ECOSYSTEM HEALTH RIVER BASIN; A PRELIMINARY CASE STUDY AT SEMERAK RIVER BASIN, KELANTAN ON THE WATER QUALITY PERSPECTIVE

by

NURUL SYAHIIRAH BINTI ISHAK

A dissertation submitted in partial fulfillment
of the requirements for the
Degree of Bachelor of Health Sciences
(Honours)
(Environmental and Occupational Health)

June 2014

CERTIFICATE

This is to certify that the dissertation entitle 'Ecosystem Health River Basin; A Preliminary Case Study At Semerak River Basin, Kelantan On The Water Quality Perspective' is the bonafide record of research work done by Nurul Syahiirah Binti Ishak, Matric Number 109520 during the period of July 2013 to June 2014 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree of Bachelor of Health Sciences (Honours) (Environmental and Occupational Health). Research work and collection of data belong to the Universiti Sains Malaysia.

APPROVAL PAGE

This is to certify that I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation submitted in partial fulfillment for the degree of Bachelor of Health Sciences (Honours) (Environmental and Occupational Health).

DECLARATION PAGE

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions.

DEDICATION

I dedicate this thesis to my parents, *Abah* and *Umi* who have always been the nearest and so close to me that I found them with me whenever I need them. It is their unconditional love that motivates me to set higher targets and gave me the power to have determination and confidence of being who I am - I hope that this achievement will complete the dream and sacrifices that you had for me all those many years ago when you chose to give me the best education you could.

I also dedicate this thesis to my sister, *Nurul Nabihah* and my little brothers, *Muhammad Amiirul Ikhwan, Muhammad Afiq Isyraf* and *Muhammad Aqiil Iqmal* who are my forever supporters and have provided me with a strong love shield that always surrounds me as a key to success in future.

Not to forget, thanks to my uncle *Ghazali Jusoh*, the one that inspires me in deciding my undergrad studies and truly able me to be whoever I am today.

ACKNOWLEDGEMENT

First and foremost, I would like to praises to Allah the Almighty for having made everything impossible by giving me ideas, strength and blessings. His power that works within me made all things possible and able me to successfully complete the study.

My deepest heartfelt gratitude goes to Dr. Maliki Hapani, my supervisor, for his continually and convincingly conveyed spirit of adventure in regard to research and excitement in regard to teaching. I am feels indebted for his guidance and persistent supports, advice and constructive comments that helped me a lot in the planning and execution of this study.

My greatest appreciation all my dear friends who giving me such commitment, encouragement and countless help in this study, a million thanks to Nasha, Aziatul Nadia, Nadzirah, Nurfatihah, Nurhafezah, Siti Norarfah, Noorsyafiqa, Mazni, Nurul Aliyana, Siti Rohana, Nurul Akmal Shazwanie, Halimah and Marlienza - thank you for being there in every situation when I needed help the most, inspires and believed in my capabilities more than I did.

My gratitude is extended to all the lecturers and Laboratory Science Officer in the Environmental and Occupational Health Programme for kindly cooperation in this study. My special appreciations and thanks to my family especially my parents Mr. Ishak Kadir and Mrs. Habsiah Ab.Razak for indirectly cooperation and continuous moral supports from the beginning until the end of this research project.

Last but not least, the acknowledgement is considered incomplete without thanking all the fellow colleagues, friends and everybody who have been given great help and supports directly or indirectly to the successful realization of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREATION AND SYMBOL

APHA	American Public Health Association
NH_3-N	Ammoniacal Nitrogen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
°C	Degree Celcius
df	Degree of freedom
DOE	Department of Environment
DO	Dissolved Oxygen (DO)
FOA	Food and Agriculture Organization of the United Nations
GPS	Global Positioning System
INWQS	Interim National Water Quality Standard
Kg.	Kampung
km	Kilometer
mg	miligram
mg/L	milligram per Litre
ppt	parts per thousand
SRB	Semerak River Basin
%	percent
SD	Standard Deviation
SPSS	Statistical Package for Social Science
TSS	Total Suspended Solids

USEPA	United States Environment Protection Agency
USM	Unversiti Sains Malaysia
WQI	Water Quality Index

KESIHATAN EKOSISTEM LEMBANGAN SUNGAI; KAJIAN AWAL DI LEMBANGAN SUNGAI SEMERAK, KELANTAN DARI PERSPEKTIF KUALITI AIR

ABSTRAK

Kualiti air Lembangan Sungai Semerak (SRB), Pasir Puteh Kelantan terjejas oleh pembangunan dari sudut pertanian dan penempatan penduduk yang sesak beserta kepadatan populasinya yang tinggi. Aktiviti perindustrian dan domestik juga giat dijalankan di kawasan ini. Tujuan kajian ini dijalankan adalah untuk menentukan kualiti air lembangan sungai berdasarkan beberapa parameter Indeks Kualiti Air (IKA) dan juga mengenalpasti faktor perubahan air kualiti air berdasarkan perubahan guna tanah. Selain itu, kajian ini juga dijalankan bagi mengenalpasti tahap ekosistem di SRB bagi berdasarkan nilai parameter kualiti ari yang dikaji. Persampelan telah dijalankan secara mingguan bermula Disember 2013 hingga Februari 2014. Pengambilan sampel air sungai dilakukan sebanyak sepuluh kali bagi setiap sepuluh lokasi di sepanjang SRB.untuk kajian ini, perkaitan antara parameter kualiti air seperti Permintaan Oksigen Biokimia (BOD), Oksigen Terlarut (DO), Permintaan Oksigen Kimia (COD), Ammonia Nitrogen (NH_3-N), Jumlah Pepejal Terampai (TSS), pH dan stesen persampelan telah dikenalpasti melalui analisa kajian statistik. Analisa statistik telah menunjukkan nilai keseluruhan purata bagi setiap parameter bagi seluruh SRB; DO (9.30 mg/L), BOD (4.42 mg/L), COD (60.02 mg/L), NH_3-N (0.28 mg/L), TSS (16.39 mg/L), dan pH (5.79). Analisa ujian *ANOVA* dengan paras signifikan ($p< 0.05$) menunjukkan terdapat perbezaan untuk semua parameter kecuali parameter COD, di mana DO, BOD, NH_3-N dan suhu signifikan pada $p= 0.001$, manakala TSS signifikan pada nilai $p= 0.010$. Keputusan aliran kualiti air pada semua stesen persampelan diklasifikasikan sebagai Kelas III. IKA bagi seluruh SRB juga dikategorikan di bawah Kelas IIIdan tercemar. Sebagai kesimpulan,keputusan dari kajian ini menunjukkan keadaan kualiti air Lembangan Sungai Semerak sedikit terganggu. Dalam masa terdekat,lebih banyak tanah akan dimajukan, disebabkan oleh peningkatan dalam aspek pembangunan infrastruktur, populasi dan aktiviti industri yang boleh mengakibatkan peningkatan tahap pencemeran Sungai Semerak. Lantaran itu, kawalan pencemaran dan pengurusan lembangan sungai yang berkesan di samping melaksanakan analisis hubungkait guna tanah dan kualiti air seharusnya dilaksanakan bagi memperbaiki kualiti air pada masa akan datang.

ECOSYSTEM HEALTH RIVER BASIN; A PRELIMINARY CASE STUDY AT SEMERAK RIVER BASIN, KELANTAN ON THE WATER QUALITY PERSPECTIVE

ABSTRACT

Water quality of Semerak River Basin (SRB), Pasir Puteh Kelantan is affected by the agricultural development and accommodation of crowded and heavy population. The industrial and domestic activities also actively carried out within this area. The aims of this study were to determine the water quality of the river basin based on several parameters of International Water Quality Index (WQI) and also to identify the causes of water quality on Semerak River based on the changes of land used. Besides that, this study was also carried out to identify the level of ecosystem health in SRB based on river water quality. Sampling was conducted on a weekly basis starting from December 2013 until February 2014. For every data collection, water sample was collected once per sampling station for every week. In this study, the relationship between water quality parameters, e.g. Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3-N), Total Suspended Solids (TSS), pH and sampling stations was identified by analyzing the statistical test. From the result, total mean value for SRB; DO (9.30 mg/L), BOD (4.42 mg/L), COD (60.02 mg/L), NH_3-N (0.28 mg/L), TSS (16.39 mg/L), and pH (5.79). The parameters were examined by correlation analysis of ANOVA test with significant level ($p< 0.05$). There were significant differences for all parameters except for COD, at which DO, BOD, NH_3-N and temperature was significant with $p= 0.001$, while TSS was significant at $p= 0.010$. The results of water quality for all sampling stations were classified under Class III. WQI for SRB were also categorized under Class III and considered as polluted for whole river basin. Based on this study it can be concluded that the water condition of SRB is slightly disturbed. In the near future, more land will be developed, due to increase in infrastructure development, population and industrial activities that will consequently increase the population level in Semerak River. Hence, effective pollution control on river basin management and new analysis on relationship between land use and water quality should be implemented to improve the quality of the water in the future.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In Malaysia, the river is the main source of water supply to all human activity. There are about 49 major river basins (with another 94 minor river basin) that were the reason for such supplies. Water used by human being in two ways, namely recruitment and flow of water, such as water consumption for industrial and domestic agriculture, while the water flows is used to generate hydroelectric power, navigation, fisheries and recreation. Hence, water quality will certainly declining if the river located nearest to the big town, estate, industrials and so on. This is because the land use pattern in the area are able to give some effect on drainage system located in the vicinity (Detwyler, 1972).

Malaysia is already setting a standard proposal while on the water quality classification issued by Department of Environment (DOE) in relation to water pollution. By 2007, the number of river basin monitored was reduced from 146 to 143. This case is due to the integration of three rivers located near to each other. Found that Linggi River Basin in Malacca is actually joined with Linggi River Basin in Negeri Sembilan; Pontian River Basin on the other hand merged with Rompin River Basin before flowing to the sea and Semerak River Basin in Kelantan joined with Kemasin River Basin. Thus, Linggi River Basin in Malacca, Pontian River

Basin and Semerak River Basin were excluded resulting in 143 river basins and no longer counted in total river basin (DOE, 2006).

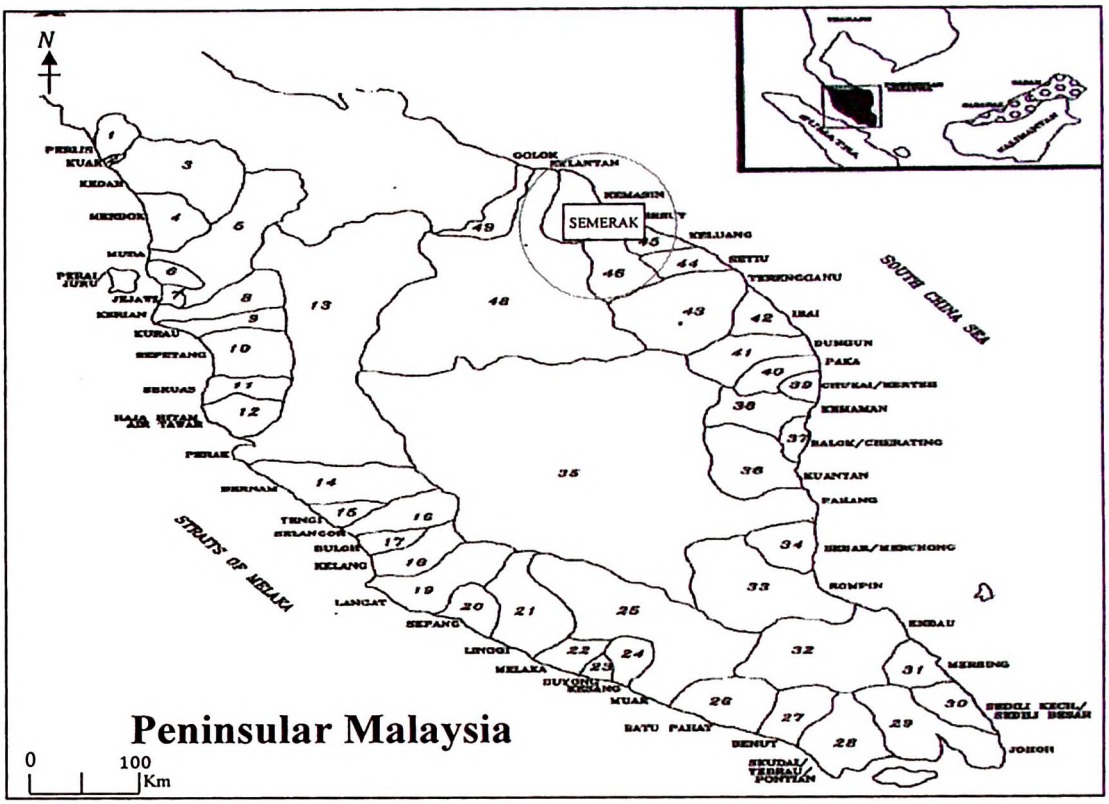

Figure 1.1: River basins monitored by Department of Environment (DOE)
(Source: DOE, 2006)

However, total monitoring station still remains the same as there were 1,064 stations (Refer Figure 1.1). From 1,064 monitoring stations, as much as 638 stations classified as clean, 376 stations slightly polluted and 50 stations polluted. There is significant increase in the river water quality during year compared to 2006. Number of clean rivers in year 2007 is 91 compared to 80 in year 2006 and totally slightly polluted total rivers a little decline from 59 during year 2006 had become 45 units in year 2007 (DOE, 2006). The statistics for clean rivers decline for next three years which in year 2008 was decreases to 76, in year 2009 was 70 and 65 in year 2010. However, slightly polluted river showed increasing trend which in year 2008 become

become 60, 64 in year 2009 and 65 in year 2010. While total number of polluted river basin remained 7 in year 2007 and 2008 but become 9 in 2009 and increase to 13 during 2010 (Refer Figure 1.2). Firstly, an increase in the number of polluting sources such as sewage treatment plants, agro-based factories and pig farms which contributed to an increased in the pollutant load. Secondly, a decrease in the amount of rainfall in the states of Pahang and Sarawak deteriorated from clean to slightly polluted (DOE, 2010).

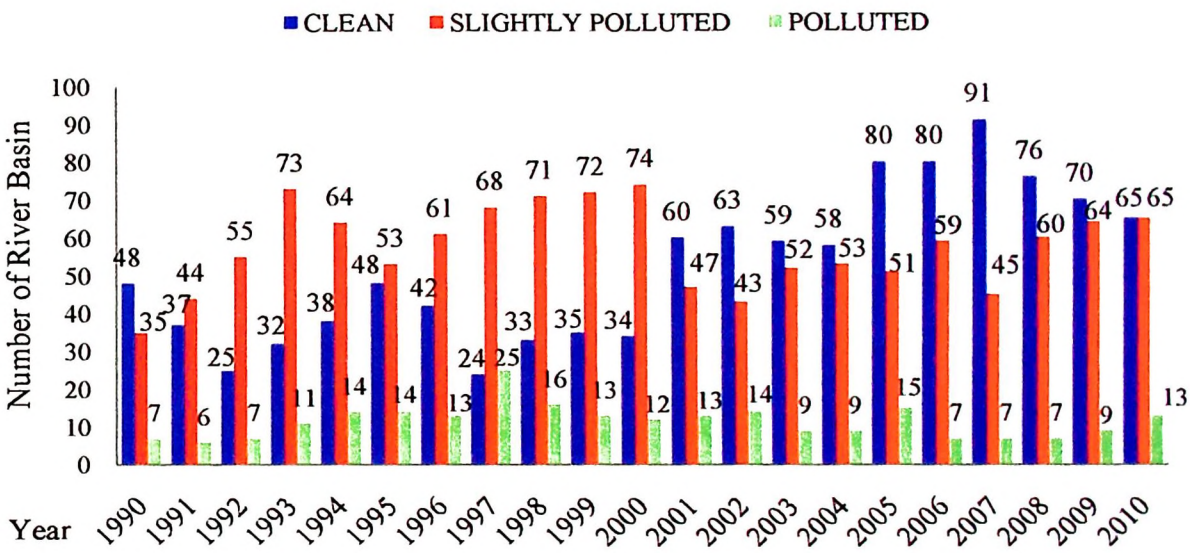

Figure 1.2: Malaysia River Basin Water Quality Trend (1990-2010)
(Source: Adopted from Department of Statistic Malaysia, 2011; DOE, 2006)

As in previous year the major pollutants detected were Biochemical Oxygen Demand (BOD), Ammonia Nitrogen (NH_3-N) and Suspended Solids (SS). In line with the overall improvement in river water quality in 2007, the number or river basins polluted by BOD decreased from 22 in 2006 to 12 in 2007 and the number of river basins polluted by NH_3-N decreased from 42 to 36 but the number of river basins polluted by SS remain at 42. High BOD can be contributed to untreated or partially treated sewage and discharges from agro-based and manufacturing industries.

5main sources of NH_3-N were domestic sewage and livestock farming, while the sources for SS were mostly earthworks and land clearing activities (DOE, 2010).

Analysis of heavy metals in 5,613 water samples revealed that almost ll samples complied with Class III , National Water Quality Standards for arsenic (As), mercury (Hg), cadmium (Cd),chromium (Cr), lead (Pb) and zinc (Zn), except iron (Fe) with 83 percent compliance (Environment Quality Report (EQR), 2006).

Therefore, the quality of water must be controlled and treated properly especially at river basin which become the main water supply to the people around as according to the specified standard. Government has appoint certain regulations under Environment Quality Act 1974, that has been gazette and implemented to prevent and control water pollution especially those effluent released from industrial sector.

Malaysia's rivers are vital for nature and human society. Major cities have been established and flourished along rivers. Rivers are rich ecosystems and sources of life, providing water supply, irrigation for agriculture, a means of transportation, a source of food in fisheries, hydro-electric power and water use for industries (Chan, 2002[a]). They are also the habitats for riverine and aquatic flora and fauna and the riparian environment supports a rich biodiversity of life forms (Naiman & Bilby, 2001). However, over the years, a combination of low priority on the government agenda, public apathy, neglect and poor management have resulted in severely degraded rivers including their water quality.

In the last four decades, the country has developed rapidly, together with urbanization increasing dramatically in all the major cities and towns (Chan, 2012). Coupled with this, agriculture expansion and industrialization have negatively impacted rivers. The high cost of degradation has negatively affecting water supply in

terms of quantity and quality for irrigation, navigation, recreation, and tourism, and resulting in floods and pollution (Chan, 2002[b]).

The environment is absolutely essential to the development process of a country, for example, a river that became one of the early settlement of human civilization and thus now or later the river will always being manipulated by all human activity. Thus the river will threaten not only to human, but all living things in the ecosystem of the earth.

1.2 PROBLEM STATEMENT

Almost 1.1 billion world communities faced the problem of getting clean water supply and in line with water crisis that getting aggravated; water supply pollution also said contributes up to 80 percent to various diseases in developing countries (Jamison, 2006) and getting increase year by year. In Malaysia, water pollution had become one of the major topics which showed the important of environment conservation especially on water sources.

There were some main causes of water pollution in Malaysia such as the usage of chemical, insecticide and weed poison in agriculture sector, disposal of organic waste from industry, disposal of rubbish and waste sewage, logging activity and also petroleum and natural gas mining (Berita Harian, 2014). This multitude of interacting stressors adversely affects physical, chemical and ecological water status. It is no longer possible to examine stresses, nor indeed ecosystems, in isolation. With aquatic ecosystems and resources facing truly global problems, problems caused by multiple interacting stresses operating across ecosystem types, all inextricably linked to human or socio-economic systems.

Requirements of the development had becoming important due to the rapid growth of population recently. However, economic development has been specifically undertaken that causing side effects on the environment, which severe environmental pollution was due to development is impacted on water quality. This situation occurs due to the absence of effective control of pollution of river water quality.

Pollution issues are actively discussed recently. Regarding to DOE Malaysia (2006), there are 5 rivers that had been identified as the most severely polluted rivers. Those are Pinang River and Juru River in Penang, Klang River and Penchala River, Kuala Lumpur and Segget River, Johor Bahru.

Water pollution from industrial waste in Kuala Krai cause pollution in the area of Nal River. Parties act detected when several black spots visible effects of pollution on the sand arose in the river during low tide. Nal River is the focal point for the shower and water resources, sandy areas, also the area for the residents find 'etak'. Some effects from waste pollution can be seen in the depletion of community health even threatened the fisheries activities which also resulting in deterioration of Nal River water quality (Sinar Harian, 2013).

The garbage disposal into the river system also contributed to the decline in water quality. Rubbish thrown into the river not only from the waste sector development, but also from an industrial plant. Garbage disposal and industrial waste problem can clearly be seen on Kelantan River and Pengkalan Chepa River.

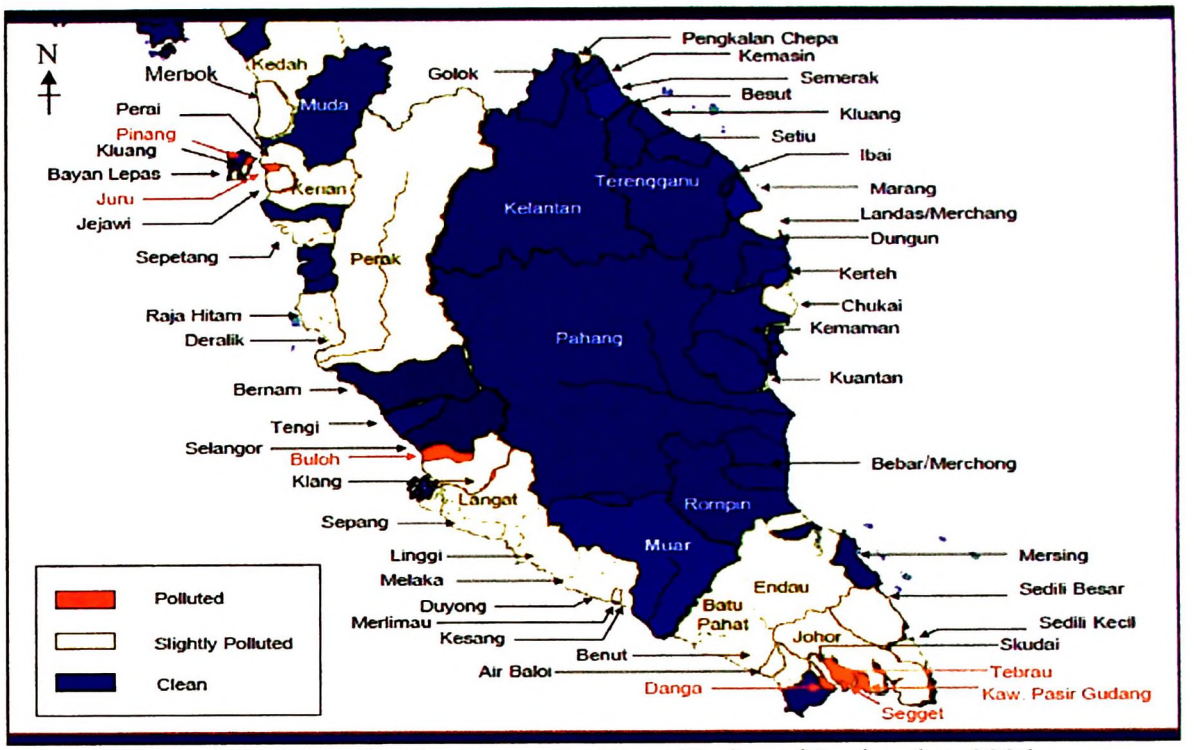

Figure 1.3: Water Quality Status for River Basins of Peninsular, 2006
(Source: DOE, 2006)

In Kelantan, more forest and floodplains in urban area has been modifies into industrial and urban activity purposes. Currently, certain distinct ecosystems or habitat types also are threatened by these human activities such as Pengkalan Chepa and Pasir Puteh. Water quality is becoming degraded as human activities nearby riverbank and floodplains are increasing (Rohasliney, 2010). Based on DOE (2010), Pengkalan Chepa River is the only polluted river at Kelantan, while the other river such as Semerak River, Kemasin River, Besut River, Keluang River and Golok River was classified as clean rivers (Figure 1.3). Semerak River Basin was chosen due to the new development of land use and rapid agricultural activities to the area. It also due to construction of the Tok Bali channel- jetty and channelization of the Semerak River has been removed and it has reduced its fringing mangrove (Chong *et al.*, 2010) at which these factors are also could indirectly contributed to the pollution and modified the water quality of the river.

1.3 OBJECTIVES

1.3.1 GENERAL OBJECTIVES

To determine the status of ecosystem health of Semerak River Basin based on the land use factors by the assessment of river water quality.

1.3.2 SPECIFIC OBJECTIVES

i. To determine the water quality of Semerak River Basin based on several parameters of Water Quality Index (WQI) which are six parameters of Water Quality Index (WQI) which are Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Ammoniacal Nitrate (NH_3-N), Temperature, Total Suspended Solid (TSS) and pH.

ii. To indicate the level of ecosystem based on water quality parameter status.

iii. To identify the latest river water quality classification of Semerak River Basin in accordance to the Water Quality Index (WQI).

iv. To find the relationship between water quality parameter status and land use of sampling stations of Semerak River Basin.

1.4 HYPOTHESIS

1.4.1 Alternate hypothesis (H_A)

There is a significant difference of water quality parameter status between the sampling locations of Semerak River Basin.

1.4.2 Null hypothesis (H_O)

There is no significant difference of water quality parameter status between the sampling locations of Semerak River Basin.

1.5 SIGNIFICANCE OF THE STUDY

Agricultural activities and developments in this area is currently affecting the river load change. The implementation of development projects will indirectly bring changes to the environment as it will affect the river environment pollution. The purpose of this study was to prove the relationship between water quality affected by the current land use at the sampling location such as agricultural activities, industrial activities and also domestic emissions generated by many sources. This study also prove the level of pollution of the river and deterioration of water quality without control that will affect not only human health but also river ecosystem health as Semerak River is the main water supply to the area Pasir Puteh District.

Semerak River Basin was chosen as study area which located at Pasir Puteh. Main problems faced by the river are it has actively been used as agricultural and fisheries activities that might affecting the water quality of the river. Semerak River also functioned as the main source of water supply and agricultural irrigation, besides active in aqua-cultures and agro-tourism activities. Development such as the construction of the new bridge is now being carried forward in the area. This study was investigated on the pollution level on water quality of the Semerak River Basin and the sources form the land used that contribute to the deterioration of water quality in this study area.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

River plays a major role for community especially in fisheries and as a source of water for people residing within the vicinity. Water quality is of utmost importance and it covers a wide range of approaches and conflict. The continuous increase in socio-economic activities in this area has been accompanied by an even faster growth in pollution stress on river quality. One of the challenges in evaluating and improving water quality are the many different factors affecting water quality.

According to United State of Environmental Protection Agency (USEPA, 2013) stated that water quality is affected by air quality, pesticides and toxics. Airborne pollutants such as nitrogen and sulphur compounds do not disintegrates, they remain the same or undergo chemical alteration when they contact other substance, causing direct pollution into the water such as formation of acid rain. Regarding to the Natural Resources Management and Environment Department (FAO, 2014), agricultural use of pesticides is kind of chemicals that are intentionally released into the environment, which at the same time causing the toxic chemicals such as heavy metals give major impact on water quality and leads to serious environmental consequences. Industrial wastes are known to adversely affect natural life by direct toxic action or indirectly through qualitative alterations in the character of the water as well as that of the stream bed (Ahmed & Reazuddin, 2000). Water quality is highly

variable over time due to both natural and human factors (Ali, 2010). The chemical, physical and biological aspects of water quality are inter-related and must be considered together.

2.2 ECOSYSTEM HEALTH

Ecosystem health is focusing on comprehensive, multi scale and hierarchical measure of system in term sustainability which implies the system's ability to maintain its structure and function over time in the face of external stress. The term "ecosystem health" is generally defined by analogy to human health (Costanza *et al.*, 1992), which is familiar and therefore helpful for communicating ecosystem status to the public (Ryder 1990; Lackey 2001). Definition based on ecological principles define a healthy ecosystem as being stable and sustainable with resilience to stress that allows it to maintain its organization (Costanza *et al.*, 1992). Because humans benefit from ecosystem resources and services and exercise control over ecosystem processes, healthy ecosystems are also identified as those capable of sustaining economic activity and human health while maintaining organization, resilience and vigor (Rapport *et al.*, 1998).

Regarding a study by Schaeffer *et al.*, (1995), it stated that ecosystem health can be identified from one or a few test, such a shallow procedure drives virtually all environmental management strategies. For example, single species, or limited multispecies, testing is the basis for water quality criteria. The study also stated that the needed on the classification of ecosystem states as diseased or non-diseased (healthy or unhealthy), using objective criteria for a range of parameters which are appropriate to each ecosystem. Additional criteria are needed to distinguish between

acceptable and unacceptable degrees of a diseased state (illness) because recovery from disease is possible and often leads to improved system resistance to future disease insults.

While, another concept in ecosystem health can be classified based on 'health' status of the ecosystem (e.g. good, satisfactory, poor) with regard to a reference condition. It was linked to the system of ecological quality issues and ecological quality objectives that should be established and appropriately cover the components of the particular marine ecosystem that are impacted by human activities (Christopher, 2005).

Generally, ecosystem's health described about the local environment which retains biology diversity, integrity all the time and has endurance with current changes (Rapport *et al.*, 1995). Apart from that, ecosystem's health also debating regarding particular area balance resilience and organism community adaptation that consisting of various species and fungi to the immemorial state or habitat that pristine (Wright, 2012).

In discussing regarding ecosystem river basin, the most important matter highlighted is the indicator on health system. The indication proposed or used nowadays was more converging to water pollution level measurement and air, life diversity and the level of possible danger that would be occur due to human activity (Maliki, 2010).

2.3 RIVER BASIN

.River plays an important role in the global cycling of water between the sea, air and land from a hydrologic perspective. Rivers gather precipitation and carry it as runoff to the sea along with underground aquifers, which then cycle moisture back to the land via atmosphere. The finite supplies of water on the continents are constantly renewed through this cycle and thus sustain all life on land (Postel & Ritcher, 2003). Based on the study by Wan Ruslan & Zullyadini (1994), distribution source of water in the world by river, channel an lake was only 0.0085 percent compared to other sources such as sea and salt-water lake with 97.20 percent, ground water with 0.64 percent and by other sources (ice cap and glacier, atmosphere and biosphere) with 2.15 percent and 0.00015 percent each.

While river basin is refer to the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta (Europe Water framework Directive 2000; Department of Irrigation and Drainage Kuala Lumpur, 2013).

River : From Source to Mouth

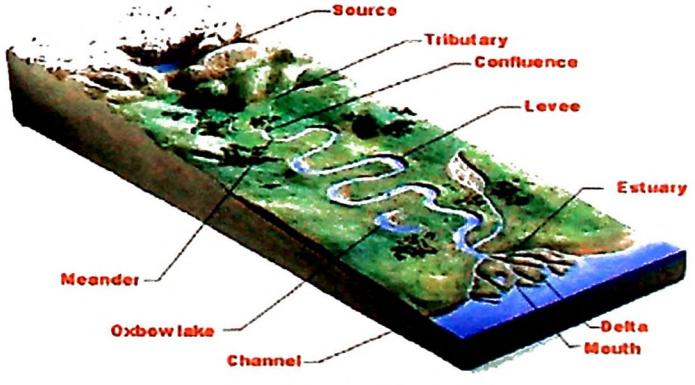

Figure 2.1: River System

(Source: Department of Irrigation and Drainage Kuala Lumpur, 2013)

Based on Christopher (1998), most of the world's land surface, apart from the most arid and cold areas, is divisible into river basins. Chitale (1992), recognized river basin into three divisions; "large"+ver 20,000 km^2; "mediurn"-2,000 to 20,000 km^2; and "small''--less than 2,000 km^2 basins (Christopher, 1998). The features of river basin are also affected the total stream flow of the river such as the size of the basin, shape, gradient, height, orientation of the basin, drainage density, and type of land use surrounding the basin (Wan Ruslan & Zullyadini, 1994).

According to Axel (2001), a river basin is an area which is defined by nature itself, essentially by the limits of the run-off areas of surface water converging towards a single watercourse. The river basin, its natural resources and it is inhabitants have physical, biological, economic, social and cultural qualities which endow them with their own special characteristics. Physically, a river basin represents a natural area of collection and concentration of surface and ground water and therefore has an essentially volumetric and hydrological connotation. At the same time, both the river basin and, above all, the water collected in it represent a source of life for mankind though it can also be a source of danger when extreme natural phenomena take place or it is affected by pollution. In river basins, it is all too easy to see the negative effects of human actions on the environment, especially in the form of water pollution.

2.4 WATER QUALITY PARAMETERS

Water is a natural resource and lately it was increasingly threatened by pollution and most of the water quality in Malaysia doubted on its use. Regarding Laboratory of Echohydrology (ECHO, 2013) water quality can be assessed by measurement of physical parameters, chemical and bacteriological. The measurements of its physical parameters will affect the smell, color, temperature, solids and its water taste. For chemical parameters covers in organic and inorganic forms, at which the organic parameter measurement usually involving measurement Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Dissolved Oxygen (DO). The inorganic parameters were measured by the pH, iron, sulfate and chloride.

DOE (2010), explained the concept of water quality which can be determined based on the percentage of samples in "cut-off concentration" which as much of 6 mg/L for Biological Oxygen Demand (BOD) and 150 mg/l for Suspended Solids (SS). Based on this index, the level of water quality is well in excess of 75 percent of the sample is in "cut-off concentration", while if the average level is between 66-75 percent and in the quality of contaminated water is less than 66 percent. "Cut-off concentration" term usually used for the concentration in mixture or substances; at which in this water quality analysis was referred to the specific concentration of water in the sample that is chosen as a limit value to be taken into account for classification purpose. Samples with concentration above the cut-off level are considered unacceptable and vice versa (Yunbo, 2011).

2.5 RIVER CLASSIFICATIONS AND EVALUATION OF WATER QUALITY BASED ON WATER QUALITY INDEX

A study conducted by Fera *et al.* (2013) on water quality at selected sites along the two main tributaries of Liwagu River, Sabah has shown a result of both tributaries was characterized by excellent water quality with an average of 94.5 value of WQI. Eight water samples were collected along the river for physical and chemical water quality analysis (physic-chemical) according to American Public Health Association (APHA) procedures. This river was classified into Class I to Class II based on National Water Quality Standards for Malaysia (NWQSM) and the Water Quality Index (WQI) (Refer Table 2.1 and Table 2.2)

Al-Badaii *et al.* (2013) has carried out a study to determine the Semenyih River water quality based on the physicochemical and biological parameters. The sampling was conducted in dry and rainy seasons during 2012. Water samples were collected from 8 stations along the river and analyzed using standard methods. From the results, it showed that temperature, pH, conductivity, Total Dissolved Solids (TDS), Sulphate (SO_4^-), and Total Hardness (TH) of this river were classified as class I, while DO, turbidity, and BOD were categorized under class II, and NH_3-N, TSS, COD, and Oil and Grease (OG) were categorized as class III based on NWQS, Malaysia. Moreover, NO_3 was classified under class IV, while Phosphate (PO_4^-) and Faecal Coliform (FC) were categorized as class V and exceeded the allowable threshold levels. Therefore, the river was slightly polluted with NH_3-N, TSS, COD, and NO_3, whereas it is extremely contaminated with PO_4 and FC.

According to DOE (2006), Semerak River Basin was categorized as clean river and classified under Class II for 2006 (Refer Table 2.3). Regarding to Environment

Quality Report 2004, the WQI was calculated based on 6 major parameters of INWQS which are BOD, COD, SS, pH, DO, NH_3-N. The overall WQI for river basin is calculated by averaging WQI from all sampling stations in each basin throughout the year. The average WQI value for Semerak River was 78 with two monitoring stations, Kemasin with the average value of 84 while Kelantan River with the value of 87.

Table 2.1: National Water Quality Standard (NWQS)

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

(Source: EQR 2006)

Table 2.2: Water Quality Classification Based On Water Quality Index

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand(BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen(NH3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids(SS)	76 - 100	70 - 75	0 - 69
Water Quality Index(WQI)	81 - 100	60 - 80	0 - 59

(Source: EQR 2006)

Table 2.3: River Water Quality Classification and Uses

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

(Source: EQR 2006)

2.6 FACTORS AFFECTING THE ECOSYSTEM HEALTH OF THE RIVER

Investigation done by Wright (2012) on water quality in the upper Georges River focusing on the assessment of any impact from Brennans Creek, which contains waste water discharged from an active coal mine (West Cliff Colliery). Water quality was measured on three occasions using a calibrated field meter where water samples were also collected and tested by an accredited analytical laboratory for a range of pollution exist due to the water contaminants level. Pollution may originate from point sources or non-point sources. The major point sources of pollution to freshwater originates from the collection and discharge of domestic wastewater, manufacturing, sewage treatment plant, industrial waste or certain agricultural activities, such as animal husbandry (Watson & Burnett, 1995; DOE, 2010).

A cluster analysis by Al-Badaii *et al.* (2013) classified 8 sampling stations at Semenyih River into three clusters based on similarities of water quality features. The study also pointed out that water quality deterioration in the river was associated with industrial and agricultural activities, livestock farming, and erosion. Therefore, the river water can be used for irrigation with precaution but extensive treatment needed before using for domestic purposes.

Most other agricultural activities, such as pesticide spraying, surface runoff or fertilizer application, are considered as diffused sources which defined as non-point sources (Loague & Corwin, 2005).The investigation found that Brennans Creek was contaminated with elevated levels of salt and heavy-metals, and it acted as a major point-source of contamination to the upper Georges River. The water quality contaminants of most concern in the upper Georges River and Brennans Creek are salt, measured as electrical conductivity, and its constituent major an-ions and cat-ions and heavy-metals (Aluminium, Arsenic, Copper, Nickel, Zinc, and Lead). All results were assessed against the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) water quality guidelines (where applicable), particularly using guidelines for protection of aquatic ecosystems, and the locally derived Georges River guidelines (Tippler *et al.*, 2012). It was determined that salt, copper, nickel, zinc, aluminum and pH all exceeded guideline levels for ecosystem protection and each was at risk of contributing to toxic conditions for downstream aquatic ecosystems.

The Ganga is not only a holy river, but also a lifeline of a large population of India, which it covers more than 26% of the country's area in its basin in the north and drains 25% of the annual run-off. Fast urbanization, industrialization and steep demand for water have led to serious problems of water quality degradation. Water

quality monitoring carried out by Trivedi (2010) indicated that the river is polluted in some of the segments, the worst affected lying between Kannauj and Allahabad, approximately 350 km long. About 12,222 million litres per day (mld) of domestic and 2500 mld of industrial wastewater is generated in the entire basin, out of which about 2573 mld of wastewater is generated along its bank.

A study by Gasim (2003) on the watershed analysis was done at the Semenyih River Basin to determine the various factors of land use changes that may affect the stability of the watershed and its subsequent impacts on water quality. It has undergone various degree of land use changes since last decade, particularly associated with urbanization and industrialization. The total area of the basin is 266.60km^2 and contain 36 sub-catchments with sizes ranging from 1.37 to 35.57 km^2. 18 water quality parameters were performed from 11 sampling locations at Semenyih River. Seven categories of land use were identified and forests constitute the largest land use. Rainfall- runoff relationships based on hydrologic response analysis showed that urbanization in Semenyih town contribute to significant surface runoff compared to the other land uses.

Graphical analysis indicated that Semenyih dam regulates the flow of the Semenyih River. The principle categories of pollution sources were from domestic activities, industries, manufacturing activities and land clearing activities. The result indicated that water quality deterioration due to urban wastes was significant (WQI 56 to 48). The results of Semenyih River Basin classification was established for the 36 sub-catchments and indicated that 12 forested sub-catchments can be classified as "good"; six agriculture and forested sub-catchments as "fair"; ten agriculture and settlement sub-catchments as "slightly disturbed" and eight urban sub-catchments classified as "disturbed".

Maintenance of the ecosystem health of a river is of great importance for local sustainable development. Research done by Li *et al.* (2013) on the basis of both qualitative and quantitative analysis of the influence of natural variations and human activities on the ecosystem function of the Weihe River, the changes in major factors affecting its ecosystem health are determined, which include: 1) Deficiency of environment flow: since the 1960s, the incoming stream flow shows an obvious decreasing tendency. Even in the low flow period, 80% of the water in the stream is impounded by dams for agriculture irrigation in the Baoji district. As a result, the water flow maintained in the stream for environmental use is very limited. 2) Deterioration of water quality: the concentrations of typical pollutants like Chemical Oxygen Demand (COD) and NH_3-N are higher than their maximum values of the Chinese environmental quality standard. Very few fish species can survive in the Weihe River. 3) Deformation of water channels: the continuous channel sedimentation has resulted in the decrease in stream gradient, shrinkage of riverbed and the decline in the capability for flood discharge. 4) Loss of riparian vegetation-plant habitats and communities along the river margins and banks: most riparian land has been occupied by urban construction activities, which have caused the loss of riparian vegetation and biodiversity and further weakened flood control and water purification function.

According to Malaysia Environment Quality Report release by DOE Malaysia (2008), water pollution in Malaysia is originated from point sources and non-point sources. Point sources that have been identified include sewage treatment plants, manufacturing and agro-based industries and animal farms. Non-point sources are mainly diffused ones such as agricultural activities and surface runoffs. It stated that17, 633 water pollution point sources were recorded. These comprise of sewage

CHAPTER 3

METHODOLOGY

3.1 CONCEPTUAL FRAMEWORK OF RESEARCH METHODOLOGY

This study is structured on the basis of conceptual framework in an operation of research methodology. The detailed flow, of how water quality being analyzed is discussed throughout the study was available with supporting data for each section.

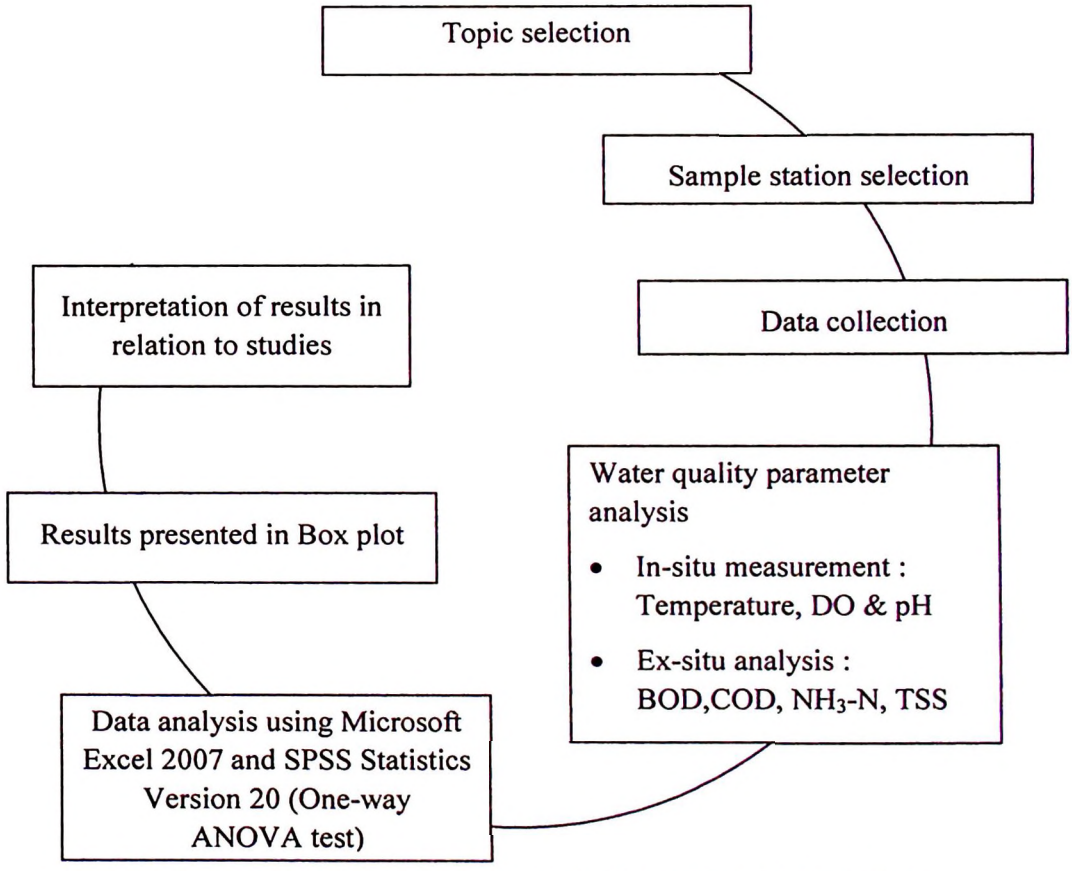

Figure 3.1: Conceptual Framework of Research Methodology

treatment plants (9,524: 54.01% inclusive of 668 Network Pump Stations), manufacturing industries (6,830: 38.73 0/o), animal farm (788: 4.48%) and agro-based industries (491:2.78%) as shown in Figure 2.2. Analysis of heavy metals in 5,613 water samples revealed that almost all samples complied with Class III NWQS for arsenic (As), mercury (Hg), cadmium (Cd), chromium (Cr), lead (Pb) and zinc (Zn) except iron (Fe) with 83 percent compliance.

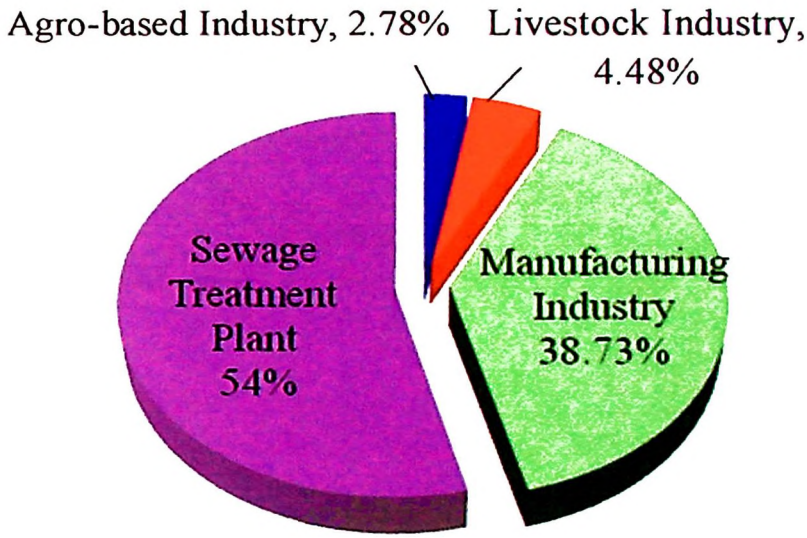

Figure 2.2: Composition of Water Pollution Sources by Sector (EQR, 2008)

CHAPTER 3

METHODOLOGY

3.1 CONCEPTUAL FRAMEWORK OF RESEARCH METHODOLOGY

This study is structured on the basis of conceptual framework in an operation of research methodology. The detailed flow, of how water quality being analyzed is discussed throughout the study was available with supporting data for each section.

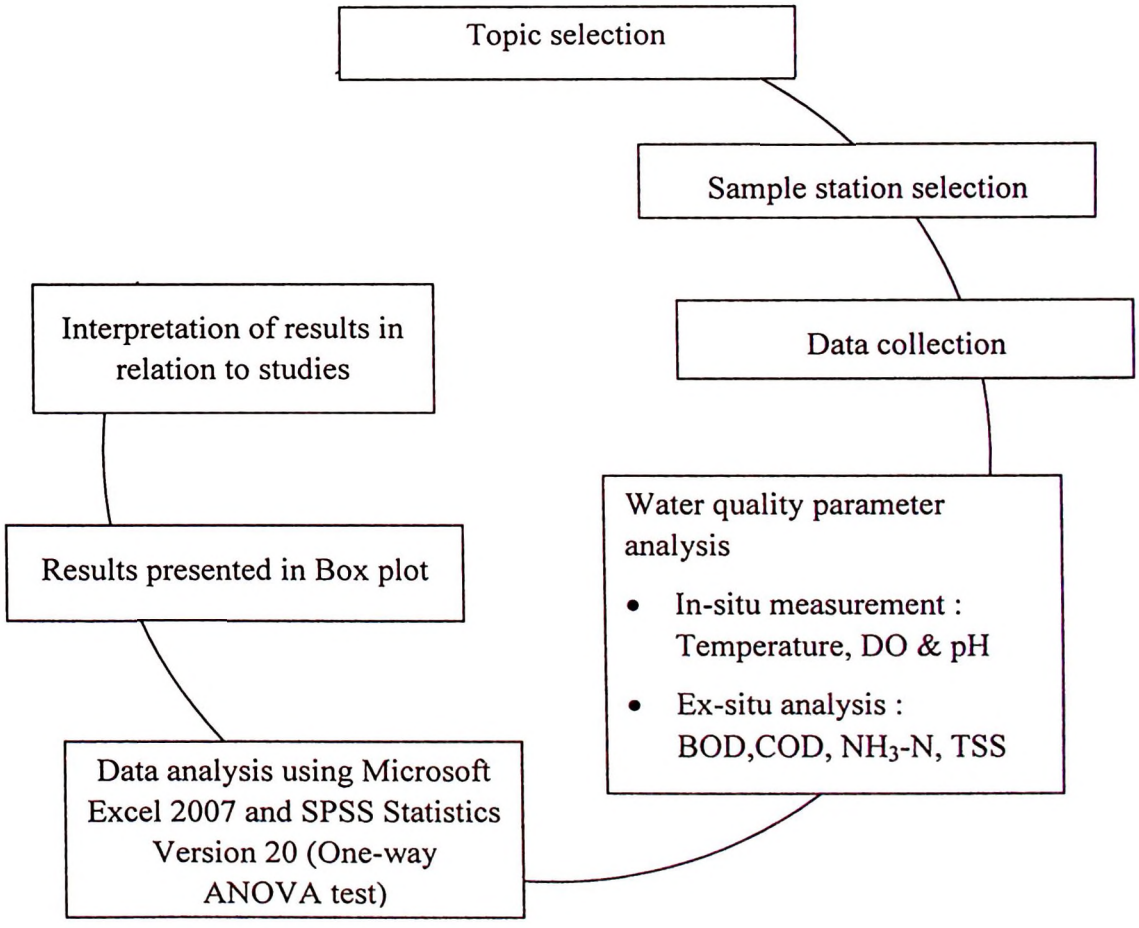

Figure 3.1: Conceptual Framework of Research Methodology

Generally, the study was designed based on the title which detail the objective and purpose statement of the research together with the research question and hypotheses.

The study was further carried out on the research designed in order to answer the research question by conducting the sampling station selection, analyzing water sample based on the in-situ and ex-situ parameter and the data been analyze by using SPSS Statistic 20. The result for each parameter was presented in box plot and interpretation of obtained result was further discussed and correlate with previous studies.

3.2 STUDY AREA

Kelantan State comprises more than 25 rivers having seven major river basins which were Galas, Kelantan, Bachok, Semerak, Pengkalan Chepa, Pengkalan Datu, and Kemasin river basin. This water quality study was carried out at Semerak River Basin (SRB). SRB is the main river basin located at Jajahan Pasir Puteh, Kelantan. Large part of the river basin is located at the south part of Pasir Puteh. SRB is also surounded by Limbong District, Gong Datok District, Jeram District and Bukit Jawa District.

SRB was drained by many rivers. The main river in this area is known as Semerak River which is continuously bounded with other creek such as Jereneh River, Yong River and Rasau River. SRB drains a catchment area of about only 8 km^2 which originate from 38 km^2 long in north-east Malaysia and flows southwards into South China Sea (Department of Irrigation and Drainage Pasir Puteh, 2013).