A STUDY ON THE PHYSICO-CHEMICAL PARAMETERS IN SUNGAI AYER LANAS, KELANTAN

by

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DECLARATION

I declare that this thesis entitled "A Study on The Physico-Chemical Parameters in Sungai Ayer Lanas, 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 ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
As	Arsenic
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
Cu	Cupper
DO	Dissolved Oxygen
DOE	Department of Environment
EPA	Environmental Protection Agency
Fe	Iron
HACH	Housing Authority of the City of Houston (Texas)
Hg	Mercury
Pb	Lead
SPSS	Statistical Package for the Social Sciences
TDS	Total Dissolved Solid
USEPA	United States Environmental Protection Agency
Zn	Zinc

LIST OF SYMBOL

pH	Potential of hydrogen
NTU	Nephelometric Turbidity Units
°C	Degree Celcius
mg/L	Milligram per liter
Sal	Salinity
ppt	Parts per thousand
g/L	Gram per liter
µS/cm	Microsiemens per centimeter

A Study on Physico-Chemical Parameters in Sungai Ayer Lanas, Kelantan

ABSTRACT

The discharge of effluents from all kinds of anthropogenic activities such as industrial, agricultural and domestic pursuits into the riverine ecological systems can affect the living aquatic resources such as fish which are later consumed by human. Apart from that some drainage has been neglected it water quality monitoring which used by local people as their water resources and also maybe as it can give effect to that particular river status as it flow from the main polluted river. This study was carried out to identify the physico-chemical parameters as well as to make a comparison of it physico-chemical parameters between two sampling areas namely residential and vegetative areas at Sungai Ayer Lanas, Kelantan for a period of two consecutive months from July to September 2016. Sixty sampling stations were selected and triplicate at two sampling areas. Physico-chemical parameters were conducted in situ which is water temperature, pH, turbidity, conductivity, total dissolved solid (TDS), dissolved oxygen (DO) and salinity with the used of YSI multiprobe parameter (Model: 556 MPS, USA) and turbidimeter (Model: HACH 2100Q Turbidimeter, USA). Based on physico-chemical parameters results of river water, indicate the water quality of Sungai Ayer Lanas is clean for domestic use as most of the parameters did not exceed the permissible limit. In this study, pH and turbidity it exceeds the permissible limit according to National Standard Water Quality for Malaysia which ranged between 7.00 to 8.00 pH and 300 to 400 NTU which revealed the usage of Sungai Ayer Lanas is not suitable as direct drinking supply as it may cause health problem as it enters the food chain by bio magnification process. Present research paper proved that the nearby river at residential area likely to affect the water quality due to some mankind activities going on. Through this study, it was found that authorities also must take part in improving the water quality at Sungai Ayer Lanas there as it can be used as the second water supply for residence in a crucial time.

Keyword: Physico-Chemical, Sungai Ayer Lanas , In-Situ, River, Permissible Limit, National Standard Water Quality for Malaysia.

Kajian Fisio-Kimia di Sungai Ayer Lanas, Kelantan

ABSTRAK

Pelepasan efluen dari semua jenis aktiviti antropogenik seperti kegiatan perindustrian, pertanian dan domestik ke dalam sistem ekologi sungai boleh memberi kesan kepada sumber hidupan akuatik seperti ikan, yang kemudian akan dimakan jua oleh manusia. Selain itu ada beberapa saliran yang telah terabai dari segi pemantauan kualiti air yang mana ianya digunakan oleh penduduk tempatan sebagai sumber air mereka dan kemungkinan boleh mencemarkan status air sungai tersebut kerana ia mengalir dari sungai utama yang tercemar. Kajian ini dilakukan bagi mengukur parameter fizio-kimia dan membuat perbandingan antara dua kawasan pensampelan daripada dapatan fizio-kimia di Sungai Ayer Lanas, Kelantan sepanjang dua bulan berturut bermula July hingga September 2016. Sebanyak 60 stesen pensampelan telah dipilih dan tiga replikasi dijalankan pada kedua-dua kawasan pensampelan. Parameter fizio-kimia ditentukan secara in-situ dalam kajian suhu air, pH, kekeruhan, kekonduksian elektrik, jumlah pepejal terlarut manakala, oksigen terlarut dan saliniti dengan menggunakan alatan YSI multiprobe parameter (Model: 556 MPS, USA) dan turbidimeter (Model: HACH 2100Q Turbidimeter, USA). Kajian ini membuktikan bahawa kualiti air di Sungai Ayer Lanas berada pada tahap yang bersih untuk digunakan secara domestik bagi kebanyakan parameter berpandukan National Water Quality Standards for Malaysia. Bagi parameter pH dan salinity, ianya melebihi had yang dibenarkan oleh National Water Quality Standards for Malaysia iaitu antara 7.00 hingga 8.00 nilai pH dan 300 hingga 400 NTU, lantas menunjukkan Sungai Ayer Lanas tidak sesuai untuk dijadikan sumber minuman kerana ia mampu memberi impak kesihatan daripada sifatnya yang boleh merebak melalui rantaian makanan. Hasil dapatan kajian membuktikan bahawa sungai yang berdekatan kawasan penempatan lebih terjejas kualiti air disebabkan oleh kewujudan aktiviti antropogenik yang dijalankan. Melalui kajian ini juga, pihak yang terlibat harus memainkan peranan dalam menjaga kualiti air sungai yang sedia ada ini seperti Sungai Ayer Lanas untuk kegunaan sebagai bekalan kedua air pada masa hadapan.

Kata Kunci: Fiziko-Kimia, Sungai Ayer Lanas, In-Situ, Sungai, Had Yang Dibenarkan, National Standard Water Quality for Malaysia.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water is an essential resource and forms the primary need of man in his environment. It is a vital component of life for both plants and animals and available in forms of rain and snow thereby making rivers, oceans, streams, lakes and springs. Throughout ages, mankind has been faced with the problem of providing suitable water of sufficient quality for his use. Water pollution is one of the most serious environmental problems facing the world today as most industrial wastes are channeled directly to water bodies thereby affecting the qualities of the surface water systems. The presence of objectionable tastes, odor, color as well as harmful substances in such water no matter how abundant it is, renders it unsuitable for domestic, industrial and agricultural uses (Ibeneme *et al.*, 2013).

Such harmful substances like heavy metals could possibly present in the water ecosystem. Heavy metals constitute an important group of environmentally hazardous substances. It also is natural components of the earth's crust that cannot be degraded or destroyed. The term heavy metal refers to any metallic element that has a relatively high density and is toxic or poisonous at low concentrations like mercury (Hg), arsenic (As) and lead (Pb). As trace elements, some heavy metal like copper (Cu), iron (Fe) and zinc (Zn) are essential to maintain the metabolism of the human body. However at higher concentrations they can lead to poisoning and resulted in degrading the water quality, give effect to human health as well as to the environment (AbShattar & Moorthy, 2013).

A number of scientific procedures and tools have been developed to assess the water contaminants or the status of water quality. Water quality refers to the chemical, physical, biological and radiological characteristics of water where situated a condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed (Amneera *et al.,* 2013).

The study on water quality at Sungai Ayer Lanas was conducted because there is none research of water quality at that area. As documented by the Department of Environment (DOE) Malaysia, Sungai Ayer Lanas has not been reported having an existed water quality report through the automatic water quality monitoring stations (DOE, 2016). It also provides importance and function to the communities in domestic activities like fishing and agriculture (Bao, 2010). The analyses include in-situ which used some special instruments, which is laboratory (HACH) spectrophotometer. The data obtained were analyzed using t-test to determine whether there is significant difference between parameters at each sampling areas. All the methods taken from the DR 2800 Spectrophotometer procedures manual have been approved to be effective in doing water quality study as stated by the USEPA authority (DR 2800 Spectrophotometer, 2007).

1.2 Problem Statement

Water quality of rivers and lakes is one of the most common issues in Malaysia. The publics and government are conscious about the future of rivers. It is advised by Malaysia government that we should protect the richest water resources as water is a vital resource, necessary for all aspects of human and ecosystem survival and health (Bao, 2010).

It is stated that, the polluted rivers also have adverse effects on plants and living organisms as well as the country's economy. According to the Environment Quality (2013) report by the Department of Environment, 5.3% of a total 473 rivers were polluted with 36.6% slightly polluted. Although the percentage of polluted rivers decreased by 1.7% compared with the year 2012, the percentage of rivers being slightly polluted increased by 2.6%. The problem of water pollution is now becoming more serious with reports indicating a downward annual trend (Dhillon, 2015).

Therefore, it is important to study the level of pollution in the river currently and determine the causes of pollution in order to recommend suitable solutions to the problem. As it is becoming a big issue, it is an urge to determine the status of water quality at underrated rivers like Sungai Ayer Lanas as it is a main sources for the people in doing their daily activities.

1.3 Objectives

There are two objectives as follows:

1. To analyze the status of water quality of Sungai Ayer Lanas, Kelantan based on physico-chemical parameters.
2. To make a comparison of physico-chemical parameters between two sampling areas alongside Sungai Ayer Lanas, Kelantan.

1.4 Significance of the Study

This study was significant endeavor in promoting environment sustainability to the people. It eventually educates people nearby in guarding the resources they have as they observed this analysis study in the river. Moreover this study provides recommendation on how to maintain the water quality played by the authorities and all the involved stakeholders. This study also was beneficial to the others independent researchers as a future reference and pursue into deeper research on the subject of water quality analysis. And importantly, this research act as information source to the stakeholders that found it helpful.

CHAPTER 2

LITERATURE REVIEW

2.1 River

Rivers are lifelines for human societies around the globe, embodying immense influence in shaping civilizations. The catchment area usually supports a wide variety of flora and fauna, creating a very diverse ecosystem composed of ecologically delicate and inter related, physical, chemical and biological entities. River ecosystem plays an essential role in maintaining it sustainable development of the whole environment. The rivers and river channels are said increasingly becoming receivers for the disposal of wastewater from industries and local population in urban areas. Today, the discharge of wastewater into water bodies has reached alarming levels and becoming the serious issue of water courses. Despite all the regulations of treating the discharges before release it into the surface water have been adopted in every developing country but, pollution still occur. This is because it already reaches and exceeds the limits for the catchment area not being able to assimilate all the wastewater that have been deposited (Lescesen *et al.*, 2015).

2.2 River Pollution

Water pollution majorly caused by the man's activities like manufacturing, agro-based industries and animal farms. It can be divided to point and non-point sources. Activities like sewage treatment plants, manufacturing and agro-based industries and animal farms are some of the activities caused from point sources. Meanwhile, non-point sources are defined as diffused sources such as agricultural activities and surface runoffs. As Malaysia is fast becoming an industrial country, many of the rivers have become polluted due to the many wastes that have been poured out into her rivers. For instance, the storm-water runoff which carries eroded soil, fertilizer, pesticides, metallic chemicals and pollutants mainly from residential areas into the Yadkin River what affect the population growth nearby (Winston-Salem Journal, 2013). The rivers are used as an outlet for the chemicals to drain away, in turn harming the water and the lives that revolve around them. Many rivers in Malaysia have been polluted including Sungai Kuantan, Pahang that happened recently because of the bauxite mining which in turn affects plants and organisms living in these bodies of water, people's health, the country's economy, and also to the natural environment. Due to its composition of high ferric oxide, water supply can be polluted and apparently the monitoring of drinking water at Sungai Kuantan still being under permissible level but need to treat the potential heavy metal contaminations (Abdullah *et al.*, 2016). The main causes of river pollution are usually due to lack of awareness, unconsciousness and the attitude of people (Suratman *et al.*, 2005).

The water quality status of rivers in Malaysia has always been a cause for concern for various local authorities, government agencies as well as the public at large.

Rivers in Malaysia are generally considered to be polluted with coherent examples such as Sg. Klang in Selangor, Sg. Juru in Penang and Sg. Segget in Johor as impact from rapid development and economic growth purpose (Chan, 2012). Clean drinking water is now recognized as a fundamental right of human beings. Around 780 million people do not have access to clean and safe water and around 2.5 million people do not have proper sanitation. As a result, around 6 to 8 million people die each year due to water related diseases and disasters. Therefore, water quality control is a top-priority policy agenda in many parts of the world (Rahmaniah *et al.*, 2015).

As a matter a fact, best management practices in urban and agricultural areas are said to be the most contributing factors to non-point source water pollution. Practices in urban or residential area like construction activities, impervious surfaces, residential yards, golf course, and septic systems mostly contribute to water pollution. Similar cases of agricultural activities including pesticides and fertilizers used to grow crops, sediment from timber harvesting and transportation, manure from livestock operations and effluent from aquaculture ponds and tank are major contributors to pollution. Previous study by Alvarez *et al*, 2016 has been made to identify the water quality and water use impacts at certain areas in Florida. Thus the cost-benefit framework has been made to determine the optimal level best management practices adoption throughout the state of Florida so that the conservation of water can be maintained (Alvarez *et al.*, 2016).

2.3 Physicochemical Parameters

Most physical parameters like water temperature, pH, conductivity, turbidity and dissolved oxygen can be conducted on-site. More complex measurements are often made in a laboratory often referred to the chemical parameter that required a water sample to be collected, preserved, transported, and analyzed at another location. Chemical parameters like biochemical oxygen demand (BOD), chemical oxygen demand (COD) and heavy metals are crucial indicators for the polluted water. These indicators majorly analyzed using massive instrument like Atomic Absorption Spectrophotometer and also HACH Spectrophotometer due to their easy-to-handle criteria (AbShattar & Moorthy, 2015).

2.3.1 Water temperature

Water temperature influences the physical, chemical and biological conditions of the water (Bhavimani *et al.*, 2016). Rising of water temperature due to changes in climate, local human activities and hydrology has a considerable potential to the degradation in water quality such as decreased oxygen-holding capacity, increased oxygen consumption and enhanced formation of potentially toxicants. Higher water temperature also can impair the habitat of a wide range of aquatic organisms (Chen *et al.*, 2016). In addition to that, temperature is in an absent value of permissible level for the use of water supply.

2.3.2 pH

The pH is a measure of the hydrogen ion concentration in water. Drinking water with a pH in between 6.5 to 8.5 is generally considered satisfactory. If the pH is below 6 the water is acidity and can be cause due to the corrosive of plumbing and faucets particularly. Meanwhile as for alkaline, pH is above 8.5 which make it less corrosive and tend to have a bitter or soda-like taste (Reda, 2016). There is a permissible level that has been fixed for pH according to the EPA at each class. This is because to identify its pH suitability for domestically water used.

2.3.3 Turbidity

River turbidity is of dynamic nature, and its stable significantly changed during the period of heavy rainfall events. In particular, global warming can lead to extreme events of rainfall with changing local rainfall duration and intensity. In general, turbidity is colloids causal and worsens it by the interaction with rainfall events and lead to higher turbidity. In some cases like in Taiwan, its water treatment plant is at risk when the turbidity value in the Gaoping river basin has been reported being at extremely high turbidity which recorded above 50 NTU (Lee *et al.*, 2016). Due to this problem, lead to the degradation in water quality.

2.3.4 Conductivity

Conductivity or electrical conductivity is a property at which a solution is able to conduct an electric current. It is governed by the migration of solutions and dependent towards the nature and numbers of the ionic species in that solution, in this study is river water solution (Reda, 2016). Usually for water supply conductivity must be at 1000 µs/ cm of permissible level (Water Environment Partnership in Asia, 2016).

2.3.5 Total Dissolved Solid

Total dissolved solid (TDS) can be taken as an indicator for the general water quality as it directly affects aesthetical value of the water by increasing the turbidity. High concentration of TDS will limit the water quality use for drinking source as well as for irrigation supply (Reda, 2016). The permissible level stated by EPA is 500 mg/ L for drinking sources (Water Environment Partnership in Asia, 2016).

2.3.6 Salinity

The salts of all total non-carbonate giving meaning to salinity. Salinity can give rise to problems if the contents exceed the preferable level (Yap *et al.*, 2011). It is known as a dynamic indicator of the nature of the exchange system that expressed as the total concentration of electrically charged ions (cations) in water per thousand (%) (Naeema *et al.*, 2015). Moreover it determines the distribution of limnology of water. The prescribed limit stated by EPA is < 80 mg/l for excellent quality to drink (Water Environment Partnership in Asia, 2016).

2.3.7 Dissolved Oxygen

Dissolved oxygen (DO) is one of the key factor good water qualities. Generally it is a mandatory factor for the survival of marine organisms (Shkelqim Sinanaj, 2014). It was proven that others parameters like salinity and pH does influences the DO value. As in previous study, the salinity and pH values will increases while the DO values decreased (Fikriah *et al.*, 2014).

2.4 Statistical Analysis

The independent t-test analysis will be used to determine whether there are any significant differences between physico-chemical parameters at each sampling areas in Sungai Ayer Lanas. Other than that, the statistical correlation also will be used to determine the relationship between the parameters at both areas. The Pearson correlation was made at the 99% level. In this study, statistical analysis of data is fulfilling using SPSS Statistics (Model: IBM Statistics Version 20). Works by Chen (2016) have shown that the spatial and temporal variation of land use have significantly differences for water quality parameters like DO and COD between years of 2005 and 2010 (Chen *et al.*, 2016).

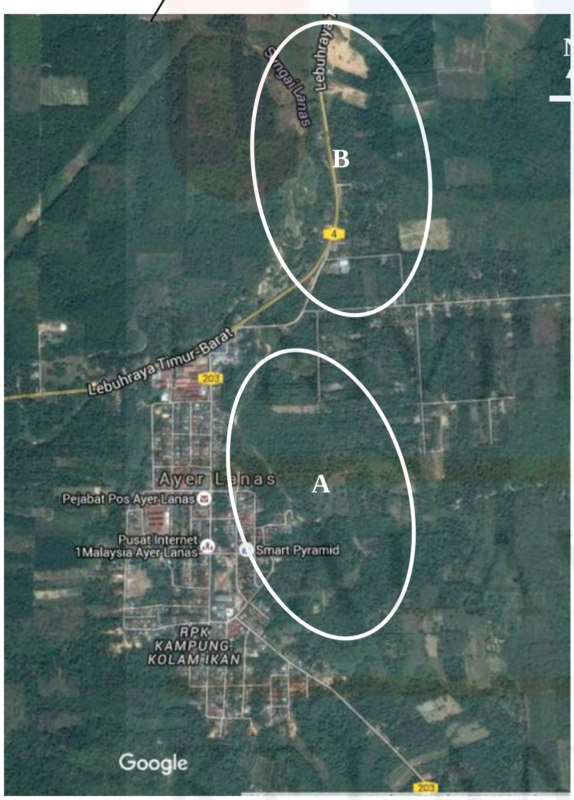
CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

The study area is an underrated river located at the Ayer Lanas town which is Sungai Ayer Lanas. Ayer Lanas town is a small developing town surrounds by hills which identified as rural Kelantan village with present of socioeconomic activities. Moreover, the residents in Ayer Lanas town mostly coming from a low-income family that later brought different neighborhood situation when the area have been accommodated with several needy facilities (Leong *et al*, 2013). In addition to that, Sungai Ayer Lanas associated with the Department of Drainage and Irrigation, Kelantan in providing river water for irrigation and drainage purposes. Even so it water quality status has not been reported yet by others research which stated by the DOE in their official portal (DOE, 2016). Sungai Ayer Lanas located at latitude of N 5° 47' 5.62" and E101° 53' 21.62'' of longitude (JPS Negeri Kelantan, 2016) Figure 3.1 is the map of West Malaysia. Figure 3.2 is the sampling stations that were taken at the residential areas with the A mark and vegetative area which marked with the area B.

Figure 3.1: Map of West Malaysia
(Source: Google Maps, 2016)



LEGEND	
A	Residential area
B	Vegetative area

200 m

Figure 3.2: Selection of sampling stations at Sungai Ayer Lanas
(Source: Google Maps, 2016)

3.2 Sampling Method

The sampling of water samples were alternately taken in the morning and evening hours, in order to prevent the natural changes in the water that ought to affect the analysis and be a representative for one whole day in two consecutive months (Saxeena *et al*., 2015).

3.3 Selection of Sampling Station

There were 60 sampling points taken in this study. The 30 points were tested in each two sampling areas. These sampling points were tested three days in a row for 10 sampling points each day within two months to avoid biasness and as representative throughout the two selective months. The 10 sampling points were evenly divided and selected systematically within each sampling areas.

3.4 In-Situ Parameter Analysis

In-situ parameters namely water temperature, pH, turbidity, conductivity, salinity and TDS were measured using the YSI multiprobe parameter (Model: 556 MPS, USA) and turbidimeter (Model: HACH 2100Q Turbidimeter, USA). The YSI Multiprobe was lowered in the river and holded for a couple of minutes to achieve a stabilized reading. For turbidimeter, a 10mL of water samples were taken in the sample cell and tested on site. Measurements were taken about 10 cm below the water surface. The readings were recorded in °C, mg/L, Sal, g/L, µs/cm and NTU.

3.5 Statistical Analysis

The independent t-test analysis was used to determine if there are any significant differences between parameters at each sampling areas of Sungai Ayer Lanas as well as statistical correlation for the relationship. It was tested at $p > 0.05$ significantly difference. In this project, SPSS Statistics (Model: IBM Statistics Version 20) was used.

CHAPTER 4

RESULTS AND DISCUSSIONS

An effort was taken to sample from two different areas namely residential and vegetation area. The samplings were conducted in two consecutive months, starting from July until September that was taken between 8.00 a.m and 12.00 noon. Water samples were analyzed for seven physico-chemical parameters to determine the overall quality with respect to temperature, pH, turbidity, dissolved oxygen (DO), total dissolved solid (TDS), conductivity and salinity. The 60 sampling stations were analyzed and expressed in mean ± standard deviation (mean ± sd) as in Table 4.1(i).

4.1 Temperature

The study recorded a steadily increase in temperature reading at both sampling areas, ranging from 25.69 ± 0.16 to 26.69 ± 0.07 °C, see Table 4.1 (i). During sampling the weather were inclusive dry and rainy days. Previous study suggested that the water temperature is governed by the atmospheric temperature (Karim & Panda, 2014).

Table 4.1 (i): Sampling of physico-chemical parameters at both areas

	Residential Area								Vegetative Area							
Parameter	Temperature	DO	pH	Conductivity	TDS	Salinity	Turbidity	Temperature	DO	pH	Conductivity	TDS	Salinity	Turbidity
Unit	°C	mg/l	pH	µS/cm	g/l	ppt	NTU	°C	mg/l	pH	µS/cm	g/l	ppt	NTU
First time sampling (July 2016)	25.73± 0.19	7.47± 1.06	6.27± 0.41	0.07± 0.02	200.00± 0.00	0.01± 0.00	473.31± 11.49	25.69± 0.16	4.41± 1.26	8.00± 0.52	0.07± 0.01	200.00± 0.00	0.02± 0.00	420.79± 72.72
Second time sampling (August 2016)	25.73± 0.19	7.44± 1.04	6.26± 0.41	0.09± 0.00	200.00± 0.00	0.01± 0.00	474.39± 12.03	25.85± 0.60	7.44± 1.04	7.91± 0.44	0.09± 0.00	200.00± 0.00	0.02± 0.00	433.01± 14.09
Third time sampling (September 2016)	26.54± 0.26	2.55± 0.27	13.89± 40.37	0.04± 0.00	200.00± 0.00	0.01± 0.00	274.25± 12.30	26.69± 0.07	3.48± 0.33	6.27± 0.51	0.05± 0.00	300.00± 0.00	0.03± 0.00	274.07± 12.03

Note: Turbidity in NTU, Dissolved oxygen in mg/l, Salinity in Sal, Total dissolved solid in mg/l, temperature in °C and Conductivity in µs/cm.
Mean ± Sd, *n* = 30

As presented in Figure 4.1, there are slightly different readings for temperature between the sampling areas, as vegetative area noted the highest reading (26.08 °C) compared to residential area (26.0 °C). High values in temperature expectedly come from the heat of sunlight that gradually risen the surface water temperature (Meme *et al.*, 2014). It is said that high water temperature can stress the aquatic ecosystem due to the ability of water to hold essential dissolved gases (oxygen) is reduce hence, kill the fish in water bodies Kumar & Puri, 2012). It was tested significantly at 95% and revealed in having significantly different (t = -1.90, p - value = 0.00, below 0.05) relationship. Furthermore a Person's correlation analysis also was conducted in testing relationship between parameters for both areas. The test revealed temperature having weak positive correlation with salinity (r = 0.21, p-value = 0.00, below 0.01) and TDS (r = 0.36, p - value = 0.00, below 0.01). Also it has been detected having a weak negative correlation at r = -0.88 of turbidity and r = -0.56 that both below 0.00 p - value. Thus a normal temperature can be concluded for the Sungai Ayer Lanas and can be classified normal level (Class IIA) according to National Water Quality Standards for Malaysia, see Table 4.1 (ii). According to National Water Quality Standards for Malaysia, water of Class IIA can be used as water supply. In previous study, it has been proven the water temperature between 25.29 °C to 25.98 °C being at normal rate (Yen & Rohasliney, 2013).

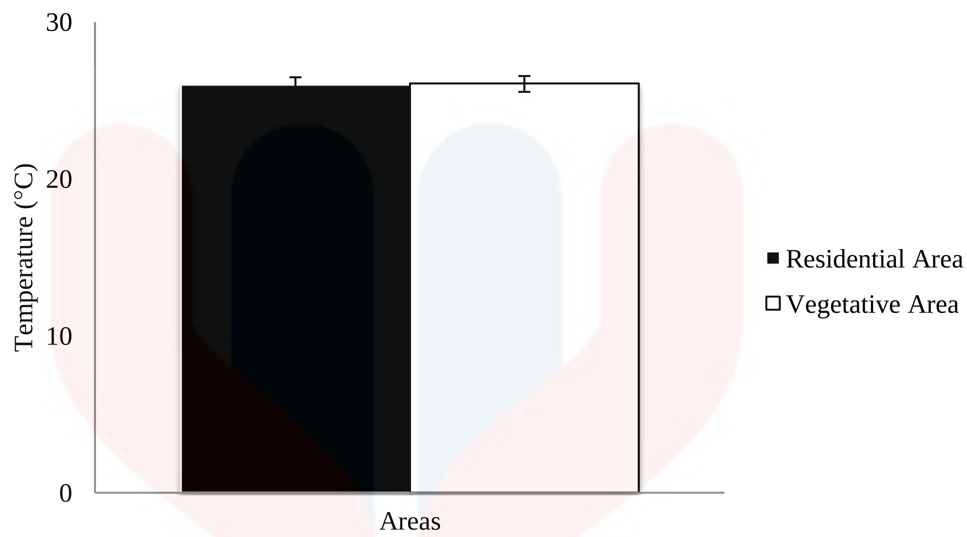


Figure 4.1: Temperature mean variation

Table 4.1 (ii): National Water Quality Standards for Malaysia

		Class					
Parameter	Unit	I	IIA	IIB	III	IV	V
Turbidity	NTU	5	50	50	-	-	-
DO	mg/l	7	5-7	5-7	3-5	< 3	< 1
pH	-	6.5-8.5	6-9	6-9	5-9	5-9	-
Salinity	%	0.5	1	-	-	2	-
TDS	mg/l	500	1000	-	-	4000	-
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Conductivity	µS/cm	1000	1000	-	-	6000	-

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)

4.2 Dissolved oxygen

DO reading recorded high at the residential area (2.55 ± 0.27 mg/l) compared at the vegetative area (7.47 ± 1.06 mg/l), see Table 4.1 (i). The differential in DO reading usually associated with factors such as temperature, decompositional activities, photosynthesis and the level of aeration (Okbah & El-Gohary, 2002).

Figure 4.2 demonstrates high reading DO at the residential area as it flows to the vegetative area. DO refers to the amount of oxygen dissolved in the water and mostly crucial in aquatic life, indicating safe for tolerant livestock species drinking being under Class III, see Table 4.1 (ii) (Yap *et al*., 2011). High DO value indicates high photosynthetic rate, and proved there are more aquatic organisms in residential area as small fishing activity occurred there. It is said that the decreased of DO level indicated to the index of water pollution (Abowei, 2010).

Based on the independent t-test analysis, it demonstrates that DO (t – value = 11.20) with significant value (0.00) below than 0.05. Thus it is proven there is statistically significant difference between two sampling areas. Furthermore, a Pearson's correlation was run to determine the relationship between physico-chemical parameters of two areas. The turbidity has been found to show strong positive correlation with DO ($r = 0.73$, $p < 0.01$), which means if DO is higher at either one sampling areas the turbidity also noted high. The correlation result is not as expected and it may due to that particular of sampling time which in warmer weather, caused the warm water temperature runoff into the stream, decreasing the DO. So the decreasing in DO will result in increasing of turbidity which proven by Bradner (2013). This study revealed that the water is within the prescribe limit (3.00–7.00 mg/l) under Class IIA and IIB (Table 4.1 (ii)) that need conventional treatment but, still can be recreationally used body contact. Recent study showed that DO content which is more than 5.00 mg/l favors a good growth of flora and fauna (Mahajan & Billore, 2014).

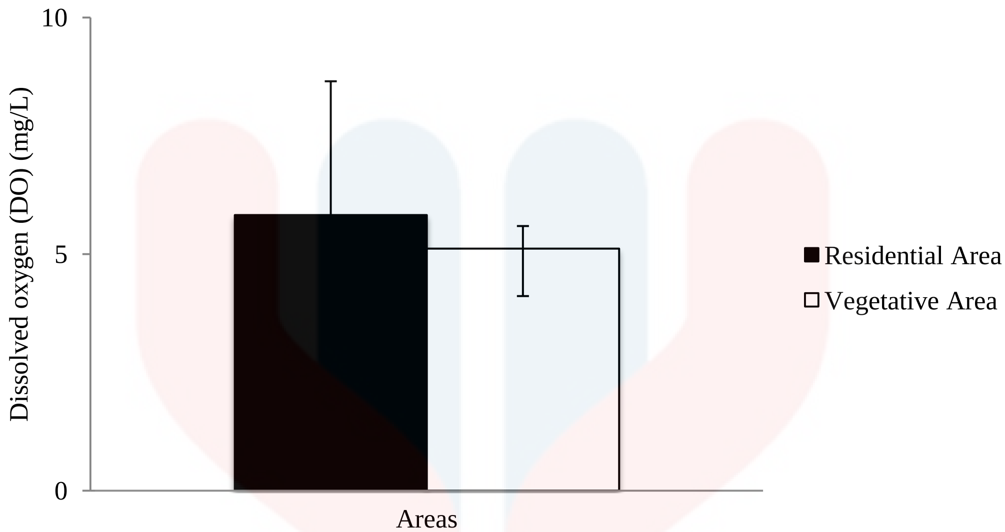


Figure 4.2: DO mean variation

4.3 pH

The pH values are recorded high in vegetative area which ranged from 6.27 ± 0.51 to 8.0 ± 0.52 pH as compared to the residential area where the lowest reading is 6.26 ± 0.41 pH and 6.89 ± 0.37 pH is the highest reading, see Table 4.1 (i). This result provides evidence of low mineral pollution at both sampling areas (Agnleszka *et al.*, 2014).

The high of pH value indicating a slightly neutral at vegetative area and some level of alkalinity can be detected in residential area as in Figure 4.3. This shows that the photosynthetic activities of aquatic plants at vegetative area hindered by the anthropogenic pollutants which lowered the pH (Yap *et al.*, 2011). It may be due to the small discharge from agriculture activities nearby the vegetative area.

The independent t-test analysis found that there is no significant different between study areas with $p > 0.05$ at $t = 0.58$. The correlation test also found no correlation significant between parameters of both areas, which tested at $p < 0.01$. Based on the National Water Quality Standards for Malaysia guideline (Table 4.1 (ii)), the river water of pH can be categorized in Class III at it prescribe limit (5.00-9.00 pH). Hence, it still can be used as water supply and fishery, but still need a conventional treatment. Previous study demonstrated that the river water that show low level of mineral pollution classified in Class III need a simple treatment (Siyue *et al.*, 2013).

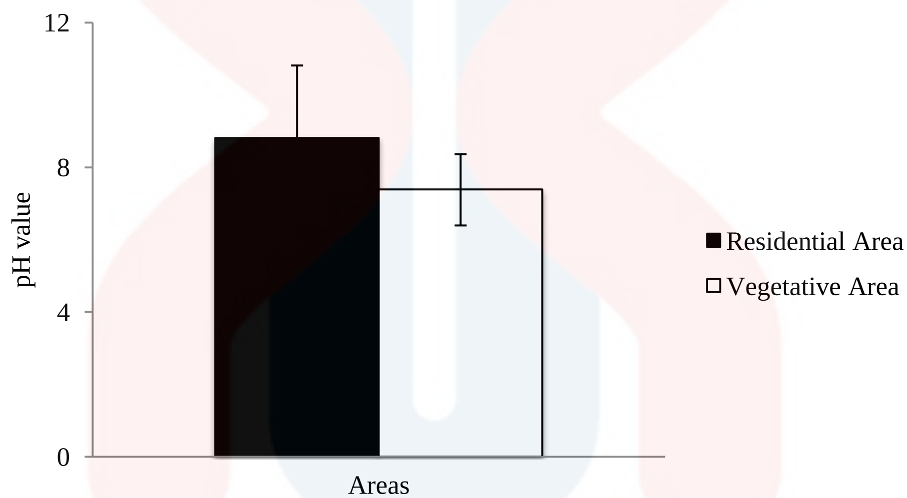


Figure 4.3: pH mean variation

4.4 Conductivity

Conductivity readings for both areas fluctuated that start recorded 0.04 ± 0.00 µS/cm for the lowest reading and 0.09 ± 0.00 µS/cm for the highest reading. The conductivity trend of river water that flow predominantly across granite rock which contain no ionisable metals will be generally lower as compared those that flow across rocks that contain ionisable metals which are eventually leached into the river (Joshu *et al.*, 2015).

Based on the Figure 4.4, the conductivity values are at the same level (0.07 µS/cm) at both areas. This result may due to the both land used which contains low level of ionisable metals that can be runoff into the river. In addition to that, a heavy rainfall before the sampling events can be one of the reasons for low conductivity values. Heavy rainfall is supposed to be accompanied with high reading in conductivity due to high surface runoffs from agricultural lands and roads as reported by Jayakumar & Vergheese, (2016).

Independent t-test shows there is no significant different between two areas at $p = 0.09$ ($p > 0.05$) and $t = -3.95$. Where else, the correlation analysis found that there is a strong positive correlation ($r = 0.82$, $p < 0.01$) with turbidity. By means if conductivity is high in either one sampling areas, turbidity also noted high. Meanwhile the test also proved a moderate positive correlation with DO ($r = 0.50$, $p < 0.01$). Apart from that, a weak negative correlation has been demonstrated with salinity ($r = -0.18$, $p <0.01$), TDS ($r = -0.38$, $p < 0.01$) and temperature ($r = -0.73$, $p < 0.01$). It is concluded that the water quality in term of conductivity is below the prescribe limit (1000 µS/cm). This means that the water can be domestically used. As reported in the previous study, high level in conductivity is not suitable for domestic use and irrigation due to it result that can lead to salinity of agricultural soils (Joshua *et al.*, 2015).

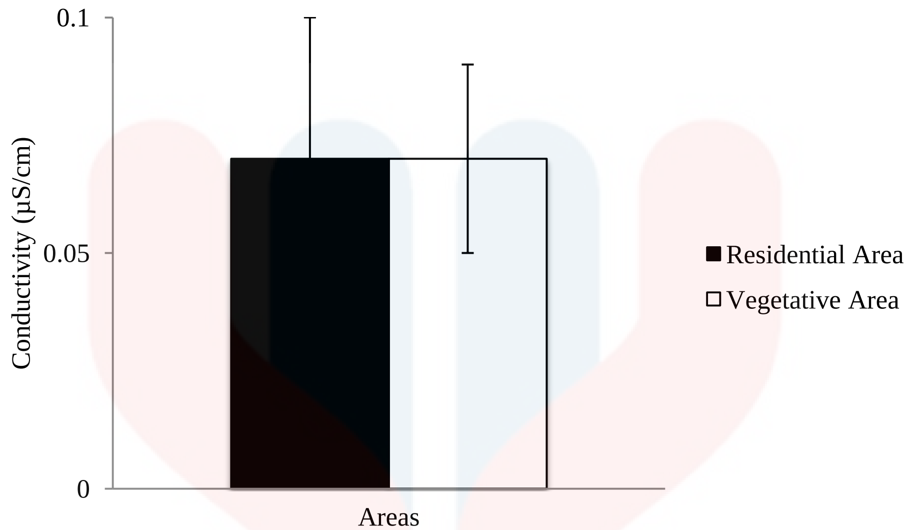


Figure 4.4: Conductivity mean variation

4.5 Total dissolved solid

The TDS value is 200.00 ± 0.00 mg/L in both area, residential and vegetative area, see Table 4.1 (i). The concentration of TDS can be high due to the internal erosion and weathering of rocks happened. In addition to that, anthropogenic activities also can eventually increase the TDS concentration in river water (Tripathi *et al.*, 2014).

Mean variation for TDS (Figure 4.5) demonstrates there is no different in concentration at both areas. Heavy rainfall may cause increasing in TDS concentration up to 200.00 mg/l. Furthermore, the surrounding of sampling areas also contributed to its concentration. Residential area nearby Sungai Ayer Lanas consists of wet market and community areas. Some of their domestic waste can washed into the river, resulting rise in TDS reading. Vegetative area that consists of various plantation and few livestock living also, can contribute to high level of TDS mostly from fertilizers.

Previous study has shown that TDS concentration significantly increased at river that located nearby where anthropogenic inputs occurred such as, domestic, excretion and agrochemical fertilizers. Moreover it also contribute to the accumulation of major ions in the water like Cl^-, NO_3^-, SO_4^{2-}, Na^+ and Ka^+ (Siyue *et al.*, 2012). Based on the result that have been obtained from this study, the TDS of river can be categorized as Class I (< 500 mg/l) which it usage as conventionally, see Table 4.1(ii).

The independent t-test having t = 0.58 with $p < 0.00$, it proved that there is significantly different between two areas for TDS reading as the result from variation in standard deviation values. As for correlation, TDS has weak negative and positive correlation at r = -0.34 ($p < 0.00$) and r = 0.20 ($p < 0.00$) of turbidity and salinity, respectively between study areas.

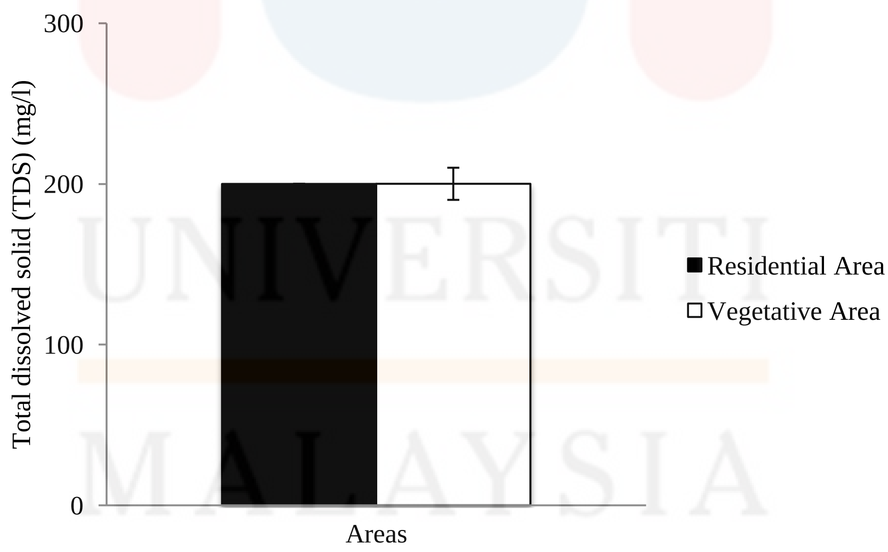


Figure 4.5: TDS mean variation

4.6 Salinity

Salinity recorded similar value (0.01 ± 0.00 %) for both sampling areas. Salinity is one of the important factors that influence the aquatic environment other than pH, temperature and DO (Naeema *et al.*, 2015).

Figure 4.6 shows there is no different in both areas for salinity. Independent t-test analysis noted t-value at 2.53 with it p - value 0.01 ($p < 0.05$). Thus this test proved there is a significant different for salinity between the two areas, residential and vegetative areas. The INWQS guideline of Malaysia (Table 4.1 (ii)) prescribed limit for salinity is 0.5 % (Class I), and hence study areas are belong to Class I (Table 4.1 (ii)). Previous study has indicated that it provide a safe environment for limnology (Naeema *et al.*, 2015).

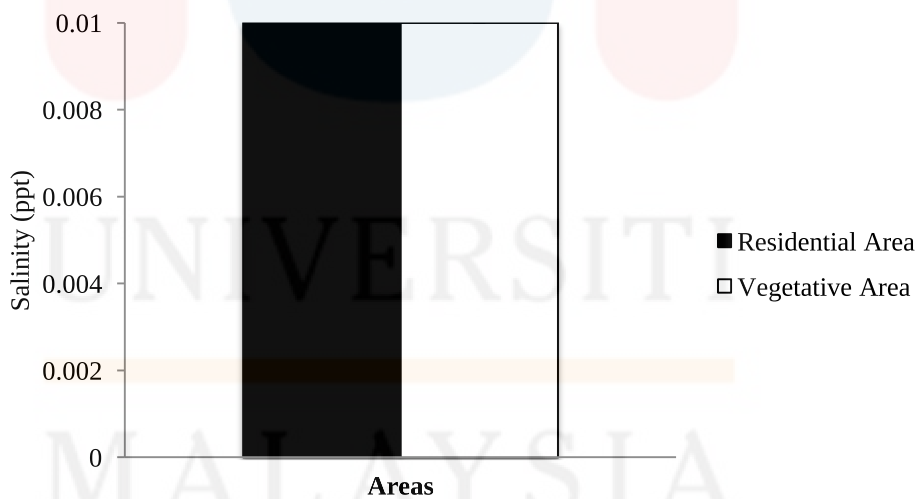


Figure 4.6: Salinity mean variation

4.7 Turbidity

The reading for turbidity at both sampling areas fluctuated with recorded readings 473.31 ± 11.49, 474.39 ± 12.03, 274.25 ± 12.30 NTU in residential area and, 420.79 ± 72.72, 433.01 ± 14.09, 274.07 ± 12.03 NTU in vegetative area. Overall the reading for turbidity in residential area is higher compared to the vegetative area.

The low value of turbidity at vegetative area may due to run off from residential area which can stir up and suspend materials of some input of wastes (Waziri *et al.*, 2012). Based on the Figure 4.7, it observed a highest reading of turbidity at residential area. This may be due to the nearby wet market being operates. In addition to that there was a heavy rainfall during the sampling, indicated muddy places with plenty of inorganic and organic wastes flowing into the river bank (Yap *et al.*, 2011). The independent sample t-test was conducted to examine whether there is a significant difference of physico-chemical between the two areas. The t - value recorded for turbidity is 3.73, with significant of 0.00 which less than p-value (0.05). So there is significant difference of turbidity between the two areas. The Pearson's correlation shows there is strong positive correlation between DO and conductivity at r = 0.73 and r = 0.82.

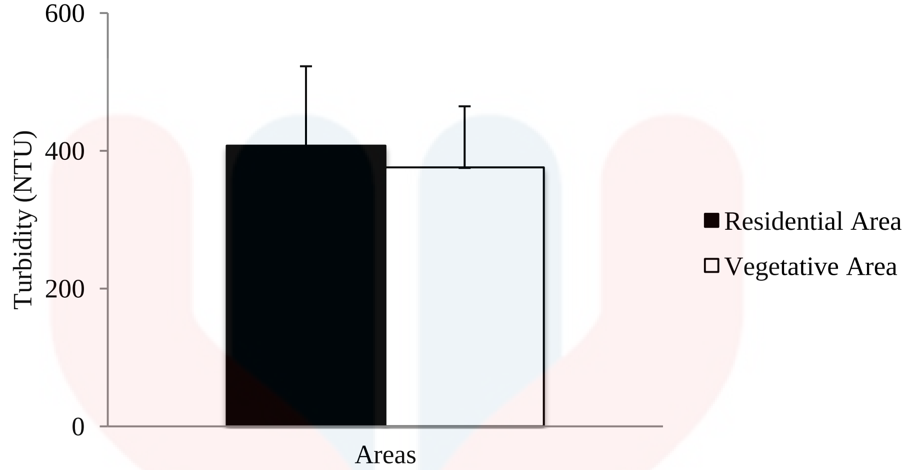


Figure 4.7: Turbidity mean variation

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study demonstrated that the Sungai Ayer Lanas was a clean river, with the exception that certain physico-chemical parameters (such as pH and turbidity) exceeded the safe limit stated in the National Water Quality Standards for Malaysia. For instance in this study, the temperature noted highest for river water nearby the vegetative area which still being in the prescribed limit stated by the National Water Quality Standards for Malaysia. Same goes with the DO reading for river water at residential area noted the highest which classified being under the prescribed limit. Next as for conductivity it revealed having the same value at both sampling areas (residential and vegetative areas), and noted being under the standard limit of National Water Quality Standards Malaysia. For others parameters such as TDS and salinity both noted being under the prescribed limit of Water Quality Standards Malaysia as it valued the same at both residential and vegetative areas. These are due to some activities that have been conducted nearby the river mostly at residential area that likely caused from agriculture, wet market and residency. This finding proved that Sungai Ayer Lanas can be used domestically by the people but also need to monitor its quality as it become the water supply by some residence nearby.

Statistical analysis results showed evidence of significant difference and relations between the parameters. From the statistical analysis it showed most of the parameters having the significance difference which proved the variation of values at both areas (Statistics Help for Students, 2016). It was tested at 95% confidence interval which proved the significantly difference less than 0.05 value. Parameters like temperature, DO, TDS, salinity and turbidity revealed having significant difference between two sampling areas which is residential and vegetative areas. Based on that, physico-chemical parameters (such as salinity, pH, temperature and DO) revealed having a strong correlation between two different areas. This study shows that these physico-chemical parameters correlated with one another. As increase temperature generated from the sun caused evaporation of the surface water making it saltier and hence more saline. Moreover DO is vital to aquatic life, as it is needed to keep organism alive. Increase in DO proved the existence of aquatic organisms at that particular area and a stable in pH making it more favors for limnology to live in it (Abowei, 2010).

5.2 Recommendation

Based on these findings it can be further into deeper research in analyzing heavy metals concentrations of the particular rivers. Scientifically, heavy metals can give effect on the limnology creatures as it enters the food chain (bio magnification process) and ultimately affect the human beings as well (Moorthy and Siti, 2015). Due to instruments limitations, this study cannot be pursuing further in analyzing concentration of heavy metals in river water. In fact, it can be very useful data if can be compared with others river which particularly located in distinct areas like Sungai Ayer Lanas. Moreover, authorities can get involve in taking effective measures to care the quality of the particular river. For instance in Bangladesh having an effluent treatment plant (ETP) and low cost water treatment process for most factories in mitigating the existing aquatic environmental problem at Turag River (Mobin *et al.*, 2014).

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APPENDICES

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
Turbidity of water	Equal variances assumed	46.109	.000	3.734	538	.000	27.73333	7.42701	13.14384	42.32283
	Equal variances not assumed			3.734	513.788	.000	27.73333	7.42701	13.14229	42.32438
Dissolved oxygen of water	Equal variances assumed	258.174	.000	11.202	538	.000	1.83611	.16390	1.51414	2.15808
	Equal variances not assumed			11.202	372.925	.000	1.83611	.16390	1.51382	2.15840
Ph of water	Equal variances assumed	2.891	.090	.583	538	.560	1.43293	2.45873	-3.39697	6.26282
	Equal variances not assumed			.583	269.287	.561	1.43293	2.45873	-3.40786	6.27371
Salinity of water	Equal variances assumed	26.104	.000	2.525	538	.012	.00089	.00035	.00020	.00158
	Equal variances not assumed			2.525	525.839	.012	.00089	.00035	.00020	.00158
Total dissolved solid of water	Equal variances assumed	1.017	.314	5.800	538	.000	.00230	.00040	.00152	.00307
	Equal variances not assumed			5.800	527.455	.000	.00230	.00040	.00152	.00307
Temperature of water	Equal variances assumed	1.147	.285	-1.903	538	.058	-.07470	.03926	-.15183	.00243
	Equal variances not assumed			-1.903	536.559	.058	-.07470	.03926	-.15183	.00243
Conductivity of water	Equal variances assumed	2.878	.090	-3.952	538	.000	-.00650	.00164	-.00973	-.00327
	Equal variances not assumed			-3.952	536.006	.000	-.00650	.00164	-.00973	-.00327

Correlations

		Turbidity of water	Dissolved oxygen of water	Ph of water	Salinity of water	Total dissolved solid of water	Temperature of water	Conductivity of water
Turbidity of water	Pearson Correlation	1	.732**	-.051	-.171**	-.339**	-.884**	.818**
	Sig. (2-tailed)		.000	.234	.000	.000	.000	.000
	N	540	540	540	540	540	540	540
Dissolved oxygen of water	Pearson Correlation	.732**	1	-.062	-.108*	-.088*	-.564**	.501**
	Sig. (2-tailed)	.000		.150	.012	.042	.000	.000
	N	540	540	540	540	540	540	540
Ph of water	Pearson Correlation	-.051	-.062	1	-.026	.039	.000	-.041
	Sig. (2-tailed)	.234	.150		.542	.369	.992	.336
	N	540	540	540	540	540	540	540
Salinity of water	Pearson Correlation	-.171**	-.108*	-.026	1	.202**	.207**	-.179**
	Sig. (2-tailed)	.000	.012	.542		.000	.000	.000
	N	540	540	540	540	540	540	540
Total dissolved solid of water	Pearson Correlation	-.339**	-.088*	.039	.202**	1	.364**	-.383**
	Sig. (2-tailed)	.000	.042	.369	.000		.000	.000
	N	540	540	540	540	540	540	540
Temperature of water	Pearson Correlation	-.884**	-.564**	.000	.207**	.364**	1	-.727**
	Sig. (2-tailed)	.000	.000	.992	.000	.000		.000
	N	540	540	540	540	540	540	540
Conductivity of water	Pearson Correlation	.818**	.501**	-.041	-.179**	-.383**	-.727**	1

	Sig. (2-tailed)	.000	.000	.336	.000	.000	.000	
	N	540	540	540	540	540	540	540

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

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

Residential area where mankind activities occurred (wet market, stalls and restaurants)

Residential area where mankind activites occurred (residency)

Vegetative areas where mankind activities occured (plantation and green plants)

Vegetative area where plantation occurred (few livestock and present residency)