POLLUTION MONITORING AT SUNGAI SEMANTAN TRIBUTARIES USING GEORAPHICAL INFORMATION SYSTEM

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Dedicated to Allah S.W.T,

my beloved husband Amron Bin Sawat

and my lovely childrens,

Nur Alya Syahirah , Muhammad Alif Safwan, Muhammad Alif Syazani

Muhammad Alif Syazwi, Muhammad Alif Firdaus and Muhammad Alif Fateh

Thanks for your valuable sacrifice and love.

To my beloved parents,

Karim Bin Hassan – Norisah Binti Abd Hamid

Rubiah Binti Kardi.

Thanks for your support and always being there for me in happiness and sadness.

~~~~~ Love you all ~~~~~
~~~~~

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ABSTRACT

The availability of fresh water for human use has become a problem due to climate change scenario. This study aims to assess the water quality patterns of pollution concentrations in Sungai Semantan catchment using GIS. This spatial pattern of each parameter was then analysed based on the Water Quality Index (WQI) and National Water Quality Standards (NWQS) to determine the locations of major pollutant sources that contribute to water quality depletion in the Sungai Semantan catchment. The considerations of sampling were focused on land use data that contributes to high potential impact to water quality. The water sampling was collected from nine different locations of the Bentong region starting from Sungai Bentong and Sungai Kelau to Sungai Semantan in the sunny and rainy seasons from November 2016 to April 2017. The samples collected were then analysed for different physicochemical parameters including pH, TSS, DO, BOD, COD, NH_3-N, turbidity, colour, iron and manganese to determine the spatial distribution of water quality in the study area. Geo-statistical analysis and Geographical Information System (GIS) were used to visualize the spatial pollution characteristics and identify potential polluted risky regions. From the obtained results of the parameters characteristics, it can be concluded that the water in Sungai Semantan is disturbed due to the presence of BOD, COD, TSS, turbidity, colour, iron and manganese concentrations. This parameter was exposed to various pollutants and seriously exceeded the standard of Category III (refer Malaysia NWQS). However, based on WQI, most of the parameters measured remained in Class II ranged from 85.12 to 90.11 (mean 88.13). In this study, the final representation of WQI has been done on the GIS map to show the spatial variation of pollution levels in the entire Sungai Semantan catchment. It is suggested that monitoring should be carried out continuously for proper management of this river basin to ensure sustainability of the water supply. WQI calculation formula should be reviewed by authorities to ensure important water quality parameter is relevant to analysis.

ABSTRAK

Perubahan iklim yang berlaku hari ini menjadi masalah utama kepada negara terhadap kecukupan bekalan air kepada masyarakat sejagat. Kajian ini bertujuan membuat penilaian kepada pencemaran corak kualiti air di kawasan tadahan di Sungai Semantan menggunakan GIS. Corak spatial setiap parameter yang telah dianalisis kemudian dikelaskan berdasarkan Indeks Kualiti Air (WQI) dan Piawaian Kualiti Air Kebangsaan (NWQS) untuk menentukan parameter pencemaran air yang utama menyebabkan mutu air di Sungai Semantan terjejas. Persampelan memberi tumpuan kepada faktor guna tanah yang menyumbang kepada potensi yang tinggi untuk memberi kesan kepada kualiti air. Persampelan diambil di 9 lokasi yang berbeza bermula dari Sungai Bentong dan Sungai Kelau ke Sungai Semantan di musim yang cerah dan hujan dari November 2016 hingga April 2017. Sampel kemudian dianalisis menggunakan sepuluh parameter merangkumi ciri-ciri fizikal dan kimia iaitu pH, TSS, DO, BOD, COD, NH_3-N, kekeruhan, warna, besi dan mangan untuk menentukan taburan spatial kualiti air di kawasan kajian. Analisis statistik dan Sistem Maklumat Geografi (GIS) telah digunakan untuk menggambarkan ciri-ciri dan potensi taburan pencemaran kawasan tercemar yang berisiko tinggi. Hasil dari analisis, dapat disimpulkan air di Sungai Semantan terganggu kerana kehadiran BOD, COD, TSS, kekeruhan, warna, besi dan mangan. Parameter ini didedahkan dengan pelbagai pencemaran melebihi kelas Kategori III merujuk kepada (NWQS). Walau bagaimanapun, WQI adalah berdasarkan parameter yang diukur kekal di dalam kelas II antara 85.12 – 90.11 (min 88.13). Dalam kajian ini, taburan WQI telah dilakukan menggunakan GIS menggunakan kaedah Kriging untuk menunjukkan perubahan tahap pencemaran keseluruhan kawasan tadahan di Sungai Semantan. Di harap pihak yang bertanggungjawab dapat menjalankan pemantauan berterusan bagi memastikan lembangan sungai ini terus kekal bersih bagi memastikan kemampanan bekalan berkekalan.

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LIST OF SYMBOLS AND ABBREVIATIONS

BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
DO	-	Dissolved Oxygen
TSS	-	Total Suspended Solid
NH_3-N	-	Ammoniacal Nitrogen
Fe	-	Iron
TDS	-	Total Dissolved Solids
TH	-	Total Hardness
EC	-	Electrical Conductivity
Mn	-	Manganese
WQI	-	Water Quality Indexs
NWQS	-	National Water Quality Standards for Malaysia
GIS	-	Geografical Information System
DEM	-	Digital Elevation Model
GPS	-	Global Positioning System
%	-	Percentage
°C	-	Degree Celcius

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is one of the most important substances on humans life. All humans, plants and animals must have water to survive. If there is no water in the world, there would be no life cycle on earth. Besides drinking to survive, humans use water for cooking, washing clothes, keeping houses and communities clean and keeping plants alive in gardens and parks. Water is necessary for all living organisms. The quality of water is getting progressively worse as a result of the pollution from industrialisation, agriculture, mining, burning, land ownership and forestation. This affects the health and socioeconomics of the region.

Malakootian *et al*. (2010) observed that the presence of colour in water effects the consumer assurance toward the quality of drinking water. People atheistically do not accept coloured and odour water. Water with high amount of colour and odour is not suitable for clothes washing and dyeing, paper industry, beverages production, dairies and other food products, the textile industry, as well as plastic production.

Water quality monitoring gives an idea about the extent of deterioration caused by this essential requirement. Water quality data is usually represented in tables and graphs. As the number of sampling stations and parameters to be analysed increases, the difficulty for analysing the data and interpretation of parameters that affect water quality increases. The visual results for water quality monitoring helps

to give a clearer picture of the water quality for river water. This can be achieved by using Geographic Information System (GIS).

GIS is applied in various fields such as agriculture, business, geography, defence and intelligence, ecology and conservation, emergency management and public safety, environmental management, forestry, health care, education, mining and geosciences, oceanography, coastal zone, marine resources, remote sensing and imagery, state and local government, telecommunications, transportation and water distribution and resources. GIS can effectively be used for water quality management. Spatially referenced data concerning water pollution can be employed, stored and displayed using GIS. Overlaying techniques is a useful tool with digital data layers.

Water quality analysis is important to understand the wealth of living organisms and environmental conditions in water bodies. Nagalakshmi *et al.* (2016) applied the ordinary Kriging interpolation method for surface analysis of water quality parameter for analysing the dispersion patterns.

The spatial distribution of water pollutants and other water quality parameters can be displayed effectively using GIS. This will helps authorities in taking effective actions to monitor the water quality that can reduce water pollution.

1.2 Problem of Statement

Water pollution is a serious environmental problem to humans' and animals' health. Saher et al.(2012) has studied pollution monitoring along the Pahang river basin and have been concluded that the most effective approach for water quality protection in a watershed is to monitor the source of pollution and make improvements and implementation plans to reduce or mitigate those critical sources. The Pahang-Selangor Raw Water Transfer (PSWT) has now completely and fully transferred water to the Selangor state.

This study will focus on the contribution of point and non-point sources of pollution using upstream – downstream sampling sites. The PSWT station located at Sungai Semantan collects water from Sungai Bentong (54.5km) and Sungai Kelau (21km) that is expected to have a synergistic effect on the water quality of the river. According to the New Straits Times, Oct 12, the Pahang Department of Environment (DOE) is prepared to meet with the Selangor state government to discuss claims about water pollution at Sungai Semantan, Bentong. The pollution contributes to the closure of the Langat and Cheras water treatment plants. The water from Sungai Semantan in Bentong transferred to the Langat and Cheras water treatment plants (LRA) in Selangor is assumed to contain chemical and hazardous waste. The water tunnel is being built as part of the PSWT project aimed to supply raw water from Sungai Semantan to the states of Pahang, Selangor, Kuala Lumpur and Negeri Sembilan. Water from the tunnel will be supplied using 858m long inlet conduit structure and the pumping station located in the Pahang River Catchment. The outlet structure in Selangor will transfer the water to the Langat and Cheras treatment plant.

The DOE has a monitoring programme that focuses on upstream and downstream in the affected area. The focus is mainly on point source. Maimon and Zainudin (2013) stated that rivers are mainly polluted due to the point and non-point pollution sources. Point sources are monitored and controlled by the DOE, whereas a significant amount of pollutants are contributed by both untreated sullage and storm runoff.

However, because of the presence point and non-point sources of pollution in the catchment area, the need to conduct an integrated assessment of the possible impacts on the river water quality is justified. Therefore, using the development of technologies, GIS modelling can be useful to analyse the data obtained.

Oke and Ogedengbe (2013) mentioned that GIS is actuality recognised as a powerful tool to overcome the issues and manage the geographical information in a universal method without losing the spatial historical variability which is often critical in monitoring and decision making. Furthermore, Kadhem (2013) also has used GIS in order to compare the water quality parameter and related information

collected from the Tigris River, displaying the distribution concentration of the river in easily viewed maps.

1.3 Background of Study

According to a report from the Department of Environmental Malaysia (DOE, 2015), the sources of water pollution can be considered into point and non-point sources. Point sources are referred to as sources with discharges entering the body of water at a specific location such as from pipes or outfalls. Point sources include the discharges from industries, sewage treatment plants and animal farms. Non-point sources are derived from diffuse sources that do not have a specific discharge point; examples of which are from agricultural activities.

Furthermore, Gyrson *et al.* (2012) stated that water colour is the problem faced by UK water companies which takes raw water from peatland catchments. A water colour model has been developed using a combined GIS and Multicriteria Evaluation approach. The model developed was then used to predict water colour production potential based on key land management practices to control colour production in UK upland catchments.

Based on research studies by Saher *et al*. (2012), the required datasets were generated using remote sensing and GIS system integrated with field GPS surveys. The representations of these datasets are an advanced method to ensure the data quality and output results. The study was to find out the Pahang River pollution and environmental threats by assessing and analysing different data layers of topographical, geological, hydrological and land cover using GIS method.

Besides that, Othman *et al.* (2011) mentioned that computer models are used extensively for the water-quality management of rivers and streams. These models must usually be calibrated to adjust a large number of parameters to reach the optimal agreement between model output and field measurements.

1.4 Aim and Objectives

The objective of this research is related to a set of aims or targets to be achieved through the completion of the research. The main objective of the study was to:-

i. To develop a map capable of predicting the patterns of pollution concentrations of the Sungai Semantan catchment.

ii. To evaluate the variation different of water quality on the contribution of point sources and non-point sources along the river for measuring changes of water quality.

iii. To construct the water quality of Sungai Semantan based on Interim National Water Quality Standard (INWQS) and Water Quality Indexes (WQI).

1.5 Scope of Study

The scope of work covers the chemical and physical characteristics of water quality using the National Water Quality Standard (NWQS) in Malaysia and WQI. This study was focused on collecting data from the sampling point. Ten (10) physical and chemical parameters were monitored to provide the baseline information on the water quality status of the rivers in the Sungai Semantan catchments.

The following are information about the data that shall be finalised:

i. Water Quality Data – pH, Dissolve Oxygen (DO), Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Ammoniacal Nitrogen (NH_3-N), Colour, Turbidity, Iron, and Manganese were selected to be measured.

ii. Land use data such as forestation, agriculture, industrial and residential at the catchment area were focused. The pollution from non-point sources may include sediment and toxic contaminants.

1.6 Significance of Study

Today, there are many human activities that cause environmental damage and deterioration of water quality in developing countries. Human activities such as industrial, mining and agriculture can cause the degeneration of water quality at water treatment plants. Therefore, the river should be restored from any contamination before being treated at the water treatment plant. However, this study was conducted to find out the main causes that lead to changes in the aesthetic value of the water supply from PSWT. The current condition of water quality at Sungai Semantan can be analysed and effective precaution steps should be taken.

GIS was used to generate the visual concentration sources of pollution that lead to problems with consumer issues. All the data evaluated will use the data collecting technology of Global Positioning System (GPS) that has been widely used in GIS. Water quality analysis was conducted at the upstream of the river from Sungai Bentong and Sungai Kelau. The data compiled to a map using Arc Gis 10.1. The system allows the delimitation of the pollution patterns across the catchment area.

This study would provide the responsible authorities with digital information and permanent database that could provide a quick and cost-effective solution assessment and mitigation of the future problem related to water quality. It is important to identify the source of pollution to develop an implementation plan to eliminate those critical sources. Besides that, this study aimed at employing this technology in the environment and hope it can help the management in designing new control structures to improve the water quality standard in Malaysia.

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