UNIVERSITI PUTRA MALAYSIA

ENVIRONMETRICS AND RECEPTOR MODELLING OF RIVER WATER QUALITY STATUS AT LINGGI RIVER BASIN, MALAYSIA

MUNIRAH BINTI ABDUL ZALI

FPAS 2013 13

ENVIRONMETRICS AND RECEPTOR MODELLING OF RIVER WATER QUALITY STATUS AT LINGGI RIVER BASIN, MALAYSIA

MUNIRAH BINTI ABDUL ZALI

MASTER OF SCIENCE

UNIVERSITI PUTRA MALAYSIA

2013

© COPYRIGHT UPM

ENVIRONMETRICS AND RECEPTOR MODELLING OF RIVER WATER QUALITY STATUS AT LINGGI RIVER BASIN, MALAYSIA

By

MUNIRAH BINTI ABDUL ZALI

© COPYRIGHT UPM

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

December 2013

COPYRIGHT

All material contained within the thesis, including without limitation text, logos, icons, photographs and all other artwork is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia

Copyright © Universiti Putra Malaysia

© COPYRIGHT UPM

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

ENVIRONMETRICS AND RECEPTOR MODELLING OF RIVER WATER QUALITY STATUS AT LINGGI RIVER BASIN, MALAYSIA

By

MUNIRAH BINTI ABDUL ZALI

December 2013

Chairman: Hafizan Bin Juahir, Ph.D

Faculty: Environmental Studies

Intensifying demands on water resource management have produced many outstanding methods in order to protect our valuable nature. Therefore, in order to conserve the river basin, pollution sources must be tracked attentively owing to land-used and water level variations (low, normal and high). Currently the increasing development trends along Linggi River Basin have pose alarming environmental issues especially on the water resources. In fact, great environmental protection must be established for the surface river water due to its important as a source of drinking water purposes in Negeri Sembilan. Foremost water research in multivariate and modelling techniques lead to combination of cluster analysis (CA), discriminant analysis (DA), principal component analysis (PCA) and receptor modelling to investigate the surface water quality at Linggi River Basin (LRB), Malaysia ranging from year 2000 to 2010. Under cluster analysis three regions were acquired such as high pollution status (HPS), moderate pollution status (MPS) and low pollution status (LPS). Based on thirty water quality parameters only fifteen variables were successfully discriminated as significant water quality parameters in the differentiation of regions and water level classification. Spatial assessment of DA revealed significant anthropogenic influences and seasonal changes at the three regions with DO as the most significant parameter; whereas oil waste and contaminated metals exhibits distinctive features during low, normal and high water level. PCA revealed that only nine river pollution sources (water hardness-natural mineral salt, surface runoff, anthropogenic input, raw sewage disposal, chemical changes, industrial activities, agricultural runoff, rubber effluent and domestic waste) were characterized. Despite that distinguishing the contamination in LRB were identified to be contributed by waste oil, traffic runoff and waste water in temporal assessment via PCA. Source apportionment results concluded that anthropogenic input was the major pollution sources at three cluster regions. However based on temporal variation, waste water, fertilizer waste, and soil runoff also show impacts on the river water quality status suggest the hydrological features and runoff from river play a major role in assimilating and carrying the pollutants during tidal changes. Therefore, this study is expected to support the local environmental agencies in managing the river basin based on the comprehensive and reliable informative results as regards to the spatial and temporal dissimilarity as well as definite pollution sources in Linggi River.

© COPYRIGHT UPM

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ENVIRONMETRIK DAN PERMODELAN RESEPTOR BAGI STATUS KUALITI AIR SUNGAI DI LEMBANGAN SUNGAI LINGGI, MALAYSIA

Oleh

MUNIRAH BINTI ABDUL ZALI

Disember 2013

Pengerusi: Hafizan bin Juahir, Ph.D

Fakulti: Pengajian Alam Sekitar

Tuntutan yang hebat ke atas pengurusan sumber air telah menghasilkan banyak kaedah yang cemerlang untuk melindungi alam semula jadi yang berharga. Oleh itu, untuk memelihara lembangan sungai, punca pencemaran mesti dikesan dengan lebih teliti berpunca dari perbezaan penggunaan tanah dan perubahan paras air (rendah, normal dan tinggi). Pada masa ini, aliran pembangunan yang semakin meningkat di sepanjang Lembangan Sungai Linggi telah menimbulkan isu-isu alam sekitar yang membimbangkan terutamanya pada sumber air. Malah, perlindungan alam sekitar perlu diwujudkan untuk permukaan air sungai kerana ia penting sebagai penggunaan sumber air minum di Negeri Sembilan. Keutamaan penyelidikan air dalam teknik multivariat dan permodelan membawa kepada gabungan analisis kelompok (AK), analisis diskriminan (AD), analisis komponen utama (AKU) dan model reseptor untuk menyiasat kualiti air permukaan di Lembangan Sungai Linggi (LSL) di Malaysia daripada tahun 2000 hingga 2010. Di bawah analisis kelompok tiga kawasan telah diperolehi seperti status pencemaran tinggi (SPT), status pencemaran sederhana (SPS) dan status pencemaran rendah (SPR). Berdasarkan tiga puluh parameter kualiti air hanya lima belas pembolehubah yang telah berjaya didiskriminasi sebagai parameter kualiti air yang penting dalam membezakan kawasan dan klasifikasi paras air. Penilaian secara tempat oleh AD mendedahkan pengaruh antropogenik yang penting dan perubahan bermusim di ketiga-tiga kawasan dengan DO sebagai parameter yang paling penting; manakala sisa minyak dan logam tercemar mempamerkan ciri-ciri tersendiri semasa paras air yang rendah, normal dan tinggi. AKU mendedahkan bahawa hanya sembilan punca pencemaran sungai (kekerasan air- garam mineral semulajadi, air larian permukaan, input antropogenik, pembuangan kumbahan mentah, perubahan kimia, aktiviti perindustrian, air larian pertanian, efluen getah dan sisa domestik) telah ditemui. Selain itu, pencemaran yang berbeza di LSL telah dikenalpasti berpunca dari sisa minyak, aliran trafik dan air sisa dalam penilaian tempoh melalui AKU. Keputusan pembahagian sumber menyimpulkan bahawa input antropogenik adalah punca pencemaran utama di tiga kelompok kawasan. Walau bagaimanapun berdasarkan perubahan tempoh, air sisa, sisa baja, dan aliran tanah juga menunjukkan kesan terhadap status kualiti air sungai menunjukkan bahawa ciri-ciri hidrologi dan larian air dari sungai memainkan peranan penting dalam menerapkan dan pembawaan pencemaran semasa perubahan pasang surut. Oleh itu, kajian ini dijangka akan menyokong agensi-agensi alam sekitar tempatan dalam pengurusan lembangan sungai berdasarkan keputusan maklumat yang komprehensif dan boleh dipercayai berhubung perbezaan dalam ruang dan masa serta sumber-sumber pencemaran yang pasti dalam Linggi River.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and Most Merciful.

I would to express millions thanks to my beloved husband for encouraging me to finish my thesis writing in ease and pain. To my supervisor, Dr Hafizan bin Juahir, Thank you for introducing new passion for me in environmental study especially in the art of data analysis. I believe in my capabilities and I want to contribute something to my nation in future. For my endless love parents Abdul Zali bin Baba and Sharipah Din, my siblings and my close friends, Ananthy Retnam, Nurul Afiqah, Nur Hazirah, Norazida Manan and Norliza Ismail, millions gratitude towards all of you for being with me from beginning of semester till we were graduated in Universiti Putra Malaysia. Special appreciation to my colleague at Jabatan Kimia Malaysia, Azlina Md Kassim for keep enlightens me in thesis writing and reviewing my thesis writing. For last, I hope this thesis can be a reference to a person who love our environment and wants to rehabilitee our precious ecosystem for our future generations.

© COPYRIGHT UPM

APPROVAL

I certify that a Thesis Examination Committe has met on (XXXXdate) to conduct the final examination of Munirah Abdul Zali on her thesis title "**ENVIRONMETRICS AND RECEPTOR MODELLING OF WATER QUALITY STATUS AT LINGGI RIVER BASIN, MALAYSIA"** in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Name of Chairperson, Ph.D
Title
Name of Faculty
Universiti Putra Malaysia
(Chaiman)

Name of Examiner 1, Ph.D
Title
Name of Faculty
Universiti Putra Malaysia
(Internal Examiner)

Name of Examiner 2, Ph.D
Title
Name of Faculty
Universiti Putra Malaysia
(Internal Examiner)

Name of External Examiner, Ph.D
Title
Name of Faculty/ Department
Name of Organization
(Internal Examiner)

_____
ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

© COPYRIGHT UPM

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of Supervisory Committee were as follows:

Hafizan Hj. Juahir, Ph.D
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Mohamad Pauzi Zakaria, Ph.D
Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

Hii Yii Siang, Ph.D
Associate Professor
Institute of Oceanography
Universiti Malaysia Terengganu
(Member)

_____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

© COPYRIGHT UPM

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: _____

© COPYRIGHT UPM

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to

Signature: _____
Name of
Chairman of
Supervisory
Committee: _____

Signature:
Name of
Chairman of
Supervisory
Committee: _____

Signature: _____
Name of
Member of
Supervisory
Committee: _____

© COPYRIGHT UPM

TABLE OF CONTENTS

	Page
ABSTRACT	iii
ABSTRAK	iv
ACKNOWLEDGEMENT	v
APPROVAL	vi
DECLARATION	vii
LIST OF TABLE	xiii
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvi
CHAPTER	
1. INTRODUCTION	**1**
1.1 General Introduction	1
1.2 Problem Statement	3
1.3 Significance of the Study	4
1.4 Hypothesis	5
1.5 Objectives of the Study	5
2. LITERATURE REVIEW	**6**
2.1 Water Quality in the Perspectives of the World and in Malaysia	6
2.2 Water Quality at Linggi River Basin	8
2.3 Statistical Evaluation Of River Water Quality Using Environmetrics Techniques And Receptor Modelling	10
2.3.1 The Application of Environmetrics Techniques in Environmental Problems	11
2.3.1.1 Classification of Spatial and Seasonal Variation	11
2.3.1.2 Discrimination of Spatial and Seasonal Variation	13
2.3.1.3 Sources of Variations Identifications	14
2.3.2 Absolute Principal Component Scores (APCS-ANN)	16
3. MATERIALS AND METHOD	**19**
3.1 Study Area	19
3.2 Dataset of Linggi River Basin	21
3.3 Pre-Treatment of Data Set	21

© COPYRIGHT UPM

3.3.1 Arrangement of Dataset 22
3.4 Descriptive Statistic 22
3.5 Correlation Test 23
3.6 Cluster Analysis 24
3.6.1 Spatial Assessment Using Cluster Analysis 24
3.7 Discriminant Analysis 25
3.7.1 Spatial Assessment Using Discriminant Analysis 26
3.7.2 Temporal Assessment Using Discriminant Analysis 26
3.7.3 Verification of Assessment Using Box and Whisker Plots 26
3.8 Principal Component Analysis 26
3.8.1 Spatial Assessment of River Pollution Sources 27
3.8.2 Temporal Assessment of Pollution Sources 27
3.9 Absolute Principal Component Scores- Artificial Neural Network (APCS-ANN) 28
3.9.1 APCS-ANN Model 29
3.9.2 Model Performance Criterion 49
3.9.3 Percentage of Contribution of Pollution Sources 30
3.10 Spatial Assessment Using Absolute Principal Component Scores- Artificial Neural Network (APCS-ANN) 30
3.10.1 Identification of Main Pollution Sources at Linggi River Basin 30
3.10.2 Identification of Type of Pollution Sources at Cluster Regions 31
3.11 Temporal Assessment Using Absolute Principal Component Scores- Artificial Neural Network (APCS-ANN) 31
3.12 Software 31
3.12.1 XLSTAT2011 31
3.12.2 JMP9 33

4. **RESULTS AND DISCUSSION** **34**
4.1 Descriptive Statistic 34
4.2 Correlation Test 35
4.3 Classification of Monitoring Stations: Water Quality Index (WQI) and Land-Used Interactions 41
4.4 Spatial Discrimination of Pollution Regions 45
4.5 Temporal Assessment of River Water Quality 50
4.6 Verification of Spatial And Temporal Assessment Using Box and Whisker Plots 56
4.7 Spatial Assessment of River Pollution Sources Using Principal Component Analysis (PCA) 65
4.8 Temporal Assessment of River Pollution Sources: Is Water Level Attributes? 75
4.9 The Estimation of Potential Source of Pollution 83

© COPYRIGHT UPM

Using Absolute Principal Component Score and Artificial Neural Network
4.9.1 Type Of Pollution Sources At Cluster Regions: A Thorough Viewpoint 88
4.10 Temporal Influences of Source of Pollution Using Absolute Principal Component Scores and Artificial Neural Network 96

5. CONCLUSION AND RECOMMENDATIONS 104
5.1 Conclusions 104
5.2 Recommendations 108

REFERENCES 110

APPENDICES 130

BIODATA OF STUDENT 145

LIST OF PUBLICATION 146

© COPYRIGHT UPM