UNIVERSITI PUTRA MALAYSIA

WATER QUALITY STUDIES IN MALACCA RIVER BASIN USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

MARRYANNA LION

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DEDICATION

To my beloved families, father and mother; Lion Bayuhan and Tineh Tokius, Mr. Dominic Borumbun and Mdm.Lily Gabil, Peter Dominic, Sisters; Esther, Paulina Marny, Marcella Maslainie, Brother; Hillary Mark.

I dedicate this work with great love and appreciation for their kindness, encouragement, and effort.

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By

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

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

A STUDY ON WATER QUALITY VARIATION IN MALACCA RIVER BASIN USING GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

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July 2003

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Faculty: **Science and Environmental Studies**

Malacca Straits is recognized worldwide due to its importance as the busiest waterway in the world. The environmental profile of the Malacca Straits points to certain stresses in the ecosystem due to pollution load. Pollutants from land-based sources are probably the most pressing environmental problem. Wastes from agricultural, industrial, and domestic source discharge directly into the Straits or indirectly via rivers, which flow into the Straits. As far as land based pollution is concerned, study on river basin is important. The Malacca River basin is of the rivers flowing into the Straits of Malacca.

Geographic Information System (GIS) was used to map the water pollution scenario due to its ability to analyze spatial and temporal data. Beside that, correlation coefficient method was used to determine the relationship and variation between rainfall and water quality parameters. Six parameters selected for this study, namely, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen, pH, Suspended Solid (SS), and Dissolved Oxygen (DO). The output of this study consists of water quality database, maps, and graphs on the water quality variations. The important of this study is the application of GIS technology in monitoring water quality. Technology plays an important role for effective environmental management.

Previously, the environmental data that stored manually requires a lot of space. This method is not efficient in handling large amount of data because it is also consume a lot of time to retrieve. The GIS was created as a spatial tool, which make the environmental monitoring easier thus changes in environment are monitored and managed properly. With the advent of GIS system, monitoring of water quality can be done more efficiently. This is because, a database could be used to interpolate and produce different result according to its purposes. The GIS function such as a data storage, query and analysis, and presentation are useful to shows the changes pattern of water quality in Malacca River basin from year to year. Based on the previous

research done in Malaysia and other countries, it was proved that GIS has the ability as a tool in water quality monitoring.

The study in Malacca River basin found that the quality of water is better at the upstream compared with the downstream. This was due to the accumulation of land use activities at the middle stream, which increased the pollution burden of the river. Even though it was expected that there is a relationship between water quality parameters and the amount of water received by this basin but the result shows that there is no strong linear correlation between these variables. The observation also shows that a good correlation value was only found in DO. The other parameters did not show the acceptable level of correlation. If we look at the distribution of each parameter, it was found that SS has the higher distribution compared to the others. Ammoniacal Nitrogen was observed higher at the beginning of the observation however its distribution became more consistent for the rest of the observation period. As an overall, the relationships between these variables are inconsistent.

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

KAJIAN MENGENAI VARIASI KUALITI AIR DI LEMBANGAN SUNGAI MELAKA DENGAN MENGGUNAKAN SISTEM MAKLUMAT GEOGRAFI

Oleh

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Selat Melaka terkenal dengan kepentingannya sebagai laluan air yang paling sibuk di dunia. Profail alam sekitar di Selat Melaka menunjukkan bahawa terdapat desakan ekosistem tertentu yang disebabkan oleh luahan pencemaran. Bahan-bahan pencemar daripada daratan adalah berkemungkinan sebagai pendesak utama kepada masalah alam sekitar. Sisa buangan daripada aktiviti pertanian, industri dan domestik dibuang secara langsung ke dalam perairan atau secara tidak langsung melalui sungai-sungai yang mengalir ke perairan Selat Melaka. Memandangkan ini melibatkan punca pencemaran daratan maka kajian ke atas keadaan pencemaran di lembangan sungai adalah penting. Lembangan Sungai Melaka merupakan salah satu sungai yang mengalir ke Selat Melaka.

mengenalpasti perhubungan di antara variabel –variabel yang terlibat. Untuk tujuan tersebut, enam parameter telah dipilih termasuklah permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD), nitrogen ammonia (AN), pH, bahan terampai (SS), dan oksigen terlarut (DO). Hasil yang dijangkakan daripada kajian ini dipersembahkan dalam pelbagai bentuk termasuklah pengkalan data untuk kualiti air, peta-peta, dan juga graf-graf yang menunjukkan variasi kualiti air sungai. Kepentingan kajian ini adalah dari segi aplikasi teknologi GIS ke atas pemantauan kualiti air sungai kerana teknologi memainkan peranan yang sangat penting terhadap pengurusan alam sekitar yang lebih efektif.

Sebelum ini, kebanyakan data-data alam sekitar disimpan secara manual yang mana memerlukan ruangan yang banyak. Kaedah ini tidak begitu efisien kerana selain daripada memerlukan ruang menyimpan yang banyak, ianya juga memerlukan masa yang panjang untuk mengeluarkan kembali data yang diperlukan untuk tujuan perancangan dan pengurusan. Dengan adanya teknologi GIS ini yang direka khas untuk menguruskan data-data ruangan, maka kerja-kerja perancangan dan pengurusan menjadi lebih mudah dan cepat. Perubahan-perubahan geografi yang terdapat dalam ruangan dapat dikendalikan dengan lebih tepat dan mudah. Dengan adanya sistem GIS ini juga, kerja-kerja pemantauan kualiti air sungai menjadi lebih mudah. Ini kerana satu pengkalan data boleh digunakan untuk menghasilkan keputusan-keputusan yang dikehendaki. Fungsi-fungsi yang terdapat pada perisian GIS seperti penyimpanan data, penganalisisan data, serta persembahan data sangat berguna untuk menunjukkan corak perubahan kualiti air sungai dari setahun ke setahun. Berdasarkan kajian-kajian yang telah dilakukan di Malaysia dan Negara

lain, telah terbukti bahawa GIS sangat berfaedah sebagai alat dalam membantu pemantauan kualiti air sungai.

Kajian di lembangan Sungai Melaka mendapati bahawa kualiti air lebih baik di kawasan hulu berbanding dengan kawasan hilir. Ini adalah disebabkan oleh penumpuan aktiviti guna tanah yang lebih banyak di bahagian tengah lembangan Sungai Melaka. Ini secara tidak langsung telah menambahkan beban pencemaran sungai. Walaupun diramalkan bahawa terdapat perhubungan di antara parameter-parameter yang terlibat dengan jumlah hujan yang diterima tetapi melalui analisis korelasi, didapati bahawa tidak terdapat perhubungan langsung yang kuat di antara kedua-dua variabel ini. Berdasarkan pemerhatian juga, didapati bahawa korelasi yang baik hanya ditunjukkan oleh DO sahaja. Manakala parameter yang lain tidak menunjukkan tahap korelasi yang boleh diterima pakai. Jika dilihat pada taburan setiap parameter, didapati bahawa SS mempunyai nilai taburan yang lebih tinggi berbanding dengan parameter yang lain. Nitrogen Ammonia (AN) didapati tinggi pada awal pemerhatian tetapi pada tahun-tahun seterusnya taburan adalah lebih konsisten. Secara keseluruhannya, perhubungan di antara variable-variabel tersebut adalah tidak konsisten.

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LIST OF ABBREVIATIONS

AGNPS	Agricultural Non-Point Source Pollution
AN	Ammoniacal Nitrogen
ASMA	Alam Sekitar Malaysia Sdn. Bhd.
BOD	Biochemical Oxygen Demand
CHRIS	Chemical Hydrologic Resource Information System
COD	Chemical Oxygen Demand
DANCED	Danish Cooperation for Environmental and Development
DEM	Digital Elevation Model
DID	Department of Irrigation and Drainage
DO	Dissolved Oxygen
DOE	Department of Environmental
EMC	Estimated Mean Concentration
EPA	Environmental Protection Agency
EPIC	Erosion Productivity Impact Calculator
ERDAS	Earth Resources Data Analysis System
ESRI	Environmental System Research Institute
GIS	Geographical Information Systems
GPS	Global Positioning System
GRASS	Geographic Resources Analysis Support System
INWQS	Interim National Water Quality Standards
IRIS	Integrated River Information System
LDC's	Less Developed Country
MACRES	Malaysian Centre of Remote Sensing
MMS	Malaysian Meteorological Services
NE	North East
NPS	Non Point Source
NSF	National Sanitary Foundation
NTU	Nephelometric Turbidity Unit
PDI	Prevalence Number of Miles of Stream in the River Being Considered
PH	Percentage of Hydrogen Demand
PM	Peninsular Malaysia
PPM	Particulate Per Meter
RSO	Rectified Skew Orthomorphic
SOM	Straits of Malacca
SS	Suspended Solid
SW	South West
TSS	Total Suspended Solid
WQ	Water Quality
WQI	Water Quality Index

CHAPTER 1

INTRODUCTION

1.1 Background

Water is a vital and precious resource and arguably Malaysia's most important renewable resources. Plants, animals, and fish depend on water of adequate quantity and quality for their survival. Good water is vital for urban supply, agriculture, industry, and recreation. Development has had an impact on our national water resources, changing both quantity and quality. These changes affect the long-term viability of the resource and the aquatic ecosystems. Future generations of Malaysians will rely on these same water resources for their existence. As a developing country, Malaysia is striving towards industrial development especially in the oil and chemical-based industries. This may cause large amounts of oil and chemical compounds discharge into rivers, estuaries and finally into our coastal water.

This research will be carried out as a response to the environmental problems in Malaysia. The Malacca River had been labeled as one of the less productive rivers in Malaysia due to its pollution concentration, which originated from the nearest land use activities (Maheswaran, *et. al.* 1980). This has shown us that our environment has experienced deterioration. Mitigations action must be taken up due to the importance of the environment for not only humans but also other living things.

Aidah (1991) mentioned that in Malacca, water demand is high. It is known that the population in the Malacca state is the second highest in Malaysia after Penang with the highest concentration in Malacca city which has a high level of water consumption. Basically, water supplies in Malacca is managed by the Malacca Water Board (Lembaga Air Melaka), which was establish in 1971. The Malacca River is the most important river as it supplies 80 % of the raw water resources to the state of Malacca (DID Malacca, 2002). According to the report from the Department of Irrigation and Drainage, Malacca, rapid development has resulted in the degradation of water quality. It was found that the water contained bacteria, chemical constituents, heavy metals, and etc. The study conducted by the Department of Environment in co-operation with the Danish Cooperation for Environmental and Development (DANCED) found that the Malacca River had to be categorized as a polluted river. The Federal government had gazetted about RM6.5 billion for the Malacca River Rehabilitation project through the Department of Irrigation and Drainage Malaysia. The government of Denmark had also supported by providing a technology transfer as well as the equipment, which cost about RM 4.0 billion.

According to Pauziah (1983), changes in water quality always associated with land use patterns. Various land uses such as residential, and industrialization contribute several pollutants to surface and ground water via different pathway. In urban areas, industrials and domestic waste has known to contribute to the major rise in Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) concentrations. The local authorities of Malacca have been identifying the major pollutant sources which includes of industrial effluents,