UNIVERSITI PUTRA MALAYSIA

COMPARISON STUDY OF WATER QUALITY IN SELECTED DISTURBED AND UNDISTURBED PEAT SWAMP FOREST RIVERS OF SIBU AND BINTULU SARAWAK

NORAINI ROSLI

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By

NORAINI ROSLI

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

JULY 2012

DEDICATIONS

Special dedicated to my beloved families, father and mother; Rosli Ebi and Dramatasiah Wen Sia @Abdullah, my friends & my fiancé; Micheal Gonzalez@Muhammad Firdaus Abdullah

I dedicate this work with Love. Thanks for everything….

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

COMPARISON STUDY OF WATER QUALITY IN SELECTED DISTURBED AND UNDISTURBED PEAT SWAMP FOREST RIVERS OF SIBU AND BINTULU SARAWAK

By

NORAINI BINTI ROSLI

July, 2012

Chairman: Assoc. Prof Dr Seca Gandaseca, PhD

Faculty : Faculty of Agriculture and Food Sciences

A study on status of water quality at natural peat swamp forest and converted peat swamp forest into oil palm plantation was conducted. The peat swamp forest of Batang Igan Sibu and Ladang Semanok Tatau (disturbed peat swamp forest) and Pandan Sebauh Bintulu and Sepadok Bintulu (undisturbed peat swamp forest) were chosen. Peat swamp forest of Batang Igan Sibu and Ladang Semanok Tatau was an oil palm plantation area while Pandan Sebauh Bintulu and Sepadok Bintulu was a natural peat swamp forest. This study was conducted to determine a status of water quality at peat swamp forest of Batang Igan Sibu and other peat swamp forest area for comparative study and to investigate differences between water quality condition in disturbed and undisturbed peat swamp forest. A total of 180 water samples were collected at four different sampling stations (S1, S2, S3 and S4) in six different months

from July 2009 to July 2010 at Batang Igan Sibu and once each at Ladang Semanok Tatau, Pandan Sebauh Bintulu and Sepadok Bintulu within December 2010 to April 2011. *In-situ* data included temperature; conductivity, dissolved oxygen (DO), pH and turbidity were recorded. Ammoniacal nitrogen (NH_3-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids (TSS) were conducted in the laboratory. The Water Quality Index (WQI) which was calculated based on six water quality parameters namely dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, pH, ammoniacal nitrogen and total suspended solids, was representative of the state of water quality at study area. Results for water quality parameters shows, temperature range (29.4-30.31°C), pH range (3.66-4.1), DO range (3.37-3.86 mg/L), conductivity (69.67-80.73 μS cm^{-1}), TSS range (25-27.7 mg/L), turbidity (4.15-5.2 NTU), BOD range (3.55-3.6 mg/L), COD (30-38 mg/L) and ammoniacal nitrogen (0.38-0.41 mg/L) at river water of Batang Igan Sibu and Ladang Semanok Tatau. This study showed that the physical-chemical parameters of water in peat swamp forest of Batang Igan Sibu and Ladang Semanok Tatau were range from Class II, Class III and Class IV respectively. The most influence parameter that causes the deteriorating of water quality to Class III is DO, BOD, COD and ammonia analysis and Class IV for pH. pH and dissolved oxygen of the water were found under very poor water quality status; however it is normal for peat water. Based on WQI of river water at peat swamp forest at Batang Igan Sibu and Ladang Semanok Tatau, S1, S2, S3 and S4 were categorized under Class III (moderate water quality) while river water at Pandan Sebauh Bintulu and Sepadok Bintulu categorized under Class II (good water quality). The physical-chemical

parameters of water at Pandan Sebauh Bintulu and Sepadok Bintulu were range from Class I and Class II; except for DO of water that is categorized under Class III and Class IV for pH. This study showed that the river water of peat swamp forest at Batang Igan Sibu and Ladang Semanok Bintulu (disturbed peat swamp forest) was affected due to agricultural and oil palm plantation activities that took place at that area while compared to river water at peat swamp forest of Pandan Sebauh Bintulu and Sepadok Bintulu (undisturbed) were under Class II (good water quality).

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

KAJIAN PERBANDINGAN KUALITI AIR SUNGAI HUTAN PAYA GAMBUT TERGANGGU DAN TIDAK TERGANGGU TERPILIH DI SIBU DAN BINTULU SARAWAK

Oleh

NORAINI BINTI ROSLI

Julai, 2012

Pengerusi : Prof. Madya Dr Seca Gandaseca, PhD

Fakulti : Fakulti Sains Pertanian Dan Makanan

Satu kajian untuk menentukan status kualiti air hutan paya gambut semulajadi dan hutan paya gambut yang telah diubah menjadi ladang kelapa sawit telah dijalankan. Hutan paya gambut di Batang Igan Sibu dan Ladang Semanok Tatau (hutan paya gambut terganggu) dan Pandan Sebauh Bintulu dan Sepadok Bintulu (hutan paya gambut tidak terganggu) telah dipilih sebagai kawasan kajian. Hutan paya gambut Batang Igan Sibu dan Ladang Semanok Tatau telah di tukar menjadi ladang kelapa sawit manakala Pandan Sebauh Bintulu dan Sepadok Bintulu adalah hutan paya gambut semula jadi. Kajian ini dijalankan untuk menentukan status kualiti air di hutan paya gambut Batang Igan Sibu dan lain-lain hutan paya gambut untuk kajian perbandingan. Sejumlah 180 sampel air telah diambil dan dikumpulkan di empat stesen persampelan yang berlainan (S1, S2, S3 dan S4) iatu sebanyak enam kali pada Julai 2009 sehingga Julai 2010 di Batang Igan Sibu dan satu kali untuk setiap satu di

Ladang Semanok Tatau, Pandan Sebauh Bintulu dan Sepadok Bintulu dalam tempoh bermula Disember 2010 hingga April 2011. Data *in-situ* termasuk suhu, kekonduksian, oksigen terlarut (DO), pH dan kekeruhan masing-masing direkodkan. Nitrogen ammonia (NH_3-N), permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD) dan jumlah pepejal terampai (TSS) telah dijalankan di makmal. Indeks Kualiti Air (WQI) yang dikira berdasarkan enam parameter kualiti air iatu oksigen terlarut, permintaan oksigen biokimia, permintaan oksigen kimia, pH, ammonia nitrogen dan jumlah pepejal terampai menunjukkan keadaan kualiti air di kawasan kajian. Keputusan bagi setiap parameter kualiti air seperti berikut; julat suhu (29.4-30.31°C), julat pH (3.66-4.1), julat DO (3.37-3.86 mg/L), julat kekonduksian (69.67-80.73 μS cm^{-1}), julat TSS (25-27.7 mg/L), kekeruhan (4.15-5.2 NTU), julat BOD (3.55-3.6 mg/L), julat COD (30-38 mg/L) dan ammonia nitrogen (0.38-0.41 mg/L) di Batang Igan Sibu and Ladang Semanok Tatau. Kajian ini menunjukkan bahawa parameter fizikal-kimia air di hutan paya gambut Batang Igan Sibu dan Ladang Semanok Tatau adalah dari Kelas II, Kelas III dan kelas IV. pH dan oksigen terlarut air ditemui berada di bawah status kualiti air yang sangat teruk, tetapi ini merupakan perkara yang normal bagi air paya gambut. Parameter air yang paling banyak mempengaruhi dan menyebabkan kemerosotan kualiti air ke kelas III ialah DO, BOD, COD dan nitrogen ammonia dan pH dalam kelas IV. Berdasarkan Indeks Kualiti Air (WQI) di hutan paya gambut di Batang Igan Sibu dan Ladang Semanok Tatau, S1, S2, S3 dan S4 dikategorikan berada dalam Kelas III (kualiti air sederhana) manakala air sungai di Pandan Sebauh Bintulu dan Sepadok Bintulu berada dalam Kelas II (kualiti air baik), kecuali DO dalam kategori Kelas III dan pH dalam Kelas IV. Hasil kajian mendapati

bahawa air sungai hutan paya gambut Batang Igan Sibu dan Ladang Semanok Bintulu (hutan paya gambut terganggu) telah terjejas disebabkan oleh aktiviti pertanian dan perladangan kelapa sawit yang berlangsung di kawasan itu manakala kajian perbandingan kualiti air sungai di kawasan hutan paya gambut di Pandan Sebauh Bintulu dan Sepadok Bintulu (hutan paya gambut semulajadi) berada dalam Kelas II (kualiti air baik).

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I certify that a Thesis Examination Committee has met on 6 July 2012 to conduct the final examination of Noraini Rosli on her thesis entitled "Comparison of Water Quality in Selected Disturbed and Undisturbed Peat Swamp Forest Rivers of Sibu and Bintulu, Sarawak" 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 (with Thesis).

Members of the Thesis Examination Committee were as follows:

Joseph Bong Choon Fah, PhD
Associate Professor
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
(Chairman)

Hishamuddin Omar, PhD
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Zelina Zaiton Ibrahim, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Muhammad Barzani Gasim, PhD
Professor
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
Malaysia
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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

Seca Gandaseca, PhD
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Sarawak Campus
(Chairman)

Mohd Hanafi bin Idris, PhD
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Sarawak Campus
(Committee Member)

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

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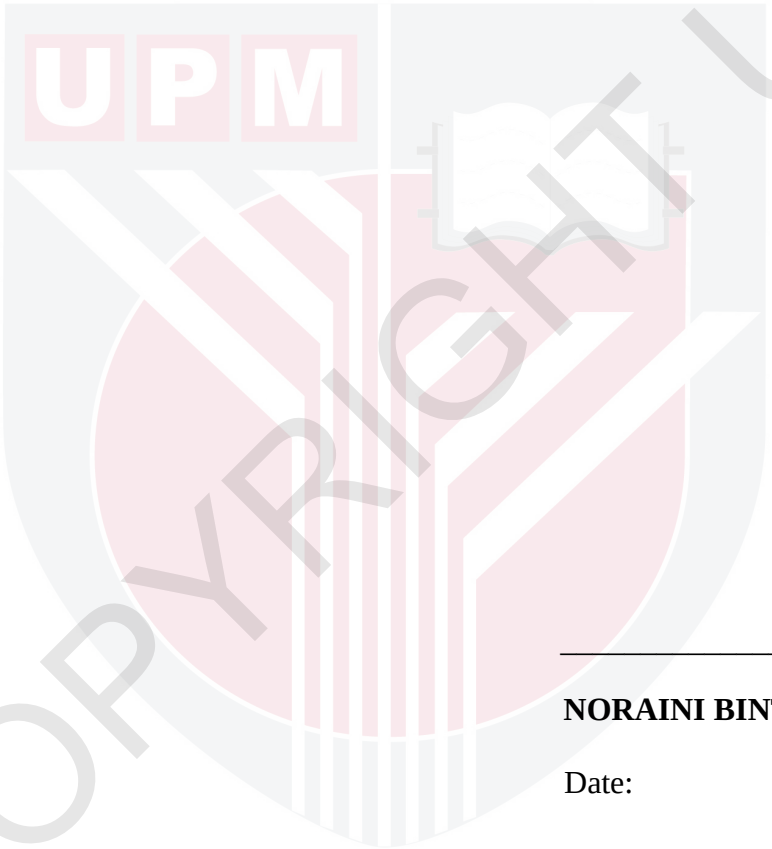
DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



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NORAINI BINTI ROSLI

Date:

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LIST OF ABBREVIATIONS

ANOVA – Analysis of Variance

AN – Ammoniacal Nitrogen

APHA – American Public Health Association

BOD – Biochemical Oxygen Demand

COD – Chemical Oxygen Demand

Cond - Conductivity

DO – Dissolved Oxygen

DOE – Department of Environment

EPA – Environment Protection Agency

GPS – Geographical Positioning System

NWQS – National Water Quality Standard

mg/L - milligrams per liter

NREB – Natural Resources and Environment Board

PSF – Peat swamp forest

Temp - Temperature

TSS – Total Suspended Solids

Turb - Turbidity

UPM – Universiti Putra Malaysia

WQI – Water Quality Index

SAS – Statistical Analysis System

% -Percent

°C - degree Celsius

mg/L - Milligram Per Liter

CHAPTER 1

INTRODUCTION

1.1 Background

Peat swamp forests are tropical moist forest, which grew and formed on a layer of dead leaves, wood and all parts of tree and plant. It is an accumulation of 100% of pure organic material (Firdaus *et al*., 2010; Salimin *et al*., 2010). They comprise a unique ecosystem characterized by water logging that is low in nutrients and dissolved oxygen levels in acidic water condition. Peat swamp forests are an important component of wetlands that are closely related between land and water, the transition zone or place where the water flow, nutrients cycling and sun energy which eventually form a perfect ecosystem of hydrology including soil and vegetation (UNDP, 2006).

Peat swamp forests are unique habitats for flora and fauna that containing a high proportion of endemic species (Page *et al.*, 1999). It is well known those tropical peat swamp forest is one subset of the wetland ecosystem that is ecologically and economically important globally (Mashhor *et., al*, 2004). Peat swamp forests provide benefits in variety of products from forestry, fisheries, water resources, ground water absorption, energy resources and also act as flood mitigation (UNDP, 2006). They play an important role in stabilizing the ecosystem, particularly in regulating drainage, microclimate, soil formation and water quality (Page *et al.*, 1999).

Peat swamps play a major role in supplying water to Sarawak's coastal lowlands and an important reservoir of water (Shakeran and Tsu, 2001). Water stored in the active layer or catotelm in peat swamps and the volumes remains constant for a long time if the peat is not disturbed by any activity. Most of the changes in water storage occurred in conjunction with the level of water table. It is estimated that the change in water storage is not more than 3-10% of it storage volume (Ingram, 1983; Mashhor *et., al*, 2004). Water flows freely in the active layer of water or acrotelm. Water storage is critical to the balance of water in peat swamps and at surrounding areas. Agricultural activity, logging activity, peat extraction and destruction of peat swamp drainage also give a negative effect and negative implication on the hydrology (Hamilton, 2005).

The water in peat swamp is almost black in color. The main reason is the presence of an organic material from peat decomposition. The black water produced from the contact of water with organic litter and debris such as leaves and wood in various and at different stages of decomposition. Humic acid and tannin is derived from the decomposition of lignin and it is a principal of coloring matter. All of this played very important role in maintaining water balance in the peat swamp forest ecosystem (Sawyer and McCarty, 1978; Gasim *et al*., 2007).

Malaysia is considered as one of the major tropical peat country in the world. Peat swamp forest (PSF) is Malaysia's largest wetland type that is cover about 75% of the Malaysia total wetlands (UNDP, 2006). There are more than 70% of the peat swamp

forests are located in Sarawak, about 20% in Peninsular Malaysia and the remainder in Sabah (UNDP, 2006). Peat swamp forests in Malaysia are being extensively cleared for agriculture, plantation and variety of development project that may cause destruction in the quality of peat swamp forest. PSF is treating due to increasing of unsustainable development activities in the PSF areas (Sawal, 2003; UNDP, 2006; Gasim *et al*., 2007). Sarawak is a state in Malaysia that has a land area of 12.4 million hectares. Out of this, more than 13% has been drained and developed mainly for agriculture, reforestation and rural settlement. About a third of peat land areas in the coastal lowland of Sarawak have been converted to oil palm plantation because Sarawak Government has identified the oil palm plantation sector as one of the core export-oriented industries that would contribute towards the long term economic growth to the state. Many more of tropical peat land is being cleared and converted into agriculture and plantations for economic return (Melling, 1999). Therefore, have causing the destruction of biodiversity, loss of soil and serious threat to the water resources in the peat swamp forests area (John, 2005).

The utilization of peat for agricultural and plantation purposes includes drainage and the use of fertilizers. Any of uncontrolled drainage will change the physical and chemical properties of the land. Its function as a buffer against saltwater intrusion between upland and the coastal zones and as a provider of essential freshwater for the coastal mangrove forests will be reduced or even eliminated (Mashhor *et., al*, 2004). Beside, their also play a main role as reservoirs for flood and storm water and have an ability to let it flow out during the dry periods. Thus it is important to make sure the peat water is not polluted.

1.2 Problem statement

The tropical peat swamps forests have been facing tremendous challenges in the face of development and exploitation lately. Majority of the forest in Malaysia especially in Sarawak state has been selectively logged resulting in reduced of biodiversity. The increasing rate in population due to the exploitation of forest areas by human activities through deforestation, logging, agricultural and plantation activity cause the destruction to peat swamp forest ecosystem and causing various problems such as soil loss and serious threat to the water resources in the peat swamp forests area. Without proper planning, the continuous exploitation, conversion and development of peat swamp forest area will cause long-term negative impact to the environment include its water quality. The understanding to identify the class of river water by referring to Water Quality Index (WQI) and National Water Quality Standards (NWQS) is very important and essential because it's showing the quality of the water. Therefore, this study is conducted to determine water quality of this river and also focuses on investigating different between water quality condition in disturbed and undisturbed peat swamp forests in order to achieve sustainable development and for better understanding of the effective water conservation and management.

1.3 Objective

The objectives of this study were:

1. To determine the water quality status of peat swamp forest at Sibu Sarawak and Bintulu Sarawak area based on Water Quality Index (WQI) classification and National Water Quality Standards (NWQS).
2. To investigated differences between water quality condition in disturbed and undisturbed peat swamp forests.

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