µS/cm and lowest at vegetative area which is 40.00 ± 0.01 µS/cm. The salinity was in ranges between 0.02 to 0.04 and the mean concentration of TDS was in ranges between 60.00 ± 0.00 mg/L 30.00 ± 0.01 mg/L. The highest mean value of turbidity is 95.30 ± 2.83 NTU for residential area and the lowest is, 91.91 ± 16.37 NTU for vegetative area. As compare to WHO, EPA and FAO for drinking and irrigation purposes, most of the physico-chemical parameters in this study shows there were within the permissible limit. The mean concentration of DO were not achieve the standard which it must >4 mg/L and there were no prescribed standards suggested by EPA and FAO for salinity. Independent t-test was conducted and most of the parameter shows significance between two areas. Pearson's correlation shows there were positive correlation between temperature, conductivity, salinity, TDS and turbidity parameters. DO and pH have negative correlation to the other parameters.

Keywords: Physico- Chemical, Water Quality, Sungai Galas, Permissible Limit, River

Kajian Kualiti Air Menggunakan Pengukuran Fizikal dan Kimia di Sungai Galas, Kelantan

ABSTRAK

Kajian ini dilakukan bagi menentukan status kualiti air di Sungai Galas berdasarkan pengukuran fizikal dan kimia. Terdapat 60 puluh stesen persampelan dipilih di dua kawasan persampelan dan tiga replikasi dijalankan pada setiap stesen persampelan menggunakan pengukuran Multiprobe YSI dan turbidimeter. Parameter in-situ yang ditentukan dalam kajian adalah suhu air,pH, kekonduksian air, kemasinan, oksigen terlarut jumlah pepejal terlarut, dan kekeruhan air. Kajian ini dijalankan bermula dari bulan Julai, Ogos dan September 2016. Daripada keputusan yang diperolehi, kebanyakan parameter fiziko-kimia di kawasan kediaman (hilir) mempunyai nilai min yang lebih tinggi berbanding dengan kawasan vegetatif (hulu) iaitu suhu, kekonduksian air, kemasinan, jumlah pepejal terlarut dan kekeruhan. Nilai min pH dan DO menurun mengikut aliran air sungai dari hulu ke hilir. pH tertinggi yang dicatatkan adalah di kawasan vegetatif, 7.12 ± 0.08 dan yang paling rendah, 6.30 ± 0.07 dari kawasan kediaman. Suhu yang dicatatkan kurang perbezaan iaitu dalam julat 26.50 ± 0.18 ^{o} C hingga 29.55 ± 0.26 ^{o} C. Kepekatan tertinggi DO dicatatkan ialah 6.45 ± 0.44 mg / L dari kawasan vegetatif dan yang paling rendah ialah 2.12 ± 0.29 mg / L dari kediaman kawasan manakala nilai kekonduksian adalah paling tinggi di kawasan kediaman iaitu 90.00 ± 0.01 μS / cm dan terendah di kawasan vegetatif iaitu 40.00 ± 0.01 μS / cm. Kemasinan adalah dalam julat antara 0.02 to 0.04 dan min kepekatan TDS adalah dalam julat antara 60.00 ± 0.00 mg / L 30.00 ± 0.01 mg / L. Nilai min tertinggi bagi kekeruhan ialah 95.30 ± 2.83 NTU untuk kawasan kediaman dan yang paling rendah ialah 91,91 ± 16.37 NTU bagi kawasan vegetatif. Perbandingan dengan WHO, EPA dan FAO untuk tujuan minuman dan pengairan, kebanyakan parameter fiziko-kimia dalam kajian ini menunjukkan terdapat dalam had yang dibenarkan. Min Kepekatan DO tidak mencapai standard yang iaitu > 4 mg / L dan tidak ada standard yang ditetapkan oleh EPA dan FAO untuk kemasinan. Ujian-t bebas telah dijalankan dan kebanyakan parameter menunjukkan signifikasi antara kedua-dua kawasan. Perkaitan Pearson menunjukkan terdapat hubungan yang positif antara parameter suhu, kekonduksian, kemasinan, jumlah pepejal terlarut dan kekeruhan. DO dan pH mempunyai perkaitan negatif kepada parameter lain.

Kata Kunci: Fiziko-Kimia, Kualiti Air, Sungai Galas, Had Yang Dibenarkan, Sungai

CHAPTER 1

INTRODUCTION

1.1 Background of Study

River is the major water source of water supply for many purpose (Mustapha *et al*., 2013). It is very much essential for a country especially for supply valuable drinking water to humans, irrigation water to farmlands and provide habitat to many aquatic plants and living organism (Katyal *et al*., 2012). Rivers have always been the most important freshwater resources for life, as ancient civilizations have flourished along them, and most developmental activities are still depend on them (Varol *et al*., 2012).

Rapid industrialization and consequent urbanization has contribute to several problems in management of water quality (Katyal *et al*., 2012). Many cities in developing countries have been developed without adequate and proper planning (Mustapha *et al*., 2013). This has driven to indiscriminate actions, including dumping of wastes into the water and washing as well as bathing in open surface of water bodies (Cukrov *et al*., 2012). Because of their role in carrying away municipal and industrial wastewater and runoff from agricultural land, rivers are among the most vulnerable water bodies to pollution. Most cases, the effluents discrete from various industries are not treated before disposal to water way because of treatment cost, unconsciousness and other various causes (Rafiquel *et al*., 2016). As a result, it is being highly polluted with different kinds of harmful contaminants.

The river water quality is truly a sensitive issue today because of its effects on human health and aquatic ecosystems (Zhang *et al*., 2009). The discharge of untreated or partially treated industrial waste waters containing heavy metals into the water bodies, especially rivers, prevail in aquatic bodies and get bioaccumulated along the food chain. Biomagnification of these heavy metals along the food chain occurs leading to various health hazards to both humans and other living organisms (N. Patil & Puttaiah, 2014). The contamination of river water by heavy metals is a seriously ecological problem as some of them like mercury (Hg) and lead (Pb) are toxic even at low concentrations, are non-degradable and can bio-accumulate through food chain (Manoj *et al*., 2012). From the environmental, economical, and social point of view, it is important to identify these sources and their contribution to the total contamination of an area.

The accurate determinations of water quality using the physico-chemical parameters is ultimately important for controlling their pollution. Therefore, water quality assessment is a helpful tool not only to evaluate the impacts of pollution but also to ensure an efficient management of water resources and the protection of aquatic life (Varol *et al*., 2012).

For this analysis, Sungai Galas at Dabong was selected as study area. Sungai Galas has been used heavily by the local people for domestic uses, transportation, recreation, agricultural irrigation and also small scale fishing industries (Hashim *et al*., 2015). The Sungai Galas is form from the combination of Sungai Betis and Sungai Nenggiri. Sungai Pergau combine with Sungai Galas near Dabong and then the combination of Sungai Galas and the Sungai Lebir near Kuala Krai form Sungai Kelantan. Because Sungai Galas is not the main river as Sungai Kelantan, there are insufficient data and information on the physico-chemical parameters in this area.

There were 60 sampling stations chosen along Galas River at Dabong for in-situ analysis. The sampling area were systematically select depend on different land used where 30 stations were located in residential area (upstream) and the other 30 stations in vegetative area (downstream) along Sungai Galas at Dabong. In-situ parameters reading taken at the stations were water temperature, water conductivity, dissolved oxygen (DO), total dissolved solid (TDS), pH, total suspended solid (TSS), and turbidity. The data obtained was statistically analyses using t- test analysis to determine the significant difference between parameters at each sampling areas and the correlation between the physico-chemical parameters.

1.2 Problem Statement

River water finds multiple uses in every sector of the economy, including agriculture, industry, transportation, aquaculture and the public water supply, among others (Varol *et al*., 2012). River water resources, especially in developing countries where the heavy industrialization, increasing urbanization, and adoption of modern agricultural practices play and important role in improving the living standard but at the same time cause severe environmental damage and declining quality of life for many people (Kumar *et al*., 2015).

In recent years, there has been increasing awareness of water pollution all over the world, and new approaches toward the sources of pollutants and achieving sustainable exploitation of water resources have been developed (Mustapha *et al.*, 2013).

Sungai Galas is the important river in formation of Sungai Kelantan. Since Sungai Kelantan is the main water resources in Kelantan, it has a lot of data about the water quality assessment compared to other river such as Sungai Galas. So, determination of physico-chemical parameters is necessary to provide data for Sungai Galas management and improvement.

Constant monitoring of a river system is required to evaluate the effects of the environmental factors on water quality for proper utilization and sustainable of the resources. While monitoring rivers, water need to be chemically characterized and if there are pollutants in water, these should be identified and concentration quantified. The results of these analyses are essential to good water management as they provide the basic information required for proper assessment (Djuikom *et al.*, 2009). All the data obtained can be used to identified either the river water are suitable for domestic uses, fishing industry, plantation irrigation and small scale industries.

1.3 Significance of Study

The deterioration of water quality has led to the destruction of ecosystem balance, contamination and pollution of ground and surface water resources (Gebreyohannes *et al.*, 2015). Anthropogenic influences which release pollutants into the environment, as well as natural processes, deteriorate surface water and impair their use for drinking, industrial, agricultural, recreation or other purposes and led to an adverse effect upon aquatic ecosystems. Network of variable in physico-chemical parameters namely temperature, pH, dissolved oxygen (DO), conductivity, salinity, total dissolved solid (TDS) and turbidity can be used to determine the quality of river water. Any changes in these physical and chemical variables can affect aquatic biota in a variety of ways (Kolawole *et al.*, 2011). Since the quality water is directly related to health and is important for determination of water utility, it is very essential and important to test the quality of the water before it is used for drinking, domestic, agricultural or industrial purposes (Gebreyohannes *et al.*, 2015). The utility of river water for various purposes is governed by physicochemical and biological quality of the water (Singh *et al.*, 2013).

1.4 Objective

a) To determine the status of water quality in Sungai Galas, Kelantan based on physico-chemical parameters.

b) To compare the significant differences between parameters in residential area (upstream) and vegetative area (downstream).

CHAPTER 2

LITERATURE REVIEW

2.1 River Water

River constitute the main inland water body for domestic, industrial, and agricultural activities. River water serves as an important tools in irrigation of agricultural lands, generation of hydro-electric power, municipal water supply, fishing, boating and body contact recreation, communication as well as unending domestic activities of human and animals (Shakirat & Akinpelu, 2013).

Human development activities have led to the deterioration and degradation of the environment due to increase of human population and waste generation (Shakirat & Akinpelu, 2013). The disposal of municipal and industrial wastes in the water sources is causing major problems regarding the environment and making it fragile (Rafiquel *et al*., 2016).

Contamination can come from nonpoint sources and point sources along the river settlement. Nonpoint sources of contamination include domestic and wild animal defecation, malfunctioning sewage and septic systems, storm water drainage and urban runoff, while point sources include as industrial effluents and municipal wastewater treatment plants (Chigor *et al*., 2012). The waste released into the river may contain harmful chemicals such as heavy metals, oil, settle-able solids, nutrients and ammonia. These pollutants have various effects on the organisms in the receiving water body.

Human activity is one of the most important situational factors affecting hydrology and water quality. Water chemistry of the rivers can reflect change in their watersheds, making rivers good indicators of land use. The chemical alteration associated with human activity is related to development of city and intensification of agriculture, especially the discharge of untreated sewage wastes. Thus, human activities, and urbanization, result in alterations of river water quality.

The main parts of the first group are dominated by natural vegetation, which represent rural basin. Therefore, the anthropogenic contribution to their major ion budget is unlikely to be of importance. The main part of the second group are affected more significantly by human activities than the first group (Yang *et al*., 2012).

2.2 Physico-chemical Parameters

2.2.1 Temperature

Water temperature is an important water quality parameter, which regulates the biogeochemical activities in the aquatic environment and relatively easy to measure in water bodies which naturally show change in temperature seasonally (Kumar *et al*., 2015). The water temperature is a measure of the heat content of the water mass and influences the growth rate and survivability of aquatic life. Different species of fish have different needs for an optimum temperature and tolerances of extreme temperature. Effect on physical phenomena such as rate of biochemical and chemical reactions in the water bodies can be determined by temperature (Olajire & Imeokparia, 2001).

2.2.2 Turbidity

Turbidity is an important measurement of water clarity which expression of optical property in which the light is scattered by the particles present in the water. Low turbidity necessary for light to reach submerged aquatic vegetation and promote growth (Le *et al*., 2013). High turbidity resulting from suspended solids in the water, including silts, clays, industrial wastes, sewage and plankton. Turbidity is measured in Nephelometric Turbidity Units (NTU) which measures the extent to which a focused light beam scatters in the medium.

2.2.3 Total Suspended Solid (TSS)

Suspended solids (SS) are natural pollutants and cause turbidity in the river water. The excess amount of SS in water can also be an indicator of land erosion in the river catchment (Naubi *et al.*, 2016). Total suspended solid is usually referred to the particles in water which is usually larger than 0.45 μm. Pollutant such as toxic heavy metals can be attached to suspended solid which is not good for the aquatic habitat and lives. High suspended solid also prevent sunlight to penetrate into water (Al-Mamun & Abad Consultant Sdn Bhd, 2009).

2.2.4 Total Dissolved Solid (TDS)

Total dissolved solid consist of dissolved minerals and indicates the presence of dissolved materials that cannot be removed by conventional filtration. The presence of synthetic organic chemicals such as fuels, detergents, paints and solvents imparts objectionable and offensive tastes, odors and colors to fish and aquatic plants even when they are present in low concentration (Al-Mamun & Abad Consultant Sdn Bhd, 2009).

2.2.5 pH

pH is a measure of the acidity and alkalinity in the water. The lower the pH, the more acidic the water. Low pH causes toxic elements and compounds to become available for uptake by aquatic plants and animals (Naubi *et al.*, 2016). pH of a water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity (Kumar *et al*., 2015).

2.2.6 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is one of the important parameter in water quality assessment which measure the amount of oxygen freely available in water and it is commonly expressed as a concentration in terms of milligram per liter (mg/L) (Naubi *et al*., 2016). DO concentrations are influenced by many factors including water temperature, the rate of photosynthesis, the degree of light penetration (turbidity and water depth), the degree of water turbulence or wave action, and the amount of oxygen used by respiration and decay of organic matter. The colder the water, the more oxygen it can hold as it is temperature dependent. Low DO in any river water makes aquatic species move away, weaken, or even die. Decrease DO in water also tend by inorganic reducing agent such as ammonia, nitrite, ferrous iron and certain oxidizable substance (Kumar *et al*., 2015).

2.2.7 Conductivity

Conductivity shows significant correlation with ten parameters such as temperature, pH value, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, and chloride and iron concentration of water (Patil *et al*., 2012).

2.2.8 Salinity

According to Unite States Environmental Protection Agencies (U.S.EPA), salinity is the measure of all the salts dissolved in water. Change in salinity can affect biota in freshwater directly or indirectly. Toxic effects as a consequence of increasing salinity cause physiological changes, resulting in a loss (or gain) of species. Indirect changes can occur where increasing salinity modifies community structure and function by removing (or adding) taxa that provide refuge, food or modify predation pressure. Other factors such as water-logging or loss of habitat may interact with salinity or have a more immediate impact on species richness (Nielsen *et al.*, 2003).

2.3 YSI Portable Multi Probes

YSI 556 MPS (Multi Probe System) was used to determine all physicochemical parameters in the water quality analysis. Parameters measured were dissolved oxygen, pH, conductivity, temperature, total dissolved solid (TDS) and salinity which the measurement range for dissolved oxygen is 0 to 500% air saturation / 0 to 50 mg/L, 5 to 45 ^{o}C for temperature, 0 to 200mS/cm for conductivity, 0 to 70 ppt for salinity, 0 to 14 units for pH and 0 to 100 g/L for total dissolve solid (TDS).

Rugged and reliable, the YSI 556 MPS water quality analyzer (Multi probe system) combines the versatility of an easy-to-use, easy-to-read handheld unit with all the functionality of a multi-parameter system. Featuring a waterproof, impact resistant case, the YSI 556 MPS simultaneously measures dissolved oxygen, conductivity, temperature, and pH, salinity and total dissolved solid (TDS). A simple cellular phone style keypad and large display make the instrument easy to use. All of the sensors, except temperature, require periodic calibration to assure high performance.

2.4 Sungai Galas

Part of Sungai Galas near Dabong where the study was conducted is observed that there are many activities such as domestic uses, small scale fishing industries and recreation and the local people directly consume the river water (Hashim *et al.*, 2015). In addition, development in Dabong is quite higher compare to other area along Sungai Galas.

2.5 Sampling Point

For selecting of the sampling point, systematic sampling is used based on the environment and activities run along the Sungai Galas. In systematic sampling, measurements are taken at locations and/or times according to a predetermined pattern. This approach does not require the prior knowledge of pollutant distribution, is easy to implement, and should produce unbiased samples. A systematic method also provides researchers and statisticians with a degree of control and sense of process. This might be particularly beneficial for studies with strict parameters or a narrowly formed hypothesis, assuming the sampling is reasonably constructed to fit those parameters (Ross, 2016).

This is usually the method of choice for practical purposes. Sample areas are chosen at appropriate locations. These locations are chosen on the basis of experience and/or judgement. Samples are usually drawn at prescribed, not necessarily regular, points along horizontal and vertical transects (Chapman, 1996).

2.6 Statistical Analysis

The most reliable method of ascertaining water quality conditions is through statistical analyses of data. The specific analyses performed will have been decided upon during the design phase of the monitoring program. Statistical analysis also have been used by Yap *et al*. (2011), Chigor *et al*. (2012) and Tan & Rohasliney, (2013) in their water quality assessment. For this water quality assessment, we use a two-sample, two-tailed t-test. In this test, two samples are required, generally an upstream and a downstream site. It is considered a `two-tailed test' because the null hypothesis is phrased to determine if the mean values of the samples are equal without regard for the direction of a potential difference. An example of when this test might be applied would be a pre-treatment analysis of two sites (control and future treatment sites) to demonstrate that no difference exists between the two (and as such, the control is appropriately located). Future post-treatment differences that might be detected between the two sites would therefore, be attributable to the anthropogenic activity (treatment effect).

This analysis is preferable due to its advantage which it can be applied to a relatively small number of samples. It is specifically designed to asses statistical differences for sample of 30 or less.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

Study site that has been chosen is Sungai Galas at Dabong, Kelantan. Sungai Galas is one of the channel rivers of the Sungai Kelantan which has 3970 km^2 of total catchment area and 7770 km^2 of total area. The Sungai Kelantan is formed from the combination of the Sungai Galas and the Sungai Lebir near Kuala Krai (Figure 3.1). The total length of the covered sampling area approximately 6.5 km.

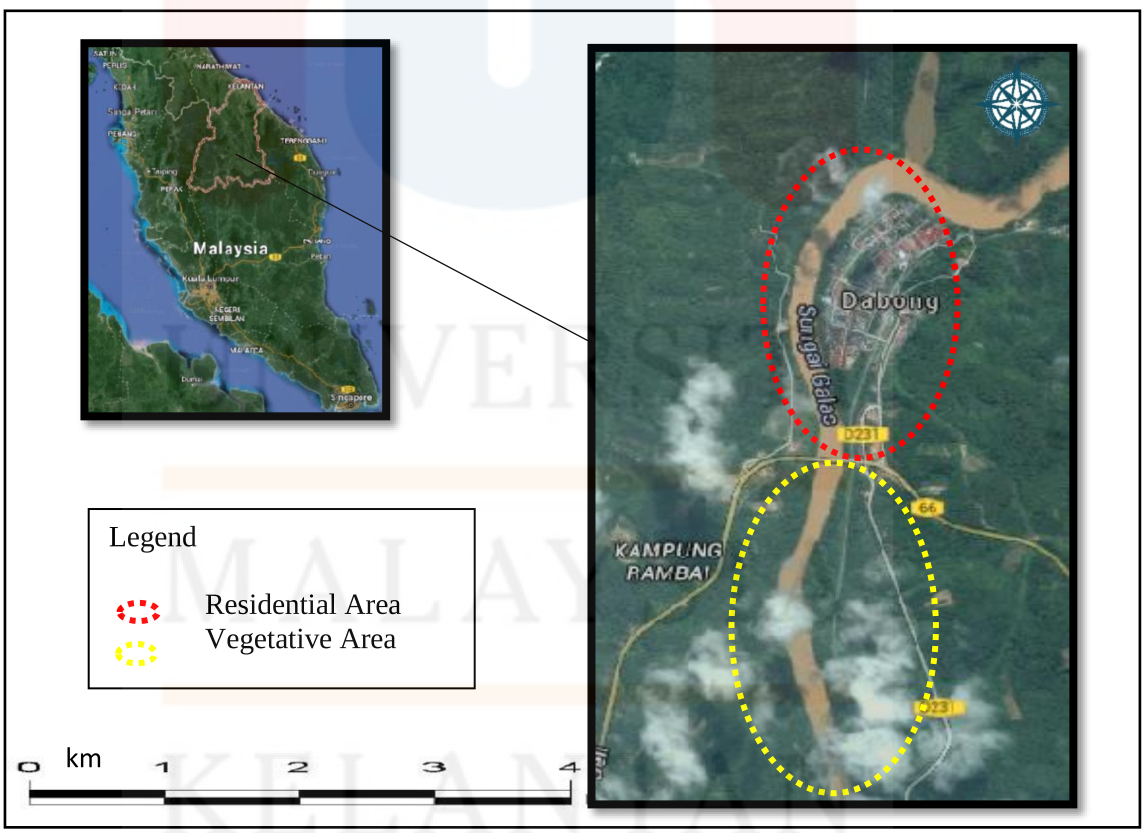

Figure 3.1: Sampling stations based on the land used run along the Sungai Galas at Dabong (Source: Google Map, 2016)

3.2 Sampling Stations

A total of 60 sampling stations were selected. 30 stations were located in vegetative area (upstream) and the other 30 stations in residential area (downstream). Vegetative area is marked A and for residential area is marked B. The water samples were tested triplicate for each stations between 8.00 a.m. to 11.00 a.m. Repeated measurements were made to ensure precision and accuracy of result and the water analysing were conducted monthly for three consecutive month namely July, August and September to avoid biasness and to confirm if there is similarity or differences in the reading. Global Positioning System (GPS) (GPSMap® 62s, Ohio) was used to determine the coordinate of sampling stations. The sampling area were systematically select depend on different land used which is residential and vegetative area along Sungai Galas at Dabong. The distance between 30 sampling stations in each area are equally divided into approximately length.

Table 3.1: Location of starting and ending sampling point for both area

	Coordinates	
Area	Start	End
Vegetative Area	N 5º 20' 1.1832" E 102º 0' 53.0928"	N 5º 21' 37.2708" E 102º 0' 22.7124"
Residential Area	N 5º 21' 45.9" E 102º 0' 20.8944"	N 5º 22' 53.0508" E 102º 0' 32.0544"

3.3 In- Situ Analysis

Water temperature, conductivity, dissolved oxygen (DO), total dissolved solid (TDS) and pH of the river water samples were measured in- situ by using YSI portable multi probes water quality equipment (YSI incorporated, Yellow Spring®, Ohio, USA). The probe was submerged fully into the water at least around 10cm from the water surface. The YSI 556 model MPS simultaneously measure the dissolved oxygen, pH, conductivity, salinity, total dissolved solid and temperature. For turbidity, portable Turbidimeter Hanna Model 2100P was used to measured turbidity of the water. The equipment was submerged fully into the water at least around 10-20 cm from the water surface (Yap *et al*., 2011).

3.4 Quality Control

Water quality test was conducted in- situ for 30 stations located in vegetative area (upstream) and the other 30 stations in residential area (downstream) in the morning hours between 8.00 to 11.00 a.m. (Manjare *et al*., 2010). A day with no rainfall for the previous 24 hours was chosen for the water quality analysis. The day with no rainfall for the last 24 hours provides a better opportunity to get water quality tests in normal river flow conditions (Naubi *et al*., 2016). All the instruments were calibrated before use for observing readings. The repeated measurements were made to ensure precision and accuracy of result (Arasu *et al*.,2007).

3.5 Statistical Analysis

The significant differences of the parameters between two sampling areas was determined by t- test analysis and Pearson correlation (r) test at the 99% confidence level was analyzed to identify the association between pairs of variables for sampling areas. The statistical analysis was performed using IBM SPSS Statistics version 23 software.

CHAPTER 4

RESULT AND DISCUSSION

Analysis of water quality using physico-chemical parameters were conducted in Sungai Galas, Kelantan. The parameters namely temperature, pH, total dissolved solid (TDS), dissolved oxygen (DO), turbidity, electrical conductivity (EC) and salinity were analyzed. Assessment of the river water for pollution is made by comparison of the assessed values of all the physico-chemical parameters in vegetative area (upstream) and residential area (downstream) with the corresponding standards prescribed for drinking water by WHO (2008) and EPA (2006).

Physico-chemical parameters analysis for river water is important because according to the World Health Organization's (WHO) decision, water for consumption should be free from pathogenic organisms and toxic substances. It is a fact that good water quality produces healthier humans than one with poor water quality (Mehari, 2013). Sungai Galas is important for local people in Dabong and its water is used for domestic and agricultural purposes. Physico-chemical characteristic may describe the water quality of Sungai Galas and effective maintenance of water quality can be done through appropriate measurements.

There were 30 sampling for each area namely vegetative and residential area. These area were selected to represent the different type of land use can contribute to different water quality of the same river. Gebreyohannes *et al*., (2015) state that the increased anthropogenic activities due to industrialization have contributed to decline in water quality including climate and precipitation, soil type, vegetation, groundwater and flow conditions

Mean values of the measured physico-chemical parameters of the river water are showed in Table 4.1. The results of the study show that the physico-chemical nature of water of the Sungai Galas has been affected but the concentration of some of the constituents are not over the permissible limit as recommended by World Health Organization (WHO), Environmental Protection Agency (EPA), Food and Agriculture Organization (FAO) standard (Table 4.1) and National Water Quality Standards For Malaysia (NWQSM) (Table 4.2) . Independent t – test at 95% confidence level were calculated (Appendix A) and the results were presented as mean and standard deviation (Mean ± SD)(Table 4.1). Pearson's correlation coefficient (r) is used to show the relationship between the physico-chemical parameters recorded in Sungai Galas (Appendix A).

Table 4.1: Mean value of physico-chemical parameters for both area and guidelines of water quality

Parameters	Month						Guidelines of Water Quality		
	July		August		September				
	Vegetative Area	Residential Area	Vegetative Area	Residential Area	Vegetative Area	Residential Area	WHO	EPA	FAO
Temperature	26.50 ±0.18	26.90 ±0.32	29.22 ±0.12	29.55 ±0.26	27.80 ±0.08	28.19 ±0.23	<40	-	-
pH	6.61 ±0.18	6.30 ±0.07	6.61 ±0.18	6.30 ±0.07	7.12 ±0.08	6.76 ±0.29	6.5 – 8.5	6.5 – 9.5	6.0 – 8.5
DO	6.45 ±0.44	4.78 ±0.51	4.29 ±0.28	3.55 ±0.22	3.36 ±0.37	2.12 ±0.29	5.0 - 7.0	-	>4.0
Conductivity	40.00 ±0.00	50.00 ±0.00	80.00 ±0.01	90.00 ±0.01	60.00 ±0.00	60.00 ±0.00	750	2500	3000
Salinity	0.02 ±0.01	0.04 ±0.01	0.04 ±0.00	0.04 ±0.01	0.03 ±0.01	0.04 ±0.01	250	-	-
TDS	30.00 ±0.00	30.00 ±0.00	50.00 ±0.00	60.00 ±0.00	40.00 ±0.00	50.00 ±0.00	500	500	2000
Turbidity	94.15 ±3.07	95.04 ±3.87	91.91 ±16.37	94.86 ±6.16	94.96 ±2.21	95.30 ±2.83	5.0	0 - 5	-

Mean ± S.D., n = 30

(Source: WHO (2008), EPA (2006), FAO Standard (Ayers and Westcot, 1994)

Table 4.2: National Water Quality Standards for Malaysia

Parameter	Unit	Class					
		I	**IIA**	**IIB**	**III**	**IV**	**V**
Temperature	^{o}C	-	-	-	-	-	-
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
DO	mg/L	7	5 - 7	5 - 7	3 - 5	< 3	< 1
Conductivity	µS/cm	1000	1000	-	-	6000	-
Salinity	-	0.5	1	-	-	2	-
TDS	mg/L	500	1000	-	-	4000	-
Turbidity	NTU	5	50	50	-	-	-

Note: Class I: conservation of natural environment, Class IIA & B: conventional treatment and recreational use body contact, Class III: extensive treatment required, Class IV: irrigation, Class V: None of the classes

(Source: NWQS, 2016)

4.1 Temperature

The temperature for the residential area shows there is slightly higher for first, second and third times of sampling respectively 26.90 ± 0.32 ^{o}C, 29.55 ± 0.26 ^{o}C and 28.19 ± 0.23 ^{o}C compared to the vegetative area which are 26.50 ± 0.18 ^{o}C, 29.55 ± 0.12 ^{o}C and 27.80 ± 0.08 ^{o}C (Table 4.1). Figure 4.1 shows the difference in temperature between two areas as a result of rising population in urban area that placed significant stress on water quality and availability.

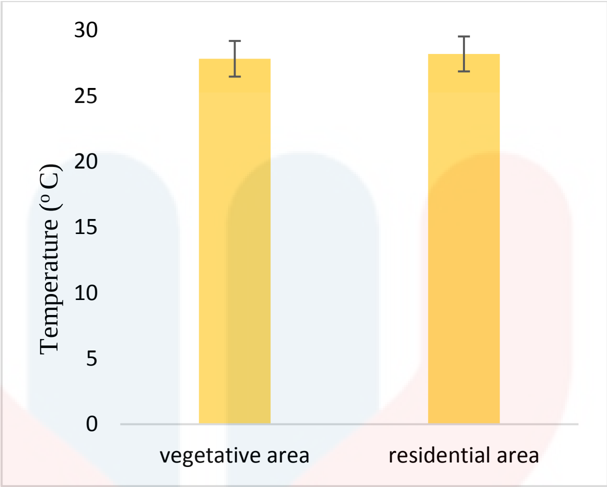

Figure 4.1: Mean variation for temperature (°C)

Naturally water bodies show changes in temperature daily and seasonally due to different activities that can contribute to changes in surface water temperature (Gebreyohannes *et al.*, 2015). Some of the factors that affect river water temperature are heat exchange on the earth surface under controlled radiation in and out, groundwater movement and chemical and thermonuclear processes occurring in an aquifer (Gasim *et al.*, 2007).

Moreover, the temperature of the water increase as it goes down from the vegetative area (upstream) to residential area (downstream) and this might due to the lack of canopy cover on the river banks. Slightly lower temperature on the upstream compare to downstream because of the condition of upstream site that covered by tree and shrub and according to Mahazar *et al.* (2013), this shows how plant vegetation play important role in regulating temperature in aquatic environment.

Furthermore, in this analysis the temperature increased progressively from upstream to downstream, and statistically significant differences were found between areas (t-test, $p < 0.05$) as the value of t-test, t = -2.229 with $p = 0.027$ (Appendix A). Pearson correlation shows that there are negative correlation between temperature and pH, as well as temperature and DO which means as the temperature increase from upstream to downstream, the pH and DO is decrease. Correlation is significant at the 99% confidence interval between temperature and DO ($p < 0.05$).

Temperature obtain from this analysis is considered lower compared to WHO maximum permissible limit (WHO, 2008) which is <40 ^{o} C (Table 4.1). Thus, the temperature of Sungai Galas is consider to be suitable for aquatic live. This result is similar to other studies reported within a range of 26.15 - 28.9°C in Sungai Bebar, Pahang (Gasim *et al.*, 2007) (Table 4.3).

4.2 pH

The pH of the investigated samples is slightly lower for residential area than vegetative area for all sampling days. The highest pH recorded was 7.12 ± 0.08 obtained from vegetative area where as the lowest mean pH value were 6.30 ± 0.07 for residential area (Table 4.1). The river water with the lowest pH 6.30 may be attributed to the discharge of acidic products into this source by the agricultural and domestic activities.

Table 4.3: Previous study of physico-chemical parameter of river in Malaysia

River	Parameters							Reference
	Temperature (º C)	**pH**	**DO (mg/L)**	**Conductivity (µS/cm)**	**Salinity**	**TDS (mg/L)**	**Turbidity (NTU)**	
Kelantan River, Kelantan	-	6.4	7.2	587.00	-	36.6	44.0	Ahmad *et al.*, 2009
Bebar River, Pahang,	26.15 - 28.90	3.80	1.15	55.78	-	88.5	9.33	Gasim *et al.*, 2007
Bertam River, Cameron Highlands	18.19	6.54	6.31	58.33	-	43.33	-	Khalik *et al.*, 2013
Semenyih River, Selangor	26.04	8.41	5.79	71.35	-	46.33	105.35	Al-badaii *et al.*, 2013
Manggaris River. Sabah	30.25	7.66	6.34	240.00	0.10	0.14	9.92	Aris *et al.*, 2014
Langkon River, Sabah	29.51	7.38	5.10	330.00	0.14	0.20	8.40	Aris *et al.*, 2014
Sungoi River, Sabah	28.24	7.35	5.34	210.00	0.09	0.12	10.74	Aris *et al.*, 2014

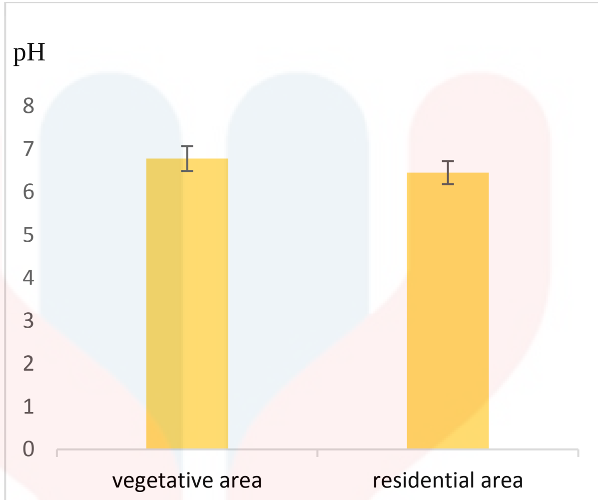

Figure 4.2: Mean variation for pH

Basically, the pH is determined by the amount of dissolved carbon dioxide (CO_2), which forms carbonic acid in water (Gasim *et al.*, 2007). The pH concentration increase as a result of the photosynthetic algae activities that consumes carbon dioxide dissolved in (Al- Badaii *et al.*, 2013). There are also possibilities that the drainage system in the residential area (downstream) might influence the water chemistry that flow in the water bodies. As state by Mahazar *et al.* (2013), due to the leaching of minerals from this infrastructure into the water bodies thus modified the water chemistry by making it tends to be neutral pH.

Statistically significant differences were found between areas (t-test, $p < 0.05$) with the value of t-test, t = 7.598, and $p = 0.000$. There is negative significant correlation between pH and DO as $p < 0.05$ (Appendix A).

Overall, the range of pH from 6.3 to 9 is mainly appropriate for aquatic life as the range within the permissible limit of WHO (2008), EPA (2006) and FAO (Ayers and

Westcot, 1994) set for drinking and irrigation purposes (Table 4.1). Therefore it is very important to maintain the aquatic ecosystem within this range because high and low pH can be destructive in nature (Al-badaii *et al.*, 2013). As compared to NWQS for Malaysia, 2016 (Table 4.2), the pH is within Class IIA and B which is suitable for conventional treatment and recreational use body contact.

4.3 Dissolved Oxygen

Figure 4.3 shows mean concentration of dissolved oxygen (DO) in Galas River significantly decreases from vegetative area (upstream) to residential area (downstream). The highest mean concentration of DO recorded was 6.45 ± 0.44 mg/L for vegetative area and the lowest was 2.12 ± 0.29 mg/L for residential area.

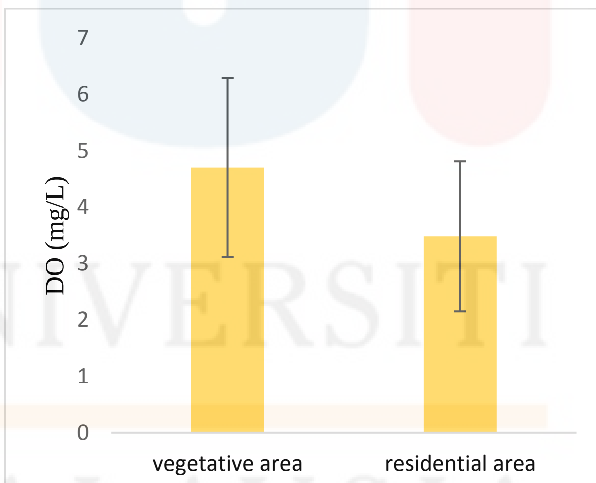

Figure 4.3: Mean variation for DO (mg/L)

The decreasing concentration of DO may resulted from the different level of nutrient contain in river water. When sampling areas have high nutrient levels (residential area), the upper section of surface waters may have higher oxygen levels as a result of increased algal activity, while below the water loses oxygen as microorganisms consume oxygen to break down algae (Henderson *et al.*, 2014). Activities in residential area such as small scale agriculture and location of the houses near to the river may contribute to the runoff of nutrient or chemical to the water bodies.

Moreover, the findings also indicate that at 95% confidence level, there is significant difference between the areas (t-test, $p < 0.05$). The value of t-test, t = 6.510 with $p = 0.00$ (Appendix A). Concentration levels of DO below 5.0 mg/L adversely affect aquatic life. Thus, DO values of the study area are not suitable for life of the aquatic ecosystem.

There is negative significant correlation of DO to the other parameters such as temperature, conductivity, salinity and TDS. This show that as the concentration of DO decreases from upstream to downstream, the other parameters increases. According to Patil *et al.* (2012) dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity.

Previous studies on different river also shows that, dissolved oxygen has an inverse relationship with water temperature. Studies conducted by Singh *et al*. (2013) observed the higher values of DO during winter, when temperature was lowest, and this might be due to the fact that the solubility of oxygen in water increases with decrease in temperature.

The mean concentration of DO in Sungai Galas did not achieve the permissible limits set by WHO (2008) and FAO (Ayers and Westcot, 1994) which is >4 mg/L (Table 4.1) and within Class V of NWQS for Malaysia (Table 4.2).

4.4 Conductivity

Conductivity values ranged from 90.00 ± 0.01 µS/cm to 40.00 ± 0.01 µS/cm at different locations and on different sampling days. The conductivity value is highest for residential area which is 90.00 ± 0.01 µS/cm and lowest at vegetative area which is 40.00 ± 0.01 µS/cm (Table 4.1).

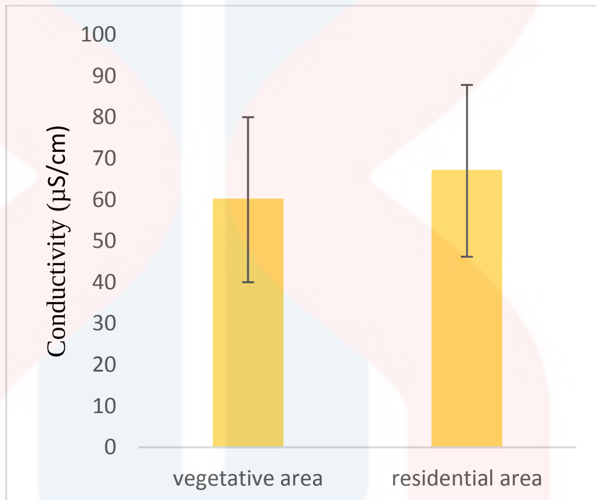

Figure 4.4: Mean variation for conductivity (µS/cm)

This indicate that the river water has different quality at different locations. High conductivity mostly are located within the densely populated area (Figure 4.4). Hence the relatively higher values may be associated to concentrated dissolved salts as a result of human activities (Gasim *et al.*, 2007).

The value of t-test, t = -2.668 with $p = 0.008$. At $p < 0.05$, there is significant difference between areas (Appendix A). Pearson correlation shows there is positive and strong significant correlation at the 0.01 level (2-tailed) between conductivity and temperature as well as TDS. It proves the gradually increasing in temperature as the river water flow from vegetative area to residential area will also increase the conductivity.

Warmer environment at the residential area increase the conductivity of water (Al- Badaii *et al.*, 2013). Other than that, the conductivity for residential area might be influenced mostly by the anthropogenic effluent that rich with dissolved solid which carry electrical charges (Mahazar *et al.*, 2013).

In addition, the higher the dissolved salt content present in the water, the higher the conductivity values obtained (Aris *et al.*, 2014). Mean variations in conductivity and TDS followed a similar trend (Table 4.1) which showed that there is a direct relationship between these variables. This is supported by a strong significant relationship between conductivity and TDS.

Conductivity values obtained from this analysis found that Sungai Galas has lower conductivity compared to the WHO maximum permissible limit by WHO (2008), EPA (2006), FAO Standard (Ayers and Westcot, 1994) and NWQS for Malaysia (2016). Hence, the water is suitable for irrigation indicating the presence of low amount of dissolved inorganic substances. Lower the conductivity, great amount of water will be available to plants. This is because plants can only transpire "pure" water as the usable plant water (Gebreyohannes *et al.*, 2015). Therefore, irrigation water with lower conductivity rise yield potential.

4.5 Salinity

This study shows less variation in salinity between vegetative and residential area and it ranges between 0.02 to 0.04. The highest salinity is 0.04 for residential area and the lowest is 0.02 for vegetative area (Figure 4.5). Salinity affects the taste of the water and be a good indicator of pollution (Joshi *et al.*, 2009).

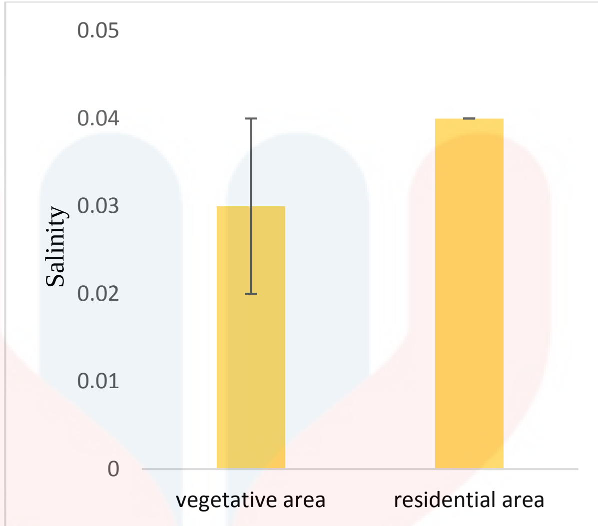

Figure 4.5: Mean variation for salinity

Figure 4.5 shows that residential area has higher salinity compared to vegetative area. Excessive level of salinity can affect the agricultural activity especially in plantation in term of specific toxicity of a particular ion. Moreover, it also contribute to the prevention of water absorption efficiency by the plant roots due to high osmotic pressure.

Statistically significant differences is found between areas (t-test, $p < 0.05$) as the value of t-test, t = -10.827 with $p = 0.000$ (Appendix A). Pearson correlation shows that there is positive significant correlation of salinity to the conductivity and TDS which means as the temperature increases from upstream to downstream, the conductivity and TDS also increases.

There is no prescribed standards suggested by EPA and FAO for conductivity parameter for domestic and irrigation purpose but the range is within the permissible limit of WHO (2008) (Table 4.1).

4.6 Total Dissolved Solid

TDS can be used as an indicator for general water quality because it directly affects the aesthetic value of water by increasing turbidity. High concentrations of TDS limit the suitability of water as a drinking source and irrigation supply (Reda, 2016). Generally, high values of total solids are mainly due to the presence of silt and clay particles in the river water (Weldemariam, 2013).

TDS in the water sample investigated at two different area, namely vegetative and residential area, is slightly different (Figure 4.6). The highest mean concentration of TDS was 60.00 ± 0.00 mg/L for residential area and the lowest is 30.00 ± 0.01 mg/L for vegetative area (Table 4.1). The mean value of the TDS is relatively higher for residential area for second and third times of sampling but this value is still within the limit permissible by the WHO, FAO and EPA standard for drinking purpose and irrigation water (Table 4.1). Table 4.2 shows that TDS of Sungai Galas is within Class I in NWQS for Malaysia which important in conservation of natural environment.

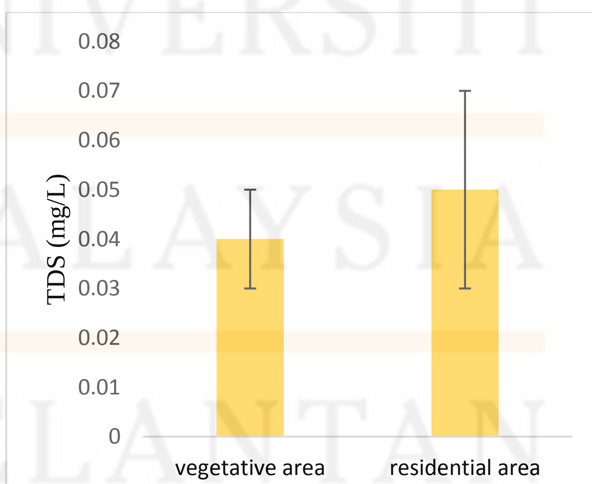

Figure 4.6: Mean variation forTDS (mg/L)

T- test result showed that there is significant difference ($p < 0.05$) in TDS between areas. The value of t-test, t = -4.391 with p = 0.000 (Appendix A). The high TDS concentration in the river is attributed to presence extreme anthropogenic activities along the river course and runoff with high suspended matter (Al- Badaii *et al.*, 2013). Higher TDS can be toxic to aquatic life through increases in salinity or changes in the composition of the water (Gebreyohannes *et al.*, 2015). There are positive correlation of TDS to the temperature, conductivity and salinity, and negative correlation toward DO which is significant at the 99% confidence level. It shows the higher the TDS of the river water, the higher the temperature, conductivity and also salinity. In contrast with DO, the increasing value of TDS will descend the DO concentration.

Previous studies on water quality assessment of the Semenyih River, Selangor (Table 4.3) also shows similar trend which upstream area have lower TDS values compared to the downstream ones because anthropogenic and land use activities were much less at upstream area (Al- Badaii *et al.*, 2013).

4.7 Turbidity

The highest mean value of turbidity is 95.30 ± 2.83 NTU for residential area and the lowest is, 91.91 ± 16.37 NTU for vegetative area (Figure 4.7). It shows that turbidity for residential area is higher than vegetative area for all three times of sampling. As people move into an area, new support facilities are needed such as roads, housing, shopping and commercial facilities. Land is disturbed during such construction, which can affect water quality. Increased human activity raises the likelihood of increased contaminants in the water supply (Henderson *et al.*, 2014).

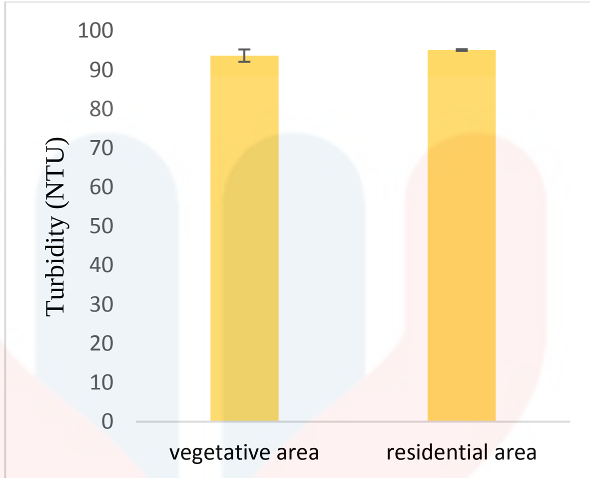

Figure 4.7: Mean variation for turbidity (NTU)

Prevalently, turbidity is resulted from the presence of suspended particles such as silt, plankton, clay, organic matter, and other microscopic or decomposers organisms. Generally, the clarity water decreased as a result of the presence of these suspended particles that deposited in the water. The murkier water in general was ascribed to the higher amount of sediments. This can also be the indicator of a high measured turbidity, and stream flow, surface runoff, and overland flow in natural waters also increase the turbidity levels in the water (Al-badaii *et al.*, 2013).

As the turbidity increases progressively from upstream to downstream, there is no statistically significant differences between areas (t-test, $p > 0.05$) as the value of t-test, t = -1.239 with $p = 0.217$ (Appendix A). Pearson correlation shows that mostly there are negative correlation of turbidity to the temperature, DO, conductivity, salinity and TDS. As the turbidity of river water increases from upstream to downstream, the concentration of DO decreases. Study conducted by Joshi *et al*. (2009) shows the similar negative correlation between turbidity and DO.

According to International Standards the acceptability of water for domestic use ranges from 5-25 NTU. Hence, Sungai Galas is not suitable for directly use by local people especially for drinking.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this study, most physico-chemical parameters in residential area (downstream) has higher mean value compared to vegetative area (upstream) namely temperature, conductivity, salinity, TDS and turbidity except pH and DO values. Mean value of pH and DO descend from upstream to downstream. This might result of rising populations in urban area that placed significant stress on water quality. The highest pH recorded was in vegetative area, 7.12 ± 0.08 and the lowest, 6.30 ± 0.07 from residential area where the discharge of acidic products by the agricultural and domestic activities is higher. The temperature recorded was less varies which within range 26.50 ± 0.18 ^{o} C to 29.55 ± 0.26 ^{o} C. The highest mean concentration of DO recorded was 6.45 ± 0.44 mg/L from vegetative area and the lowest was 2.12 ± 0.29 mg/L from residential area resulted from the different level of nutrient contain in river water. The conductivity value recorded is highest at residential area which is 90.00 ± 0.01 μS/cm and lowest at vegetative area which is 40.00 ± 0.01 μS/cm. This values may be associated to concentrated dissolved salts as a result of human activities in residential area. The salinity obtained was in ranges between 0.02 to 0.04 and the mean concentration of TDS obtained was in ranges between 60.00 ± 0.00 mg/L to 30.00 ± 0.01 mg/L. The highest TDS concentration in river is attributed to presence extreme anthropogenic activities along the river course and runoff with high suspended matter. The highest mean value of turbidity recorded by turbidimeter was 95.30

± 2.83 NTU for residential area and the lowest is, 91.91 ± 16.37 NTU for vegetative area. This resulted from the presence of suspended particles which decrease the water clarity water. As compare to WHO, EPA and FAO for drinking and irrigation purposes, most of the physico-chemical parameters in this study shows they are within the permissible limit. The mean concentration of DO did not achieve the standard which is >4 mg/L and there is no prescribed standards suggested by EPA and FAO for salinity. Independent t-test was conducted and most of the parameter shows significance between two areas. Pearson's correlation shows there were positive correlation between temperature, conductivity, salinity, TDS and turbidity parameters. DO and pH have negative correlation to the other parameters.

5.2 Recommendation

It is recommended that effective management of the Sungai Galas is required in order to minimize some problems associated to human health whose consume the river water for drinking and plant irrigation. There is also need for public awareness on the state of the water and implement legal and relevant laws enforcement regarding proper treatment of industrial and domestic discharge before entering to the river course.

In addition, a continuous monitoring of the river water covering both wet and dry seasons over a period time is necessary for fresh water source management such as river. Since the water body serves as potable source as well as for other human, animal and plant needs, periodic monitoring from time to time will be helpful to reassure the publics and safeguard the precious common property resource like river from illegal and improper exploitation. With a sampling time period limited to two month, results do not show changes in water quality over time. Then, it is recommend that the further research with a sampling period over a year where the data might show more variability and give a better estimate of typical parameter values.

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Appendix A

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Temperature	Equal variances assumed	.015	.904	-2.229	178	.027	-.37256	.16711	-.70233	-.04278
	Equal variances not assumed			-2.229	177.995	.027	-.37256	.16711	-.70233	-.04278
pH	Equal variances assumed	1.849	.176	7.598	178	.000	.32122	.04228	.23779	.40465
	Equal variances not assumed			7.598	177.975	.000	.32122	.04228	.23779	.40465
DO	Equal variances assumed	5.720	.018	6.510	178	.000	1.21856	.18717	.84920	1.58791
	Equal variances not assumed			6.510	173.472	.000	1.21856	.18717	.84914	1.58797
Conductivity	Equal variances assumed	5.898	.016	-2.668	178	.008	-.00749	.00281	-.01303	-.00195
	Equal variances not assumed			-2.668	169.628	.008	-.00749	.00281	-.01303	-.00195
Salinity	Equal variances assumed	5.716	.018	-10.827	178	.000	-.01122	.00104	-.01327	-.00918
	Equal variances not assumed			-10.827	173.318	.000	-.01122	.00104	-.01327	-.00918
TDS	Equal variances assumed	.062	.804	-4.391	178	.000	-.00718	.00163	-.01040	-.00395
	Equal variances not assumed			-4.391	177.150	.000	-.00718	.00163	-.01040	-.00395
Turbidity	Equal variances assumed	.123	.727	-1.239	178	.217	-1.39222	1.12345	-3.60922	.82478
	Equal variances not assumed			-1.239	125.131	.218	-1.39222	1.12345	-3.61565	.83121

Correlations								
		Temperature	pH	DO	Conductivity	Salinity	TDS	Turbidity
Temperature	Pearson Correlation	1	-.122	-.561**	.956**	.445**	.952**	-.077
	Sig. (2-tailed)		.102	.000	.000	.000	.000	.301
	N	180	180	180	180	180	180	180
pH	Pearson Correlation	-.122	1	-.238**	-.100	-.427**	-.133	.165*
	Sig. (2-tailed)	.102		.001	.182	.000	.075	.026
	N	180	180	180	180	180	180	180
DO	Pearson Correlation	-.561**	-.238**	1	-.549**	-.420**	-.687**	-.005
	Sig. (2-tailed)	.000	.001		.000	.000	.000	.942
	N	180	180	180	180	180	180	180
Conductivity	Pearson Correlation	.956**	-.100	-.549**	1	.436**	.912**	-.033
	Sig. (2-tailed)	.000	.182	.000		.000	.000	.657
	N	180	180	180	180	180	180	180
Salinity	Pearson Correlation	.445**	-.427**	-.420**	.436**	1	.516**	-.045
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.547
	N	180	180	180	180	180	180	180
TDS	Pearson Correlation	.952**	-.133	-.687**	.912**	.516**	1	-.049
	Sig. (2-tailed)	.000	.075	.000	.000	.000		.517
	N	180	180	180	180	180	180	180
Turbidity	Pearson Correlation	-.077	.165*	-.005	-.033	-.045	-.049	1
	Sig. (2-tailed)	.301	.026	.942	.657	.547	.517	
	N	180	180	180	180	180	180	180

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

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

Sungai Galas, Dabong

Residential Area along Sungai Galas

Residential Area along Sungai Galas

Agricultural Activity (Goat Rearing) near Sungai Galas

Agricultural Activity (Banana Plantation) near Sungai Galas

Agricultural Activity (Plantation)

Recreational Activity (Camping) along Sungai Galas

Small Scale Fishing Activity at Sungai Galas

Sekolah Kebangsaan Dabong located near Sungai Galas

Vegetative Area along Sungai Galas