COMPARISON OF WATER QUALITY STATUS BETWEEN TWO DIFFERENT TYPES OF RIVER: A CASE STUDY OF KEMASIN RIVER AND PENGKALAN CHEPA RIVER

by

NADZIRAH BINTI MORSAD

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

JUNE 2014

ACKNOWLEDGEMENT

I would like to thank the School of Health Sciences, Universiti Sains Malaysia (USM) for the support and trust given to me in preparing the study of 'Comparison of Water Quality Status Between Two Different Types of River: A Case Study Of Kemasin River And Pengkalan Chepa River'. I am indebted to Dr.Nurulilyana Sansuddin, my supervisor for her encouragement, guidance and patience that she demonstrated during the completion of this study. My appreciation also goes for her supports and constructive comments through this period.

My deepest gratitude goes to all the lecturers and Laboratory Science Officer in the Environmental and Occupational Health Programmer for kindly helping in this study. Greatest appreciation to Puan Hafizah, staff of Department of Irrigation and Drainage, En.Ghazali who is Technician at IADA Kemasin Semerak and En.Nasir Salleh, Executive of IADA Kemasin Semerak in provided data and material that useful in my study.

I would not have completed this study without help and encouragement from my dear friends Nur Fatihah and Noorsyafiqa that together accompany to collect the data and believed in my capabilities more that I did. My special appreciation goes to my family especially beloved parents, Mr. Morsad Osman and Mrs. Yang Chek Zainal for their constant encouragement, affection and support throughout this study.

Last but not least, I would like to thank everybody who help and supported either directly or indirectly to the successful realization of this thesis.

TABLE OF CONTENTS

	Pages
CERTIFICATE	**ii**
APPROVAL PAGE	**iii**
DECLARATION PAGE	**iv**
ACKNOWLEDGEMENT	**v**
TABLE OF CONTENTS	**vi**
LIST OF TABLES	**x**
LIST OF FIGURES	**xi**
LIST OF PLATES	**xiii**
LIST OF ABBREVIATIONS AND SYMBOLS	**xiv**
ABSTRAK	**xv**
ABSTRACT	**xvi**
CHAPTER 1 – INTRODUCTION	
1.1 Background of Study	1
1.2 Problem Statements	5
1.3 Objectives	7
1.3.1 General Objective	7
1.3.2 Specific Objectives	7
1.4 Hypothesis	8
1.5 Significance of Study	8
CHAPTER 2 – LITERATURE REVIEW	
2.1 Introduction	9
2.2 River Pollution Issues in Malaysia	10
2.3 River Classification in Malaysia	12
2.4 Water Quality Parameters	14

2.4.1 Ammoniacal Nitrogen (NH_3-N) 15
2.4.2 Biochemical Oxygen Demand (BOD) 16
2.4.3 Chemical Oxygen Demand (COD) 17
2.4.4 Dissolved Oxygen (DO) 18
2.4.5 pH 19
2.4.6 Total Suspended Solids (TSS) 19
2.4.7 Temperature 21

CHAPTER 3 – METHODOLOGY

3.1 Sample Stations Selection (Site Description) 23
3.2 Data Collection 28
3.2.1 Instrumentation 30
3.3 Sampling Method 33
3.3.1 In-Situ Analysis 34
3.3.2 Laboratory Analysis 34
3.4 Data Analysis 42
3.4.1 Microsoft Office Excel Version 2010 42
3.4.2 Statistical Package for the Social Sciences (SPSS) 42
3.5 Determination of Water Quality Index (WQI) 44

CHAPTER 4 – RESULTS

4.1 Introduction 47
4.2 Comparison Water Quality Between Kemasin River (KR) And Pengkalan Chepa River (PCR) 48
4.2.1 Difference of Mean in Temperature Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 48
4.2.2 Difference of Mean in Dissolved Oxygen (DO) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 50
4.2.3 Difference of Mean in Biochemical Oxygen Demand (BOD) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 52
4.2.4 Difference of Mean in Chemical Oxygen Demand (COD) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 54
4.2.5 Difference of Mean in Ammoniacal Nitrogen (NH_3-N) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 56

4.2.6 Difference of Mean in Total Suspended Solid (TSS) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 58
4.2.7 Difference of Mean in pH Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 60
4.3 Summary of Descriptive Statistic of Water Quality Parameters Status at Nine Sampling Points Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 62
4.4 Water Quality Index (WQI) and Comparison Between Kemasin River (KR) with Pengkalan Chepa River (PCR) 63

CHAPTER 5 – DISCUSSION
5.1 Significant Difference of Temperature Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 66
5.2 Significant Difference of Dissolved Oxygen (DO) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 67
5.3 Significant Difference of Biochemical Oxygen Demand (BOD) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 68
5.4 Significant Difference of Chemical Oxygen Demand (COD) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 69
5.5 Significant Difference of Ammoniacal Nitrogen (NH_3-N) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 70
5.6 Significant Difference of Total Suspended Solid (TSS) Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 71
5.7 Significant Difference of pH Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 72
5.8 Land Use Activities That Influence Water Quality Rivers 73
5.8.1 Pengkalan Chepa River 74
5.8.2 Kemasin River 77
5.9 Currently Water Quality Index (WQI) Status Between Kemasin River (KR) and Pengkalan Chepa River (PCR) 81

CHAPTER 6 – CONCLUSION
6.1 Introduction 82
6.2 Strength and Limitation 83

6.3	Recommendation	84
	6.3.1 Pollution Control through Legislation	84
	6.3.2 Pollution Control through Non-Legislation	85
6.4	Further Study	86

REFERENCES 87

APPENDICES

Appendix A Application Letter of Permission to get the Data

Appendix B Application Letter to Use Lab Equipment

Appendix C Security Application Form

Appendix D Insurance Application Form

Appendix E Weather Parameter Checklist

LIST OF TABLES

Table		Page
2.1	Water classes and uses	13
2.2	DOE water quality index classification	13
3.1	Sampling station coordinate of Pengkalan Chepa River	29
3.2	Sampling station coordinate of Kemasin River	30
4.1	Result of independent t-test for temperature of Kemasin River (KR) and Pengkalan Chepa River (PCR)	50
4.2	Result of independent t-test for DO of Kemasin River (KR) and Pengkalan Chepa River (PCR)	52
4.3	Result of independent t-test for BOD of Kemasin River (KR) and Pengkalan Chepa River (PCR)	54
4.4	Result of independent t-test for COD of Kemasin River (KR)and Pengkalan Chepa River (PCR)	56
4.5	Result of independent t-test for NH_3-N of Kemasin River (KR) and Pengkalan Chepa River (PCR)	58
4.6	Result of independent t-test for TSS of Kemasin River (KR) and Pengkalan Chepa River (PCR)	60
4.7	Result of independent t-test for pH of Kemasin River (KR) and Pengkalan Chepa River (PCR)	62
4.8	Summary Of Descriptive Statistic Of Water Quality Parameters Status at Nine Sampling Points Between Kemasin River (KR) and Pengkalan Chepa River (PCR)	63
4.9	Water Quality Parameters Classification of Kemasin River (KR) based on Water Quality Index Classification	64
4.10	Water Quality Parameters Classification of Pengkalan Chepa River (PCR) based on Water Quality Index Classification	64
4.11	WQI of Kemasin River (KR) and Pengkalan Chepa River (PCR) based on DOE Water Quality Index Classification.	65

LIST OF FIGURES

Figure		Page
1.1	Malaysia River Water Quality Trend (2005 - 2012)	2
2.1	Major pollution in Malaysia	14
2.2	Status of river water quality based on NH_3-N, Malaysia 2007-2011	16
2.3	Status of river water quality based on BOD5 pollutant, Malaysia, 2007–2011	17
2.4	Status of river water quality based on SS pollutant, Malaysia, 2007–2011	20
3.1	Conceptual Framework of Methodology	22
3.2	Map for both sampling location (KR and PCR)	23
3.3	Map of overall sampling stations at Pengkalan Chepa River (PCR)	24
3.4	Map of three sampling point at upstream river, Kg. Keladi	25
3.5	Map of three sampling point at middle stream river, Kg. Baung	25
3.6	Map of three sampling point at downstream river, Kg. Pulau Panjang	26
3.7	Map of overall sampling stations at Kemasin River	26
3.8	Map of three sampling point at upstream river, Kg. Bangu	27
3.9	Map of three sampling point at middle stream river, Pengkalan China (Kg. Keluat)	27
3.10	Map of three sampling point at downstream river, Pengkalan Petah	28
3.11	Front View of YSI 556 MPS	31
3.12	Features of the YSI 5563 Probe Module	32
3.13	View of Garmin GPS 62s	33

4.1(a)	Column chart of Temperature (^oC) against sampling point of Kemasin River (KR)	49
4.1(b)	Column chart of Temperature (^oC) against sampling point of Pengkalan Chepa River (PCR)	49
4.2(a)	Column chart of Dissolved Oxygen (DO) against sampling point of Kemasin River (KR)	51
4.2(b)	Column chart of Dissolved Oxygen (DO) against sampling point of Pengkalan Chepa River (PCR)	51
4.3(a)	Column chart of Biochemical Oxygen Demand (BOD) against sampling point of Kemasin River (KR)	53
4.3(b)	Column chart of Biochemical Oxygen Demand (BOD) against sampling point of Pengkalan Chepa River (PCR)	53
4.4(a)	Column chart of Chemical Oxygen Demand (COD) against sampling point of Kemasin River (KR)	55
4.4(b)	Column chart of Chemical Oxygen Demand (COD) against sampling point of Pengkalan Chepa River (PCR)	55
4.5(a)	Column chart of Ammoniacal Nitrogen (NH_3-N) against sampling point of Kemasin River (KR)	57
4.5(b)	Column chart of Ammoniacal Nitrogen (NH_3-N) against sampling point of Pengkalan Chepa River (PCR)	57
4.6(a)	Column chart of Total Suspended Solid (TSS) against sampling point of Kemasin River (KR)	59
4.6(b)	Column chart of Total Suspended Solid (TSS) against sampling point of Pengkalan Chepa River (PCR)	59
4.7(a)	Column chart of pH against sampling point of Kemasin River (KR)	61
4.7(b)	Column chart of pH against sampling point of Pengkalan Chepa River (PCR)	61
5.1	Land Use at Kota Bharu District	74
5.2	Sub-District areas that cover up by Pengkalan Chepa River (PCR)	75
5.3	Land Use at Bachok District	77
5.4	Percentage of land use in Bachok District	78
5.5	Percentage of type of agricultural activities in Bachok	79

LIST OF PLATES

Plate		Page
3.1	Show on how to take the reading of BOD by using YSI 5000 Dissolved Oxygen Meter.	35
3.2	Show the steps on how to take the reading of COD using DRB 200 and HACH DR/890 Colorimeter	36
3.3	Show the steps on how to take the reading of NH_3-N using Salicylate method.	38
3.4	Show the steps on how to take the reading of TSS using Photometric Method.	40

LIST OF ABBREVIATIONS AND SYMBOLS

NH_3-N	Ammoniacal Nitrogen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
^oC	degree Celcius
Df	degree of freedom
DOE	Department of Environment
DO	Dissolve Oxygen
DRB	Digital Reactor Block
EQA	Environmental Quality Act
EQR	Environmental Quality Report
GPS	Global Positioning System
IADA	Integrated Agricultural Development Area
INWQS	Interim National Water Quality Standards
Kg.	*Kampung*
mg/L	milligrams per Litre
MPS	Multi Probe System
Ppt	parts per thousand
PCR	Pengkalan Chepa River
SD	Standard Deviation
SPSS	Statistical Package for Social Science
Sg.	*Sungai*
TSS	Total Suspended Solids
UNESCO	United National Educational, Scientific and Cultural Organization
USEPA	United States Environmental Protection Agency
WQI	Water Quality Index

PERBANDINGAN STATUS KUALITI AIR ANTARA DUA JENIS SUNGAI: KAJIAN KES KE ATAS SUNGAI SUNGAI KEMASIN DAN PENGKALAN CHEPA

ABSTRAK

Kualiti air merujuk kepada status fizikal, kimia dan biologi sesuatu badan air. Kualiti air Sungai Kemasin (KR) dipengaruhi oleh aktiviti pertanian yang aktif manakala Sungai Pengkalan Chepa (PCR) dipengaruhi oleh pembangunan bandar dan penempatan penduduk yang sesak beserta kepadatan populasi kerana lokasinya yang terletak di kawasan bandar. Tujuan kajian ini dijalankan adalah untuk menentukan ciri-ciri kualiti air KR dan PCR di samping menentukan perkaitan status parameter kualiti air antara KR dan PCR. Selain itu, kajian ini dijalankan untuk mengklasifikasikan status kualiti air semasa bagi KR dan PCR berdasarkan Indeks Kualiti Air (IKA). Persampelan dijalankan selama sebulan pada Januari 2014. Bagi setiap aktiviti persampelan, pengambilan sampel air sungai dilakukan sebanyak dua kali. Tiga lokasi persampelan sepanjang KR dan PCR telah dipilih sebagai stesen persampelan. Untuk stesen KR lokasi persampelan terdiri daripada Kg. Bangu (Stesen 1), Pengkalan Cina (Stesen 2) dan Pengkalan Petah (Stesen 3). Stesen PCR lokasi persampelan terdiri daripada Sg. Keladi (Stesen 1), Kg. Baung (Stesen 2) dan Kg. Pulau Panjang (Stesen 3). Enam parameter kualiti air: Oksigen Terlarut (DO), Permintaan Oksigen Biokimia (BOD), Permintaan Oksigen Kimia (COD), Ammonia Nitrogen (NH_3-N), Jumlah Pepejal Terampai (TTS) dan pH dianalisis secara *in-situ* dan *ex-situ*. Analisis statistik *independent t-test* menunjukkan terdapat perbezaan yang signifikan BOD, NH_3-N, TSS dan pH antara KR dan PCR. Keputusan bacaan kualiti air menunjukkan bahawa kebanyakan parameter kualiti air tinggi di PCR berbanding KR. IKA semasa untuk KR (65.48) menunjukkan bacaan yang baik berbanding PCR (44.71). IKA untuk KR dikategorikan dalam kelas III manakala untuk PCR dikategorikan dalam kelas IV yang dianggap sedikit tercemar. Status kualiti air KR terjejas disebabkan oleh aktiviti pertanian yang aktif dan berterusan sepanjang tahun manakala PCR tercemar disebabkan terdapat aktiviti gunatanah daripada pembangunan bandar dan kawasan perindustrian. Kesimpulannya, kualiti air KR dan PCR perlu dipantau secara meluas oleh pihak berkuasa dan kawalan pencemaran serta pengurusan sungai yang berkesan perlu dilaksanakan dengan kerjasama orang awam dan pihak berkuasa tempatan.

COMPARISON OF WATER QUALITY STATUS BETWEEN TWO DIFFERENT TYPES OF RIVER:
A CASE STUDY OF KEMASIN RIVER AND PENGKALAN CHEPA RIVER

ABSTRACT

Water quality refers to the physical, chemical and biological status of the water body. Water quality Kemasin River (KR) affected by active agricultural activities while the Pengkalan Chepa River (PCR) is influenced by urban development and accommodation of crowded with heavy population since it is situated in the urban area. The aim of this study was to determine the characteristics of water quality of KR and PCR as well as to determine the relationship status of water quality parameters between KR and PCR. In addition, this study was to classify current status water quality for KR and PCR based on the Water Quality Index (WQI). Sampling was carried out for a month on January 2014. For each sampling activities, water sample collections were done twice. Three sampling locations along the KR and PCR were selected as sampling stations. For KR sampling station consists of Kg.Bangu (Station 1), Pengkalan Cina (Station 2) and Pengkalan Petah (Station 3). For PCR the sampling stations consists of Sg.Keladi (Station 1), Kg. Baung (Station 2) and Kg.Pulau Panjang (Station 3). Six water quality parameters: Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia Nitrogen (NH_3-N), Total Suspended Solids (TTS) and pH were analyzed based on in-situ and ex-situ analysis. Statistical analysis of independent t -test indicated that there were significant differences of BOD, NH_3-N, TSS and pH between KR and PCR. The results of water quality indicated that most of the water quality parameters higher at PCR compared to KR. Currently WQI status for KR (65.48) was found better than the PCR (44.71). WQI of KR was categories under class III while PCR was categories under class IV that considered slightly polluted. The water quality status of KR was affected due to active agricultural activities throughout the year and for PCR was polluted due to land use activities from urban and industrial areas. In a conclusion, the water quality of KR and PCR should be monitored extensively by the authorities and pollution control and effective management of the river should be implemented with the cooperation of the public and local authorities.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Through the ages, rivers are the most important freshwater resources for human. Rivers are sources of natural water which serving as a source of drinking water, irrigation and fishing. Generally rivers are importance for geology, biology, history and culture. About 0.0001% of the total amount of water in the world represent as rivers. Rivers are important as vital carriers of water and nutrients to areas all around the earth. Rivers not only provide a habitat, nourishment and means of transport to most organisms but also important source of valuable deposits of sand, gravels and even electrical energy (Anhwange *et al.*, 2012). The availability and distribution of freshwater contained in riverine systems will affects the social, economic and political development (World Health Organization (WHO), 1996).

Issue on the water pollution is one of the most widespread environmental issues in 21st century. Decision makers in developed countries have been aware on this issues and an industrial and water policy already implemented their legislation. So, before the effluents being discharged, it will be treated or recycle in industrial or agricultural industries (Perrin *et al.*, 2013).

Many rivers all over the world including in Malaysia are identified and classified as pollute every year. According to Department of Environment (DOE) of Malaysia, (2011 and 2012), nine rivers within the Klang River Basin under River of Life Project were added to the national river water quality monitoring programme, making the total numbers of rivers monitored to be 473 in year 2012 compared to 2011 which are 464 rivers monitored. The river water quality was assessed based on a total of 5,083 samples taken from 473 rivers, at 832 manual water quality monitoring stations (MWQM) and 10 continuous water quality monitoring stations (CWQM) for the purpose of early detection of pollution influx.

Based on Figure 1.1, out of 473 rivers monitored, 278 (59%) were found to be clean, 161 (34%) slightly polluted and 34 (7%) polluted. Compared to 2011, 275 (59.3%) were found to be clean, 150 (32.3%) slightly polluted and 39 (8.4%) polluted. The river water quality had shown slight improvement in 2012. Out of 473, 36 rivers were found to have gained better water quality. Eleven rivers had showed improved water quality from polluted to slightly polluted, and 25 rivers had improved from slightly polluted to clean status as compared to the year 2011.

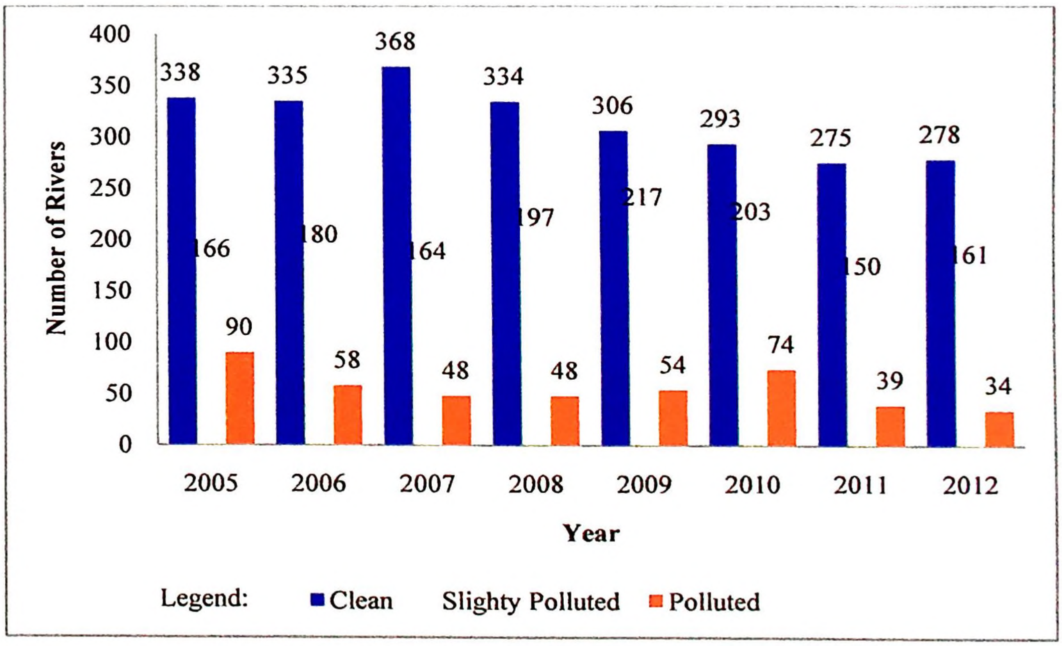

Figure 1.1 Malaysia: River Water Quality Trend (2005 - 2012)
(Source: DOE, 2012)

Rivers are most vulnerable to pollution since they provide an easy passage for the discharge of varying domestic, commercial, industrial and agricultural effluents through their natural function as drainage channels for flood mitigation. For the last three decades, Malaysia has developed very rapidly with urbanisation increasing many folds in all major cities and towns. Besides that, agricultural expansion and industrialisation have rapidly changed the land use from forest and food crops to one of estates, urban, industrial and commercial centres. All these developments have overstressed the river systems (Chan *et al.,* 2003).

Rapid development has produced great amounts of human wastes as well as wastes from all anthropogenic activities such as agriculture, industrial, commercial and transportation wastes which cause the exacerbation of the occurrence of low flows. As a result, many rivers are polluted, some extent of being not rehabilitate (Chan *et al.,* 2003). Besides that, nitrogen and phosphorus produced by human activities has increased the nutrient concentrations in lakes and rivers worldwide. The abundance and composition of consumers are changing and contributed to decline in dissolved oxygen due to increasing of production of aquatic plants (Gray *et al.,* 2006). In many cases, eutrophication occurred in rivers and lakes as result of receiving elevated input of nutrients (Fianko *et al.,* 2009).

River pollution that caused by anthropogenic activities leads to diverse negative consequences. There are numerous studies conducted by scientists in Malaysia to investigate effects of severe pollution to the rivers. The main reason is poor maintenance and management of aquatic ecosystems. Most of the forests area are cut for the construction of houses, shopping malls, factories and other facilities regarding urban development will affect the whole parts of the river basin. Construction and agricultural areas also produced a lot of mud when causing the river banks covered with thick deposit layer of mud. The presence of the mud will lead to less oxygen for fish's life. Besides that, habitat for the invertebrates will also be destroyed therefore the population of the species (especially species that are sensitive to pollutants) might be extinct (Haliza and Rohasliney, 2010).

Water quality refers to the physical, chemical and biological status of the water body. Factors such as existence, quantity, diversity and distribution of aquatic species in waters surface depend on physical and chemical effects namely temperature, pH, suspended solids, nutrients, chemicals and in-stream and riparian habitats. The composition of water affected by natural causes and human activities can be determined by the water quality (Vladimir and Harvey, 1994). In Malaysia, the Water Quality Index (WQI) was used as a guideline for assessment of a watercourse according to pollution load categorization and designation of classes of beneficial uses as stated in the National Water Quality Standards for Malaysia (NWQS). There are six water parameters measured as a standard to determine the river water quality using WQI which are Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3- N), Total Suspended Solids (TSS) and pH (DOE, 2012).

1.2 PROBLEM STATEMENTS

Malaysia today, as in many other developing countries, is facing a lot of environmental issues regarding water pollution. The state of rivers is worsen and have been literally turned into open sewers in many urban areas, some to the extent of being non rehabilitate (Chan *et al.*, 2003). The main causes of river pollution are due to flow through urban areas as they are subjected to heavy solid and liquid waste disposal from squatter settlements, drainage effluents from commercial area, food centres and wet markets, residual hydrocarbon from urban traffic and workshops and excessive silt loads from land clearings (Keizrul, 2002).

Water quality monitoring in Kelantan are implemented at 52 water quality monitoring stations in five river basins. In 2012, mostly all rivers were categories as clean river and slightly polluted river but only Pengkalan Chepa River (PCR) was categorize as polluted river (DOE, 2012). For PCR, it was found that the parameter of the main pollutants causing the deterioration of water quality is ammoniacal nitrogen (NH_3-N) (Kelantan Department of Environment (DOE), 2006)

PCR is affected by urban development and accommodates crowded and heavy population due to its location in the urban area. Improper managed construction sites and eroding stream banks due to increasing infrastructures development caused serious high sediments run-off. Sewage treatment as well as major industries including textiles and food manufacturing factories which are located near the river bank contributes to the causes of PCR pollution. River pollutants are also contributed from garages and workshops. Domestic drainage and land run-off along PCR also contributed to the non-point pollution. Besides that, the streams in the PCR are used for rubbish dumping sites in some places. Furthermore, excessive nutrients from livestock, pet wastes and faulty septic systems along the river are also the main pollutant that polluted the river (Rohasliney, 2011).

Active agricultural reported also can make a change on index water quality of river. Kemasin River (KR) in Bachok District was active with paddy and farm productivity area. Integrated Agricultural Development Area (IADA) was established by Ministry of Agricultural and Agro- Based Industry Malaysia in Kota Bharu. The purpose was to accelerate the development of rural infrastructure by providing drainage and irrigation facilities which to increase the production of agricultural (Official Portal Ministry of Agricultural and Agro-Based Industry Malaysia, 2013). KR is a river that involves with project from IADA. The developments of IADA changes this area active with agricultural activities hence leave affect to KR with pollutants from chemical, pesticides especially during paddy farming.

According to Maria *et al.* (2011), pesticides such as fenitrothion and dimethoate that used for paddy farming are toxic and may effects the water surface and environmental quality. The present of agrochemicals from agricultural fields or orchard in surface water was determined by surface and subsurface runoff. There are many studies prove that rice pesticides was the main origin of nonpoint-source pollution of surface water which mostly in Europe and Japan.

Active industrial and agricultural activities produced great amounts of pollution which can effects WQI (Hafizan *et al.,* 2011). KR also received pollution from urban areas of Jelawat which produced a great amount of non-point sources of pollution such as commercial activies. Therefore, the purposes of this study are to determine the water quality of KR and PCR. At the same time, this study would compare the level of pollution which come from point sources and non-point sources of pollution between

KR and PCR. It is important to study the level of pollution in the river and determine the causes of pollution in order to recommend suitable solutions to the problem. Government and non-government organization are requires to provide better management and more effective conservation programmes to cope with rising demands, pollution and climate change impact. This can be achieved by frequently monitoring the water quality of the river by referring the NWQS. Early detection of the river pollution can be performed by measuring the six important parameters which are Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Ammoniacal Nitrogen, Suspended Solids and pH.

1.3 OBJECTIVES

1.3.1 GENERAL OBJECTIVE

The main purpose of this research is to determine the characteristics of water quality of Kemasin River (KR) and Pengkalan Chepa River (PCR) based on six common parameters in order to classify the river through field (in-situ) and laboratory experiments (ex-situ).

1.3.2 SPECIFIC OBJECTIVES

i. To find the relationship of water quality parameters between KR and PCR.
ii. To find the relationship between water quality parameters status and sources of water pollution.
iii. To classify the current status of water quality of KR and PCR accordingly to the Water Quality Index (WQI).

1.4 HYPOTHESIS

Alternate hypothesis (H_A) :

There is a difference of water quality status between Pengkalan Chepa River (PCR) and Kemasin River (KR).

Null hypothesis (H_O):

There is no difference of water quality status between Pengkalan Chepa River (PCR) and Kemasin River (KR).

1.5 SIGNIFICANCE OF STUDY

Based on this study, there are few advantages that will covers to give benefits for environment's future. The current condition of water quality of KR and PCR can be monitored in order to fully utilize for future planning of the river efficiently. It is important to identify the sources of river pollution either from point sources or non-point sources. This can help the authorities to monitor activities along the river affected more frequently to ensure that the level of pollution can be overcome. In addition, the health effect of residents nearby of KR and PCR can be classifying based on water quality parameters status. The findings will be useful for future research in order to identify the impact on the health of residents nearby as a result of water pollution in a more detailed and comprehensive.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Water provides immense importance in geology, biology and culture. The water services in urban area mostly provided by a centralized system. However, majority of this centralized system in developing countries are unable to cope with rapid growth in population, industries ageing and deterioration of infrastructure and also inability to recover the actual cost of managing the systems. These failures lead to great pressure on limitation of water resources that available and affect some residents especially urban poor because of no access to basic safe water. Poor water quality will affect the users suffering from debilitating effects of water-borne disease such as cholera, diarrhea, and gastroenteritis (Kuyeli *et al.*, 2009).

According to Liu *et al.* (2003), Bohai Bay in China has experienced quick economic development and urbanization and has become one of China's political, economic and cultural centers. The rapid development and corresponding human activities have had severe influences on the water environment. Their investigations showed that a large part of the coastal waters of Bohai Bay have been polluted with concentrations of pollutants exceeding their standards. The pollution has deteriorated the ecology and reduced biodiversity of the waters.

For the agricultural activities, agrochemicals such as pesticides and fertilizers are used throughout the world to increase crop production. Both substances are contaminants in aquatic environments whether well-regulated or not. The widespread use of pesticides on farmland often leads to their presence in freshwaters and marine coastal environments. The transport of pesticides from treated soils to water bodies is a result of two dominant mechanisms which are waterborne runoff, and direct deposition from the atmosphere. The former is probably the most significant for chemicals such as s-triazine herbicides that have high water solubility and low vapour pressure (Okamura *et al.*, 2002).

2.2 RIVER POLLUTION ISSUES IN MALAYSIA

Water pollution can be defined as the condition of water bodies that contain various elements in it. Measuring and studying the elements contained in the water allows the water to be identified as pure water, clean and contaminated (Nayan *et al.,* 2012). A river is said to be polluted when pollutants affect the quality of the water involved. Any form of environmental changes caused by human action that ultimately produce negative effects are define as contamination (Hodges, 1973).

The study of surface water pollution of the river is important due to effluent from municipal sewage, livestock wastewater, industries, agricultural activities, and urban runoff which discharge into the river resulting in extensive variations in the water quality. Generally, most of land use and anthropogenic activities pose a grievous threat not only to aquatic ecosystem in the river but also the provinces in which river water is used as domestic supply (Fawaz *et al.*, 2013).

Historically, water pollution scenario in Malaysia has started with the beginning of agriculture in Malaysia in early 1970's (Jamaluddin, 2000). These impacts influence not only to the water flow rate through the system but also its routine and quality (Oksel *et al.*, 2009).

There was a study on the impacts of integrated farming towards Langgas River water quality in Sabah. The study area was located at district of Kunak. From economic point of view, generally Kunak is a rich agricultural district. The major crops cultivated in the area are oil palm and cocoa. Based on the studied, phosphorous and ammonia-nitrogen showed a high value due to heavy usage of fertilizer. The increased applications of fertilizers, pesticides and grazing intensities, have undoubtedly led to significant potential of river pollution (Oksel *et al.*, 2009).

River pollution also occurred at Semenyih River, which is one of the rivers in Malaysia where human activities associated with urbanization, industrialization, agricultural, and mining activities are extremely main sources of pollution. Moreover, the range of deterioration in water quality in the river varied depending on the percentage of change in land use. Therefore, the land use activities in the basin must be carefully planned and controlled on account of protecting the water resource and quality status (Fawaz *et al.*, 2013).

Langat Basin also polluted with much development such as federal government administrative capital of Putrajaya, the multimedia super corridor (MSC) and Cyberjaya. The rivers of Langat Basin not only have a significant role in the ecology of the basin, but also contribute substantially to potable, industrial and agricultural water uses in the Basin threaten the quality of its river. Langat Basin rivers was found polluted by organic and inorganic matter. Manufacturing industries, sewage treatment plants, livestock and swine farms, urban area, agricultural land and solid waste dumpsites contributed to river water quality degradation in the Langat Basin. Any deterioration of the quality of its river water adversely affect the ability of the rivers to provide vital ecosystem services and support of healthy aquatic life necessary to the health of the Basin's ecosystem (Yusof *et al.*, 2002).

2.3 RIVER CLASSIFICATION IN MALAYSIA

The assessment of river water quality and the classification of river into the number of classes in Malaysia are based on the Interim National Water Quality Standard (INWQS) that adopted by DOE. WQI is a reference to match these classes with their beneficial uses (Department of Drainage and Irrigation, 2000)

Based on WQI, the assessment of watercourse in relation to pollution load categorization and designation of classes of beneficial can be conducted which as specified in the INWQS. The WQI takes into consideration parameters including DO, BOD, COD, NH_3-N, TSS and pH (DOE, 2012).

River classification was important to identify the physical, chemical and microbiology of the river. River needs to be classified so that the source of water was clean and appropriate for human used. The suitability of river are classify according to Table 2.1. Once the class of river is known, it can be determine on how the suitable uses of river water. It is summarised that WQI in range of 81 until 100 is categories as clean river, range of 60 until 80 in slightly polluted and polluted river in WQI range of 0 until 59 (DOE, 2012).

Table 2.1: Water classes and uses

CLASS	USES
Class I	Conservation of natural environment. Water Supply I- Practically no treatment necessary. Fishery I- Very sensitive aquatic species.
Class IIA	Water Supply II- Conventional treatment required. Fishery II- Sensitive aquatic species.
Class IIB	Recreational use with 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: DOE, 2012)

Every year, the assessments of river water quality are based on WQI and INWQS. The WQI of the river is according the DOE water quality index classification whereas the WQI formula and calculation was based on DOE's standard (Table 2.2).

Table 2.2: DOE water quality index classification

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
Biochemical Oxygen Demand	mg/l	< 1	1-3	3-6	6-12	>12
Chemical Oxygen Demand	mg/l	< 10	10-25	25-50	50-100	>100
Dissolve Oxygen	mg/l	> 7	5-7	3-5	1-3	<1
pH	-	> 7.0	6.0-7.0	5.0-6.0	<5.0	>5.0
Total Suspended Solid	mg/l	< 25	25-50	50-150	150-300	>300
Water Quality Index (WQI)		> 92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

(Source: DOE, 2012)

2.4 WATER QUALITY PARAMETERS

Major parameters of water pollution in Malaysia mostly are from domestic waste, industrial effluents, land clearance with suspended solids as the major contributing up to 42% to poorly planned land development, 30% from biological oxygen demand (BOD) due to industrial waste and 28% from ammoniacal nitrogen (NH_3-N) which attributed by domestic sewage disposal and animal farming activities (Hafizan *et al.*, 2011). A mathematical instrument used to transform physico-chemical water characterization data into a single number, which represents the water quality level called WQI (Zali *et al.*, 2011).

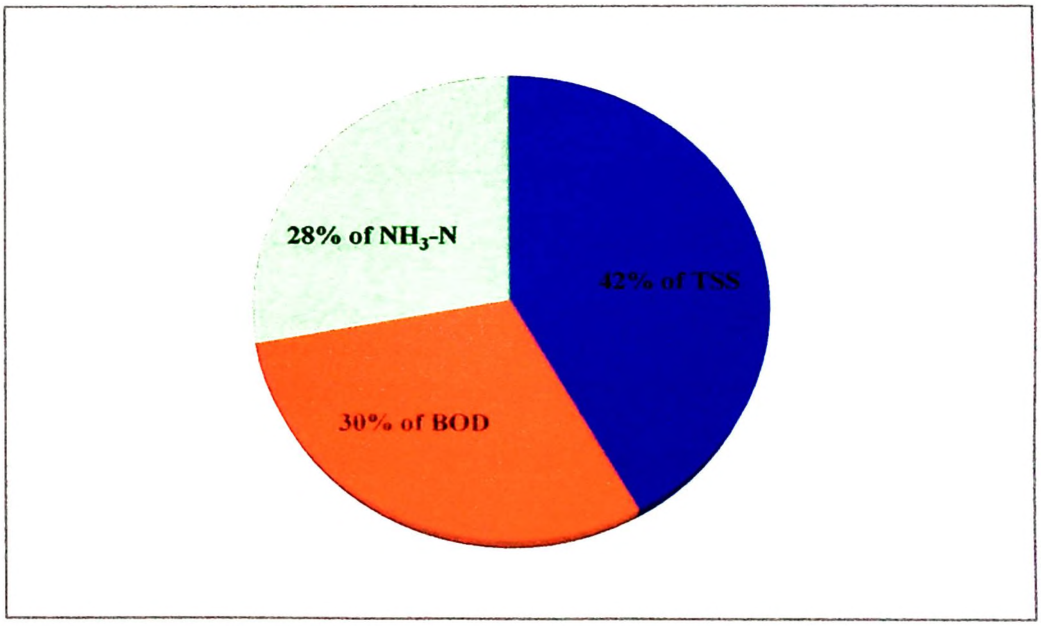

Figure 2.1: Major parameters of water pollution in Malaysia
(Adopted from Hafizan *et al.*, 2011)

WQI is the basis for environment assessment of a watercourse in relation to pollution load categorization and designation of classes of beneficial uses as provided for under the INWQS for Malaysia. WQI were used by DOE of Malaysia to evaluate the status of the river water quality. Pollution status was estimated using WQI range and water quality classes were evaluated using values of six water quality parameter which are NH_3-N, BOD, COD, DO, pH and TSS for WQI (Zali *et al.,* 2011).

2.4.1 AMMONIACAL NITROGEN (NH_3-N)

Ammonical nitrogen indicates nutrients status, organic enrichment and health of the water body (Radojevic *et al.,* 2007). Nutrients such as phosphorus and nitrogen are essential for the growth of algae and other plants. Excessive concentration of nutrients can over stimulate aquatic plant and algae growth and enhance the process of eutrophication which can lead to an abundant supply of vegetation and causes low dissolve oxygen (Addy and Green, 1997; Kramer, 1987).

According to Department of Statistics (2012), the percentage of clean river basins water free from NH_3-N increased to 29.3% in 2011 as compared to 24.5% in 2010. In directly, it cause the decreased of percentage of slightly polluted river basins (45.7%) and polluted river basins (25.0%) in 2011 (Figure 2.2). Commonly, NH_3-N exists inside surface water and groundwater and is formed from microbiology activity. Excess of ammonia levels may harm aquatic life by accumulate in the organism and cause alteration of metabolism as well as increases in body pH.

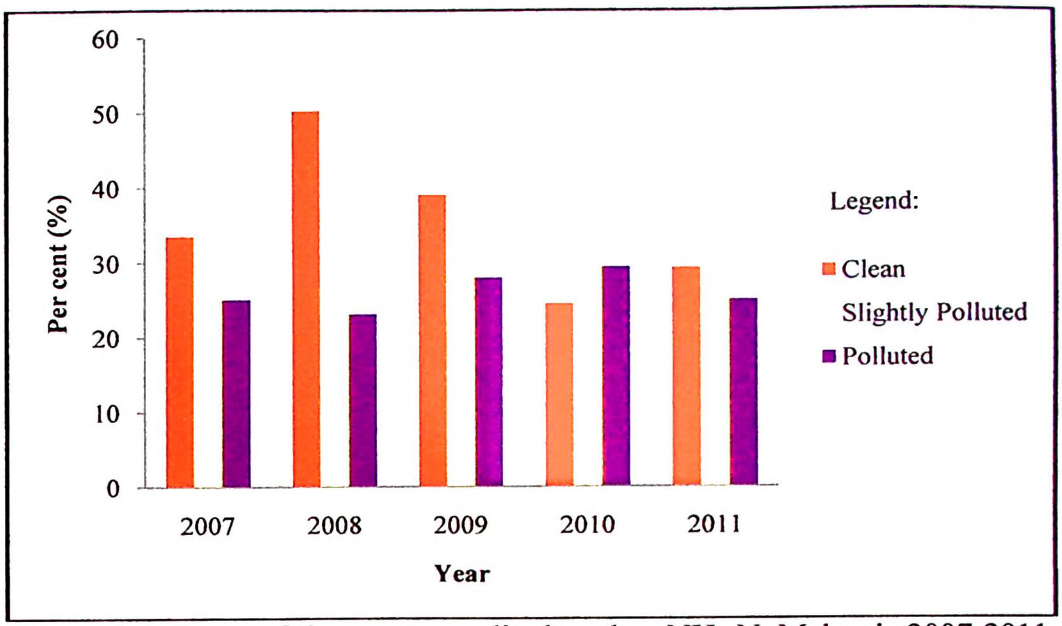

Figure 2.2: Status of river water quality based on NH_3-N, Malaysia 2007-2011
(Source: Department of Statistics, 2012)

2.4.2 BIOCHEMICAL OXYGEN DEMAND (BOD)

Biochemical Oxygen Demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions (Perry and Vanderklien, 1997).

According to the Department of Statistics (2012), the percentage of clean river basins water free from BOD_5 decreased to 2.2% in 2011 as compared to 8.4% in 2010. It is means, the number of slightly polluted basins increased by 1.9% to 57.1%. The polluted river basins also increased 4.3% to 40.7% during the same period (Figure 2.3). The increasing of BOD_5 in river basins mostly due to untreated or partially treated sewage discharge from agro-based and manufacturing industries. High BOD is an indication of poor water quality.

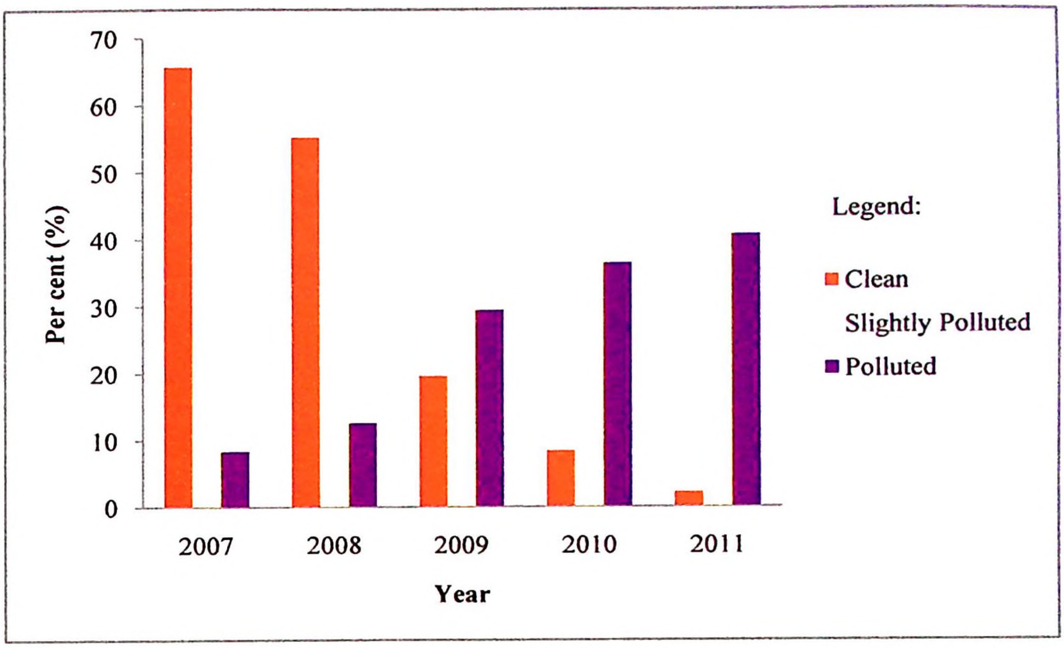

Figure 2.3: Status of river water quality based on BOD_5 pollutant, Malaysia, 2007–2011
(Source: Department of Statistics, 2012)

2.4.3 CHEMICAL OXYGEN DEMAND (COD)

Chemical oxygen demand (COD) is defined as the amount of oxygen used to oxidize chemical substances through chemical processes. COD is used as one of the main indicator of organic pollution. There are many factors that caused the increasing amount of COD such as the inflow of domestic, livestock and industrial waste that contain elevated levels of organic pollutants (Ayati, 2003). Deterioration of water quality caused by the discharge of industrial effluent can be determined by COD value (Mamais *et al.,* 1993).

BOD appears to be the most fundamental element that affects the value of COD. COD and BOD process is dependant to each other as chemical reaction and oxidization process occur when microorganisms break down organic matter into more stable.

Therefore, more oxygen are consumed when the growth of microorganisms rises leading to low DO together with and an increased in BOD (Anita, 2012). COD is the total quantity of oxygen used to oxidize all organic material into carbon dioxide and water. Therefore, COD values are always greater than BOD values (Vaishali and Punita, 2013).

2.4.4 DISSOLVED OXYGEN (DO)

Dissolved oxygen is the amount of oxygen dissolved or carried in the water (Francis-Floyd, 1993). Organisms take in oxygen and release carbon dioxide while consuming food molecules to obtain energy for growth and maintenance during respiration (Caduto, 1990). DO is very important in assessing water quality and it also reflects the physical and biological processes occurring in the water (Trivedi and Goel, 1984).

Salinity, altitude, groundwater inflow and water temperature are part of the factors that affect amount of oxygen dissolved in a water body. Salinity is defined as the amount of salt in the water. Generally, salinity is not a concern in most freshwater lakes but it can produce high impact to oxygen solubility in estuaries, brackish waters, bogs and water bodies in agricultural areas (Campbell and Wildberger, 1992)

The oxygen depletion often occurs during time of high community respiration and decomposition of organic matter. Thus, the DO content of water has been greatly used as a parameter to assess the water quality and to monitor the level of freshness of a river (Fakayode, 2005). A lot of DO would be rapidly consumed in the biological aerobic decay when the water is polluted with the large amount of organic matter which would affect the water quality. The decreased of DO in the water would affect the aquatic lifes (Chhatwal, 2011).

2.4.5 pH

A pH indicates the contamination and acidification in a natural water system (Palaniappan *et al.,* 2010). Generally, pH value is influenced by carbon dioxide - bicarbonate equilibrium system in natural waters (Lalparmawii and Mishra, 2012). By forming carbonic acid in water the dissolved carbon dioxide affected the pH value (Hem, 1985). The pH of water is very important parameters because all chemical and biochemical reactions are affected by pH. For example, the change of pH from slightly acidic to slightly alkaline condition can affect any chemical or biological reactions in the water. Therefore, the range of pH of water is important for the biotic communities (George, 1997).

Aquatic organisms are influenced by pH since most of their metabolic activities are depend on pH. pH value is very essential in monitoring the water quality and the extent pollution is watershed areas (Kumar *et al.*, 2011).

Since pH of water body influence other chemical reactions such as solubility and metal toxicity, therefore it is very important in determination of water quality. (Fakayode, 2005).

2.4.6 TOTAL SUSPENDED SOLIDS (TSS)

Suspended solid is the suspended or dissolved matter in water or wastewater. Suspended solids are the residue in a well mixed sample of water which will not pass a standard filter. Natural weathering and decomposition of rocks, solid and dead plant materials and the transport or dissolution of weathered product in water contributes a natural background of suspended and dissolved materials to natural waters (Johnson *et al.*, 2009).

Based on Figure 2.4, the percentage of clean river basins for 2011 increased 8.8% to 56.4% as compared to 47.6% in 2010. The percentage of slightly polluted and polluted river basins showed a decline from 18.8% to 18.6% and 33.6% to 25.0% in 2011, respectively. Effect of soil erosion and sedimentation from the development in highlands and clearance of land for logging and mining will contribute to suspended solids. These activities caused increasing amount of Total Suspended Solids and affects water quality in the river basins (Department of Statistics, 2012).

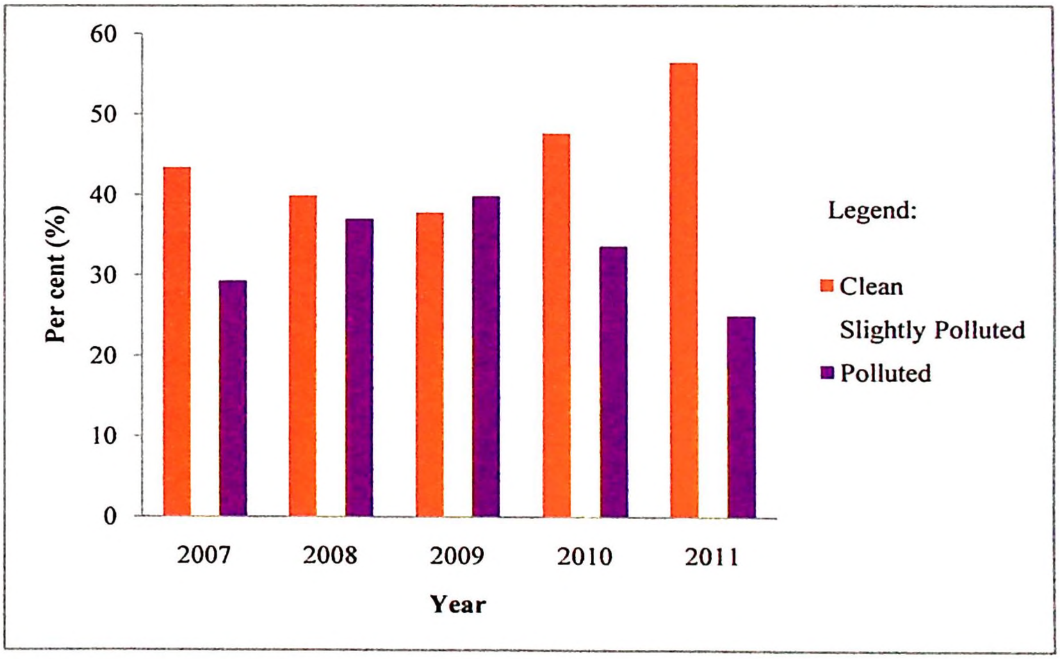

Figure 2.4: Status of river water quality based on SS pollutant, Malaysia, 2007–2011 (Source: Department of Statistics, 2012)

2.4.7 TEMPERATURE

The water temperature is a measure of the heat content of the water mass and influences the growth rate and survivability of aquatic life. Different species of fish have different needs for an optimum temperature and tolerances of extreme temperatures. Many of the physical, biological, and chemical characteristics of a river are directly affected by temperature. Most waterborne animal and plant life survives within a certain range of water temperatures, and few of them can tolerate extreme changes in temperature (Department of Drainage and Irrigation, 2009). According to Environmental Quality Act 1974, temperature limit of effluent into the river is $40^{o}C$ (Law of Malaysia, 2011). It is means, temperature more than $40^{o}C$ will affect the aquatic life in the river.

CHAPTER 3

METHODOLOGY

Figure 3.1 shows conceptual framework of methodology in this study. Kemasin River (KR) and Pengkalan Chepa River (PCR) were chosen as selected sampling location.

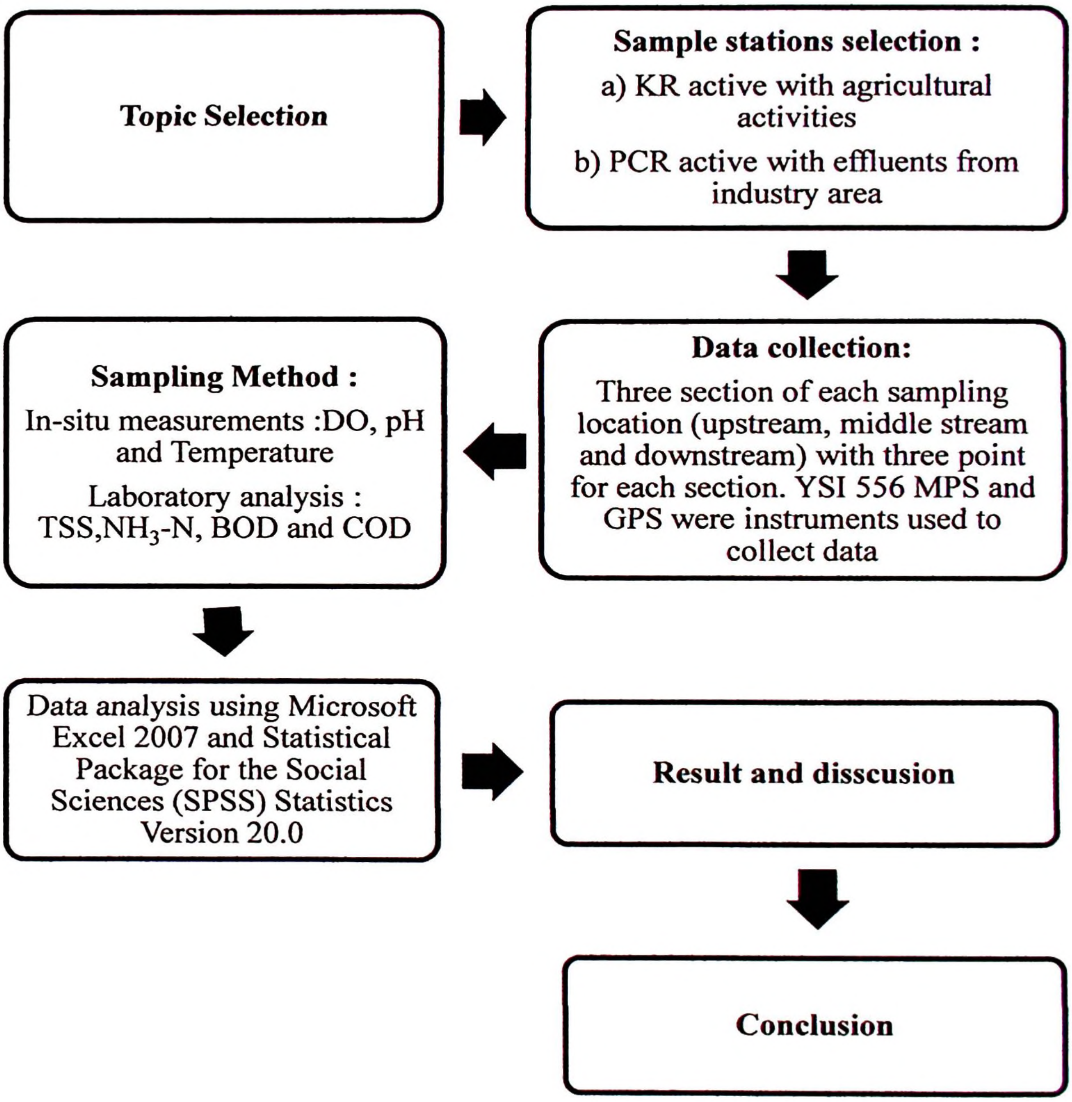

Figure 3.1: Conceptual Framework of Methodology

3.1 SAMPLE STATIONS SELECTION (SITE DESCRIPTION)

Water quality study was conducted at Pengkalan Chepa River (PCR) and Kemasin River (KR) (Figure 3.2). PCR is located in the urban area of Kota Bharu District, Kelantan State, while KR is located in the Bachok District, Kelantan State which is 30 kilometres from the river mouth. PCR is formed by the junction of Kelantan River and PCR, 15 kilometres from the river mouth.

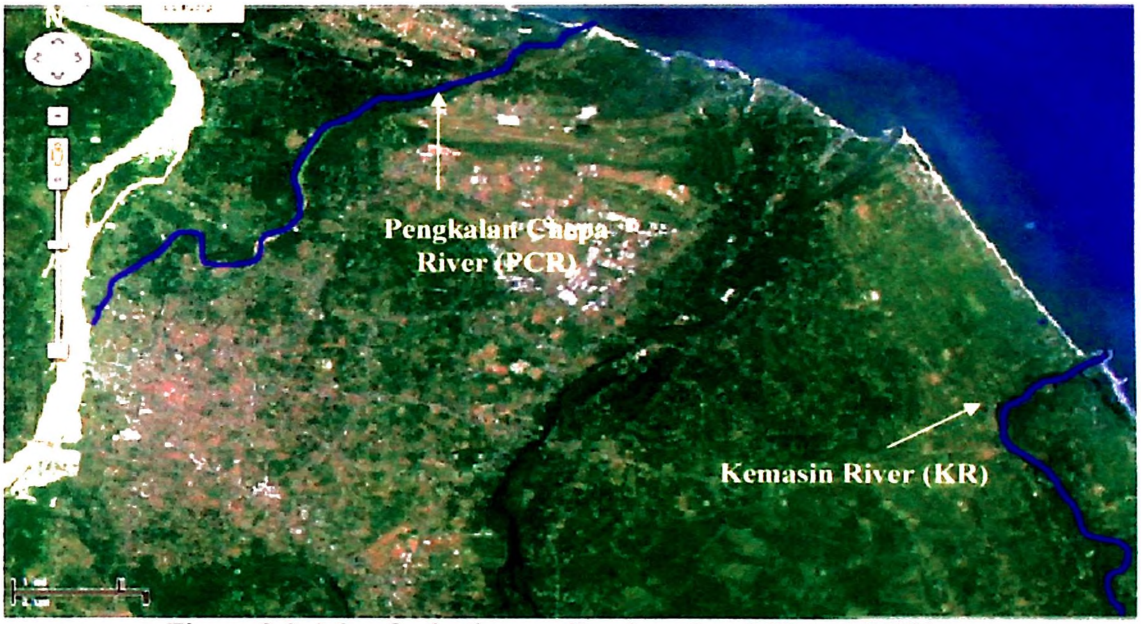

Figure 3.2: Map for both sampling location (KR and PCR)
(Adopted from Google Earth, 2014)

PCR was chosen because of the active industrial activity area where there are location of textiles, manufacturing factories, effluent from industries and wet market located near PCR. KR was chosen because the area was active with paddy agriculture activity, tobacco and farm productivity area. Moreover, Integrated Agricultural Development Area (IADA) was established by Ministry of Agriculture and Agro-Based Industry Malaysia to accelerate the development of rural infrastructure which helps increasing of agriculture's production in KR's area.

Sampling was conducted at three selected sections of PCR and KR based on stations of Department of Irrigation and Drainage Malaysia. The sections of the river were located at the upstream, middle and downstream of the river. For PCR, a station for upstream section located at Kampung Sungai Keladi. A station at Kampung Baung was chosen as the middle section and one station at Kampung Pulau Panjang as the downstream section of the river (Figure 3.3). Three sampling point were chosen at one section makes the total of sampling point for each river was nine points (Figure 3.4, 3.5, 3.6).

For KR a station for upstream section located at Kg. Bangu. A station at Pengkalan Cina, Kampung Keluat was chosen as the middle section and one section at Pengkalan Petah, Bachok as the downstream section of river (Figure 3.7). Three sampling point were chosen at one section makes the total of sampling point for each river was nine points (Figure 3.8, 3.9, 3.10).

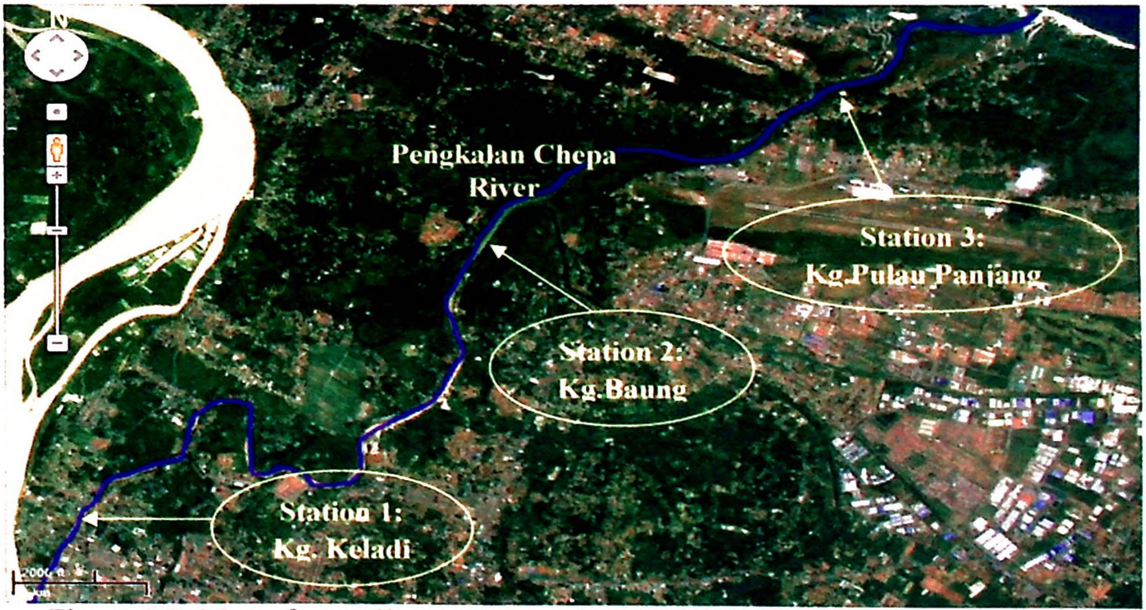

Figure 3.3: Map of overall sampling stations at Pengkalan Chepa River (PCR) (Adopted from Google Earth, 2014)