A STUDY ON THE IMPACT OF LOGGING AND AGRICULTURAL ACTIVITIES ON THE WATER QUALITY OF TASIK CHINI, PAHANG, MALAYSIA

MOHD ADAM BIN MUSA

Thesis submitted in partial fulfilment of the
requirements for the award of the degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITY MALAYSIA PAHANG

JANUARY 2014

ABSTRACT

. A study on the impact of logging and agricultural activity towards water quality in Tasik Chini was carried out in July and August 2013. Seven sampling stations were selected for this study: Gumum, Jerangking, Jemberau, Batu Busuk, Melai, Mempitih, and Dam Area. Thirteen water quality parameters were considered in this study during dry and wet season periods. The parameters were then analyzed and measured according to Department of Environment Water Quality Index (DOE-WQI) and National Water Quality Standard (NWQS) for Malaysia. The water quality of Tasik Chini falls into class II according to classification using DOE-WQI. Therefore, it is suitable for recreational uses but need conventional treatment for water supply. Agricultural activity, such as palm oil plantation at Gumum, rubber plantation near Jerangking and logging activities at Bukit Tebakang near the lake did affected water quality in Tasik Chini. If these situations continued, may have caused Tasik Chini environmental degradation and may affect the aquatic life and hydrological characteristics of water system in long term deterioration.

ABSTRAK

Kajian terhadap kesan – kesan dari aktiviti – aktiviti pembalakan dan juga pertanian ke atas kualiti air di Tasik Chini telah dijalankan pada bulan julai dan ogos 2013. Sebanyak tujuh stesyen pengsampelan telah dipilih untuk kajian ini. Gumum, Jerangking, Jemberau, Batu Busuk, Melai, Mempitih dan juga kawasa empangan telah dipilih.Sebanyak tiga belas parameter kualiti air telah diambil kira dala kajian ini semasa musa kering dan juga musim lembab. Parameter – parameter ini kemudiannya dianalisa dan diukur berdasarkan Indeks Kualiti Air Jabatan Alam Sekitar (DOE-WQI) dan juga Standard Kualiti Air Negara (NWQS) Malaysia. Kualiti air Tasik Chini dikelaskan dalam kelas II berdasarkan Indeks Kualiti Air Jabatan Alam Sekitar (DOE-WQI). Oleh Itu, ia boleh digunakan bagi tujuan rekreasi. Akan tetapi, ia memerlukan rawatan konvensional untuk dijadikan sumber bekalan air. Aktiviti pertanian seperti ladang kelapa sawit di Gumum, ladang getah berhampiran Jerangking serta aktiviti pembalakan di Bukit Tebakang berhampiran tasik telah memberi kesan terhadap kualiti air di Tasik Chini. Jika keadaan ini berterusan, ia akan menyebabkan Tasik Chini menghadapi masalah alam sekitar dan seterusnya memberi kesan langsung terhadap hidupan di dalam Tasik Chini untuk jangka masa yang panjang.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AN	Ammoniacal Nitrogen
APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
EC	Electrical Conductivity
E.Coli	Escherichia Coli
mg/L	Milligram per litre
MPN	Most Probable Number
NTU	Nephelometric Turbidity Units
NWQS	National Water Quality Standard
NH_3-N	Ammoniacal Nitrogen
NO_3^-	Nitrate
PO_4^{3-}	Phosphate
TSS	Total Suspended Solids
USEPA	Unites States Environmental Protection Agency
WQI	Water Quality Index
µs/cm	Microsiemens per centimetre

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The earth surface is covered by water approximately 70%. The water on the surface of the earth consist of ocean, lakes, river, and streams. There are a lot of lakes in Malaysia and Tasik Chini is one of these lakes. Holding the title of the second largest lake in Malaysia, Tasik Chini is located in Central of Pahang State near the Pahang River. The area of this lake actually covers almost 5,026 hectares and is consist of 12 lake area. Tasik Chini is very important and it gives many benefits to the community around the area of this lake. Jakun branch of the Orang Asli are the example of the community around the lake and they normally inhibited the lakeshores. Some benefits of this lake to them are the lake acts as a medium of transportation and also the source of the fish.

Basically, there are so many activities in the surrounding area of this lake that can contribute to the water pollution. Some of them are the agricultural activities, mining activities, resort activities and also Pusat Latihan Khidmat Negara (PLKN) activities. These are the main activities that believed to act as the factors affecting the water quality in Tasik Chini. Besides that, the dam also believed to contribute to the pollution by disturbing natural ecology of the lake. The dam actually built to maintain the lake's depth during the dry season.

1.2 PROBLEM STATEMENT

The Orang Asli who lives in the bank of Tasik Chini complained that the lake is more polluted day by day. These are to believe that the pollution comes from certain activities at the Tasik Chini such as agricultural activities, logging activities, mining activities and many other activities that can contribute to the pollution of water there. Therefore, it is important that a study is conducted to assess the water quality in Tasik Chini based on agricultural activity. This study will identify the impacts of logging and agricultural activities to the water quality of Tasik Chini. In Kampung Gumum, the village which is located at south east of Tasik Chini there is about 600 acres field of palm oil is cultivated there. Logging activities at Bukit Tebakang which situated at 210m at the north of Tasik Chini may affect the water quality and ecosystem of the lake.

1.3 RESEARCH OBJECTIVES

The objectives of this study are:

i. To study the impact of logging and agricultural activities on water quality of the Chini Lake.
ii. To identify and classify the quality of water at the Chini Lake based on DOE Water Quality Index (WQI) and National Water Quality Standard (NWQS) for Malaysia.

1.4 SCOPE OF STUDY

The scope of study on this research is basically based on the environmental studies and to be specific, the study of water quality in Tasik Chini from the impact of logging and agricultural activities inside and near the area of the lake. This research will be conducted on July 2013 until late August 2013 in both wet and dry season. However, the time frame of the research fall on normally wet season in Malaysia. Therefore, the wet season were considered after rain occurs in Tasik Chini. There are two type of test will be conducted which are in situ test and laboratory test. The parameters considered during in situ testing are temperature, pH, dissolved oxygen (DO), turbidity and electrical conductivity while parameter for laboratory test is mainly on Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids, Total Coliform, E – Coli, Phosphate, Nitrate and Ammoniacal Nitrogen.

1.5 SIGNIFICANT OF STUDY

This study of water quality can improve more understanding of the students on the water physically, chemically and also biologically. The Chini Lake has many surrounding activities on going which can affect the water there. Logging and agricultural activities were studied to identify whether they can the water quality of Chini Lake. The results produced through classification according WQI and NWQS are considered valuable. This will become more significant if the result of this study can be the reference for future research by local authorities in forming a strategic development and improvement of the water systems in Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The most important compound found on earth is water (H_2O) and it covers the surface of the earth for almost 75% in overall (Smol, 2008). As we all know, the main of the water sources in the earth comes from rivers, lakes and also the ocean. If the rivers were to be compared with the lakes, the lakes have the additional components in having greater depth and area of the water (Lippman, Cohen, & Schlesinger, 2003). The water molecules are made of an oxygen atom which bounds two hydrogen atoms together. Actually, a body of water on earth did not only consist of water only but also other particles inside them as water holds the title "the universal solvent". This chapter of literature review is mostly on the lakes, the water pollution, the water quality parameters and also the water quality classification.

2.2 CHINI LAKE

In this world, the lakes can be classified into two types that are natural lakes and also man – made lakes. The water samples of this study were taken from Tasik Chini. It is the second largest naturally occurring lake in Malaysia (Othman et al, 2007).Chini lake has 12 area division that were recognized by the local community as Gumum, Pulau Balai, Cenahan, Jerangking, Genting Teratai, Mempitih, Kenawar, Serodong, Melai, Batu Busuk, Labuh and Jemberau. Another place taken note in this study is the dam area which is situated very near to the Pahang River. The lake is surrounded by natural environment that includes rivers, swamp, lowland and hill forest as well as the

indigenous people of Jakun community for eco-tourism purposes (Wan Juliana et al. 2010).

2.3 WATER POLLUTION

The verb "pollute" is defined as "to make foul" in the Webster dictionary. The human activities have now impacted almost all water bodies on the planet to some extent. Some of the impacts can be minor and barely noticeable but others have degraded lakes and rivers to enormous stage. Normally, the pollution impacted the water physically, chemically and also biologically (Smol, 2008). The pollutants that causes pollution on the water can be categorized into "point source" and also "non – point source".

2.3.1 Point Sources Pollution

Point sources pollution comes from the pollutant that can be easily measured and discharged directly to water body at a specific place only such as the pollutants that comes from discharge pipes of a certain factory (Purohit & Agrawal, 2004).The various nutrients of the sewage from urbanization and rural building development that was discharged into a certain body of water is the common cause of the death of aquatic ecosystem (Chandra, Singh & Tomar, 2012).

2.3.2 Non – Point Sources Pollution

Non – point Sources pollution or its other name "diffuse source pollution" normally comes from the pollutants that have no specific point of entry to the water (Purohit & Agrawal, 2004). For example, during the rain, the soils erosion and debris from the human activities around the lake will enter to the water during surface runoff which will cause siltation process to occur in the lake (Shahrizaila, 2009).

2.3.3 Agricultural Runoff

The non – point sources pollution known as agricultural run-off are pollutants which are transported through soil by rainwater and snow during wet season. It normally consists of nitrogen and phosphorus. The nutrients run-off specifically phosphorus will lead to eutrophication and will change the taste and the odour of the water. Besides that, the pesticides can also leads to the contamination of the lake. It will cause ecological system dysfunctional by inhibiting the growth and reproduction of the top predators. Turbidity and sedimentation are caused by tillage. These sediments contain phosphorus and pesticides absorbed to the sediment particles. Fertilizers activities will cause contamination of water by pathogens, metals, phosphorus and nitrogen which will lead to eutrophication (Purohit & Agrawal, 2004).

2.3.4 Logging Activities

Forest is a complex living system that has a limitation on utilization of what the forest can sustain (Davidson, 1985). Forest ecosystem can adapt and is able to recover to naturally occurring phenomenon such as windstorms, fires and landslips but if there is a change in intensity, frequency or extend of the disturbance to which the ecosystem is adapted, the recovery is far more difficult (Lamb, 2011). Logging activities can accelerate erosion primarily through felling, yarding, skidding, building and using roads and landings, and burning (Lewis, 1998).

2.4 PHYSICAL WATER QUALITY PARAMETERS

The characteristics of water that responds to the sense of touch, taste, smell and sight can be defined as physical parameter (Peavy et al., 1985). The physical water quality parameters that are taken into consideration in this study are temperature, turbidity and also total suspended solid.

2.4.1 Temperature

Temperature is measureable. Normally, it is measure in the unit Kelvin, degree celcius and also degree farenheit. Temperature has the effect on the most chemical reactions which occur in our surrounding nature (Peavy et al.,1985). The temperature measured in Chini Lake did not show big difference in two different season and it was considered in its normal range of its climate (Barzani Gasim et al., 2006).

2.4.2 Turbidity

In definition, turbidity is a measure of the transparency of water due to the presence of suspended material, dissolved solid and colloidal material in the water (Farrel-Poe, 2005). Because of these materials, the water with high turbidity did not transmit light as well as clear water. The water with high turbidity normally looks cloudier compared with the water of low turbidity. Turbidity is measured in the unit of NTU which stands for Nephelometric Turbidity Unit.

2.4.3 Total Suspended Solid

Total suspended solid is a measure of the suspended particles which exist in the water such as sand, clay, and also organic material that moves along with the water flow. Too high of suspended solid in the water can affect the aquatic life such as fish. For example, the fish vision and respiratory organ; gills can be affected by the suspended solid in the water. The total suspended solid in the water are normally measured in terms of the concentration that is milligrams per liter, mg/L (Farrel-Poe, 2005).

2.5 CHEMICAL WATER QUALITY PARAMETERS

The chemical water quality parameter can be relate to the chemical compounds or combinations of them at which can be considered harmful to living organism if in abundant (Chin D. A., 2006). Electrical conductivity, pH, COD, BOD, DO, Ammoniacal Nitrogen, Nitrate, and Phosphate are the chemical parameters that were taken into consideration during the study.

2.5.1 pH

A pH reading shows the measurements of the water state in terms of acidity, neutrality, and alkalinity.7 is the reading that can show the water was in neutral state. A reading below 7 can be considered in acidic state and the reading higher than 7 can be considered in alkaline state. The pH readings can be affected by the agricultural runoff and also the overflows of sewerage. The survival of aquatic life depends on the ability to resist changes in water pH (LRCA, 2012).

2.5.2 Electrical Conductivity

Electrical conductivity is a parameter that shows the ability of a solution to conduct the electrical current. The ions exist in water transport electrical current and the increase concentration of ions results in the increase in the conductivity (Tschobanoglous & Shroeder, 1985). The unit of electrical conductivity that is normally used is μS/cm.

2.5.3 Chemical Oxygen Demand (COD)

Chemical Oxygen demand is a measure of the total quantity of oxygen required to oxidize the organic material by a strong chemical oxidant to carbon dioxide and water (Chin D.A., 2006). The COD will increase as the concentration of organic matter exist in water increase (Chandra, Singh & Tomar, 2012).

2.5.4 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen demand can be related to the total quantity of oxygen required to biochemically oxidize by the organic matter exists in the water (Chin D.A., 2006). The rate of oxygen consumption in the water is affected by many variables such as temperature, pH, microorganisms, organic and inorganic substances found in the water.

2.5.5 Dissolved Oxygen

The amount of molecular oxygen dissolved in the water is the right definition of dissolved oxygen (DO) and it is the most affecting parameter in water studies (Chin D. A., 2006). The DO values actually low during rainy season which is from September to December and the factors contributing to this phenomenon are the rate of photosynthesis, seasonal variables and the organic matter decomposition (Mir Sujaul Islam et al., 2012).

2.5.6 Ammoniacal Nitrogen

Ammoniacal nitrogen is a dissolved inorganic form of nitrogen found in the water. The sources of ammonia in a lake normally come from fertilizers, human and animal wastes and byproducts from industrial activities (Shifflett, 2012). The presence of this compound in the water can be considered harmful to human because of its toxic nature.

2.5.7 Nitrate

Nitrate ions (NO_3^-) generally occur in trace quantities in surface water and it is crucial for aquatic plants to receive nutrient for photosynthesis process. Normally, nitrite ion comes from anthropogenic sources like agricultural fields, and other waste which contained nitrogenous compound. Drinking water high in nitrates (>10mg/L) can be considered toxic to human health (LCRA, 2012)

2.5.8 Phosphate

Phosphorus is also a nutrient exist in water just like nitrogen. Phosphate and organophosphate are the types of compound that phosphorus normally exists in nature. Fertilizers, untreated sewage, domestic waste and also animal waste are some of the common sources of nutrients in the water (Farrel-Poe, 2005).

2.6 BIOLOGICAL WATER QUALITY PARAMETERS

Biological water quality parameters involve the study of microorganism in the water itself. There are 2 biological parameters that considered in this study; total coliform and also Escherichia Coli.

2.6.1 Total Coliform

Coliform are a group of microorganism which contain many type of bacteria. Some were dangerous and some were not. A disease causing microorganism may be present in the water where coliform were found (AVOCET, 2013).

2.6.2 Escherichia Coli

Escherichia Coli or E.Coli is a rod – shaped bacteria which commonly found in the lower intestine of warm blooded animals (Tschobanoglous & Shroeder, 1985). This type of bacteria can cause diarrhea to us.

2.7 WATER QUALITY INDEX (WQI)

The result of WQI can be obtained by a series of process. The process starts from the data tabulation in Microsoft Excel 2007 to calculation of the sub-indices until the classification. The WQI can be calculated using formulae shown below:

$$\mathbf{WQI = 0.22\ SI_{DO}+0.19SI_{BOD}+0.16SI_{COD}+0.16SI_{TSS}+0.15SI_{AN}+0.12SI_{pH}}$$

Sub- index for DO (in % saturation):

SI_{DO} $= 0$ for DO<8

$= 100$ for DO>92

$= -0.395+0.030DO^2-0.00020DO^3$ for 8<DO<92

Sub –index for BOD:

SI_{BOD} $=100.4-4.23BOD$ for BOD<5

$= 108e-0.055BOD -0.1BOD$ for BOD>5

Sub-index for COD:

SI_{COD} $= -1.33COD+99.1$ for COD<20

$= 103e^{-0.0157COD}-0.04COD$ for COD>20

Sub-index for AN:

SI_{AN} $= 100.5-105AN$ for AN<0.3

$=94e^{-0.573AN}-5|AN-2|$ for 0.3<AN<4

$= 0$ for >4

Sub-index for TSS:

$SI_{TSS} = 97.5e^{-0.00676TSS} + 0.05TSS$ for TSS<100

$= 71e^{-0.0016TSS} - 0.015TSS$ for 100<TSS<1000

$= 0$ for TSS>1000

Sub-index for pH:

$SI_{pH} = 17.2 - 17.2pH + 5.02pH^2$ for pH<5.5

$= -242 + 95.5pH - 6.67pH^2$ for 5.5<pH<7

$= -181 + 82.4pH - 6.05pH^2$ for 7<pH<8.75

$= 536 - 77.0pH + 2.76pH^2$ for pH>8.75

Where,

WQI = Water Quality Index

SI_{DO} =Sub-index of DO

SI_{BOD} =Sub-index of BOD

SI_{COD} =Sub-index of COD

SI_{AN} =Sub-index of AN

SI_{TSS} =Sub-index of TSS

SI_{pH} =Sub-index of pH

The tables below show the classification of water using DOE Water Quality Index.

Table 2.1: 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
Dissolved 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: Malaysia Environmental Quality Report 2010

Table 2.2: DOE Water Quality Index Classification Based on Water Quality Index

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 -90	0 - 79
Ammoniacal Nitrogen (NH_3 -N)	92 - 100	71 - 91	0 - 70
Suspended Solid (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 -100	60 - 80	0 - 59

Source: Malaysia Environmental Quality Report 2010