THE IMPACT OF AGRICULTURAL ACTIVITY TOWARDS WATER QUALITY IN TASIK CHINI

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ABSTRACT

A study on the impact of agricultural activity towards water quality in Tasik Chini was conducted at six sampling stations which were at Laut Gumum, Laut Jerangking, Laut Melai, LAut Kenawar, Laut Pulai Balai/PLKN, and Tasik Chini Resort. A total of thirteen water quality parameters were analyzed including in situ test and laboratory analysis. All the parameters were analyzed and measured according to Department of Environment Water Quality Index and National Water Quality Standard (NWQS) for Malaysia. The physical, chemical and biological variables were temperature, turbidity, total suspended solid (TSS), dissolved oxygen (DO), pH, biological oxygen demand (BOD), chemical oxygen demand, electrical conductivity (EC), ammoniacal nitrogen (NH_3-N), nitrate (NO_3^-), phosphate (PO_4^{-3}), total coliform, and Escherichia coli (E.Coli). The result show that water quality at Tasik Chini is Class II based on WQI, which means, Tasik Chini is suitable for recreational activity and body contact is allowed, however basic treatment required for water supply. Based on NWQS, electrical conductivity (EC), total suspended solid (TSS), ammoniacal nitrogen (NH_3-N), and nitrate are Class I. Parameter for turbidity, phosphate, biochemical oxygen demand (BOD), and chemical oxygen demand (COD) under Class II. pH and dissolved Oxygen under Class III. Human activities at surrounding area near Tasik Chini affected water quality there. Agricultural activity, such as palm oil plantation at Kampung Gumum, and rubber plantation at Tanjong Jerangking indeed affects water quality in Tasik Chini and if these situation continued, may have caused environmental degradation at Tasik Chini hence may lead algal bloom in lakes.

ABSTRAK

Kajian mengenai kesan pertanian terhadap kualiti air di Tasik Chini telah dijalankan di enam stesen persampelan iaitu, di Laut Gumum, Laut Jerangking, Laut Melai, Laut Kenawar, Laut Pulau Balai/PLKN dan Resort Tasik Chini. Sebanyak tiga belas parameter telah di analisis iaitu parameter untuk ujian di lokasi serta eksperimen di makmal. Semua parameter telah dianalisis berdasarkan Indeks Kualiti Air, Jabatan Alam Sekitar dan Standard Kualiti Air Negara. Antara parameter fizikal, kimia dan biologi yang diuji adalah suhu, kekeruhan pepejal terampai (TSS), oksigen terlarut (DO), pH, permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD), kekonduksian elektrik (EC), nitrogen ammonia (NH_3-N), nitrat (NO_3^-), fosfat (PO_4^{-3}), jumlah koliform, dan Escherichia coli (E.Coli). Kajian telah menunjukkan bahawa Tasik Chini adalah Kelas II berdasarkan WQI. Dengan itu, Tasik Chini sesuai untuk aktiviti rekreasi dan sentuhan air terhadap kulit adalah dibenarkan. Walaubagaimanapn, rawatan asas perlu dilakukan untuk bekalan air. Berdasarkan NWQS, kekonduksian elektrik (EC), jumlah pepejal terampai (TSS), nitrohen ammonia (NH_3-N), dan nitrat (NO_3^-) adalah Kelas I. Untuk parameter kekeruhan, fosfat (PO_4^{-3}), permintaan oksigen biokimia (BOD), dan permintaan oksigen kimia (COD) adalah Kelas II. Bagi parameter pH dan oksigen terlarut adalah Kelas III. Aktiviti - aktiviti di sekitar kawasan Tasik Chini menjejaskan kualiti air di sana. Aktiviti pertanian seperti di ladang kelapa sawit yang terdapat di Kampung Gumum serta aktiviti pertanian ladang getah di Tanjong Jerangking merupakan salah faktor yang menyebabkan terjejasnya kualiti air di Tasik Chini, dan jika keadaan ini berterusan mungkin boleh menyebabkan kemerosotan alam sekitar di Tasik Chini yang mana boleh menyebabkan terjadinya alga bloom di dalam tasik.

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
TSS	Total Suspended Solids
EC	Electrical Conductivity
E.Coli	Escherichia Coli
NWQS	National Water Quality Standard
NH_3-N	Ammoniacal Nitrogen
NO_3^-	Nitrate
mg/L	Milligram per litre
MPN	Most Probable Number
NTU	Nephelometric Turbidity Units
PO_4^{3-}	Phosphate
µs/cm	Microsiemens per centimetre
USEPA	Unites States Environmental Protection Agency
WQI	Water Quality Index

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Water is very important to human daily life. People used water for cleansing, washing, bathing and so on. River, lake and other freshwater resources also provide electrical power generation, for recreational activities, fisheries, and others. However, the most important is the quality of water which had been used for all those activities. Water quality may refer to physical, chemical and biological characteristic of water. According to USEPA, (2002), "A water quality standard is defined as the designated beneficial uses of a waters segment and the water quality criteria necessary to support those uses". Based on this statement, may conclude that, the low quality of the water will give negatives impact to the human life even to the environment as well.

Water quality in lake is about the degradation of natural processes of eutrophication. Social development will accelerate the eutrophication process, (Tchobanoglous, G., & Schroeder, E.D., 1985, p.383). Eutrophication is the increases of nutrients concentrations. According to Nixon's study as cited in National Estuarine Research Reserve System (NERRS), defined eutrophication is an increase in the rate of supply organic matter in ecosystem. Human activities increase the rate of nutrient input through point sources pollution (i.e. untreated sewage) and non point sources pollution(i.e. fertilizers run-off from agriculture) as well (Smoll, J.P., 2008, p.183). Agricultural activity, may used and applied pesticides, herbicides, and fertilizers. The application of fertilizers and pesticide may produce dissolved nutrient in surface run off

which is nitrogen and phosphorus. These nutrients may change and reduced the water quality in lake.

1.2 PROBLEM OF STATEMENT

According to the previous research, by Ari Kurnia (2010), there is palm oil plantation and rubber plantation under the monitoring and management by *Rubber Industry Smallholders Development Authority* (RISDA). About 600 acres field of palm oil is cultivated at Kampung Gumum which is located at south east of Tasik Chini. In addition, Federal Land Development Activity (FELDA) also sponsored oil plantation at Kampung Gumum. Other than Kampung Gumum, Transperancy International-Malaysia (TI-M) (2011) has stated that, there is also oil palm plantation at Jemberau. As the result, the agricultural activities near Tasik Chini will cause agricultural run-off into Tasik Chini which will polluted the lake.

Agricultural runoff consists of fertilizers, pesticides and domestic discards which will affects the quality of water and aquatic life (Seh Datul Ridzuan et al, 2009). Excessive of nitrogen and phosphorus in the lake will accelerate the eutrophication of lake (John P. Smol, 2008, p.180). Eutrophication process of lakes is depends on the water quality of the lake (Tschobannoglous, G., & Schroeder, E. D., 1985, p. 383). Therefore, it is important that a study is conducted to assess the water quality in Tasik Chini due to agricultural activity.

1.3 RESEARCH OBJECTIVE

The objectives of study are:

i. To classify water quality in Tasik Chini based on the Water Quality Index (WQI) and National Water Quality Standard (NWQS).
ii. To determine the effect of agricultural activities toward water quality at Tasik Chini.

1.4 SCOPE OF STUDY

The scope of study on this research is based on the agricultural activity near Tasik Chini. Agricultural activity near Tasik Chini caused of agricultural runoff which may affected water quality in Tasik Chini. This research is conducted on September 2012 until June 2013. Study area is at Tasik Chini. There are two type of tests are conducted which are in situ test and laboratory test. There are 8 laboratory tests that conducted which are biological oxygen demand (BOD) test, chemical oxygen demand (COD) test, total suspended solid (TSS) test, ammoniacal nitrogen test, phosphate test, nitrate test, total coliform test and E.coli test. For in situ test, 5 tests are conducted which are, temperature, pH, electrical conductivity, dissolved oxygen and turbidity.

1.5 EXPECTED OUTCOME

i. The data and result will be useful for water quality research project.
ii. Water quality in Tasik Chini was determined.

1.6 CONCLUSION

As a conclusion, water quality in Tasik Chini due to agricultural activity is determined by Water Quality Index (WQI) and National Water Quality Standard (NWQS). Agricultural activity near Tasik Chini is one of the factors that contributed pollution in Tasik Chini.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Water is very important for living things, which includes human life, flora and fauna. According to John P.S. (2008), "Water and life are intricately linked. Water makes up about 70% of our bodies. More than half of the world's species of plants and animals live in water, and even our terrestrial-derived food is totally depends on and often large composed by water".

According to Tchobanoglous, G., & Schroeder, E.D. (1985), "A plentiful supply of water is clearly one of the most important factors in the development of modern societies. Availability of water for cleansing is directly related to the control or elimination of disease. The convenience of water available at home improves the quality of life". This quotation shows the important of water in life. However, water quality cannot be ignored because water quality is a measurement how safe the water is.

2.2 SURFACE WATER

Surface water is water above land surface. (Chin, D. A., 2006, p.1).Surface water body is potential to receive pollutant from many sources. Characteristics of surface water are change with time and space. Mineral pick up from surface runoff, silt and debris are carried by surface water, will increased the concentration of impurities in water, these, will caused, muddy or turbid streams. Stagnant water, or slow moving

areas changing the aesthetic characteristics by plants and algae grow. Most of waste will discharged towards surface water. Thus, caused major impact on water quality and add greatly to the spectrum of impurities. (Tschobannoglous, G., & Schroeder, E. D., 1985, p.45).

2.2.1 Lake

The study of lake is a study of limnology. Large reservoir of water in which currents are driven primarily by wind is called lakes. The other factor of distribution of lake is bathymetry, density distribution, and inflow and outflow characteristics. Seepage lakes are lakes that intersect the ground-water table and interact significantly with ground-water table fluctuates. Drainage lakes are lakes fed primarily by inflowing streams. Lakes and reservoirs differ from river and stream in several ways. Lakes receive discharged organic matter large enough to cause serious oxygen depletion, lakes have significantly longer retention times than river and lastly, the principal of water quality gradients are in vertical direction rather than in longitudinal direction, (Chin, D. A., 2006, p. 192-193). There are two types of lakes, natural lakes and man-made lakes.

2.2.2 Tasik Chini

Tasik Chini is the study area for this research. Tasik Chini is a second largest natural lake which located at near Pahang River in Central Pahang, Malaysia. (Othman et al, 2006).This lake may categorize as the wetlands. Tasik Chini wetland acts as natural sponges to absorb floodwater and help to avoid flood damage. Tasik Chini is located in the east of Peninsular Malaysia in state of Pahang. The lake contains of 12 'seas' which recognized as 'Laut' by the local community there. The 12 'seas' are, Gumum, Pulau Balai, Cenahan, Tanjung Jerangking, Genting Teratai, Mempitih, Kenawar, Serodong, Melai, Batu Busuk, Labuh and Jemberau. Tasik Chini is drained by Chini River. The water from Pahang River will flow into Tasik Chini during the high monsoon season.

2.3 POLLUTION OF LAKE

Water pollution means contamination of water or has changed in physical, chemical or biological properties of water bodies. There are point sources pollution and non point sources for pollutants in water. In addition pollution of lakes including the eutrophication process in lake influence by other factors. Lakes can be classified to 4 classes; oligotrophic lake, mesotrophic lake, eutrophic lake, and hypereutrophic lake. Oligotrophic lake can be described as high clarity, low algal concentrations. Mesotrophic lakes are intermediate between oligotrophic lake and eutrophic lake. Mesotrophic lakes are suitable for recreational activity. Eutrophic lakes have abundant supply of nutrients and have high concentration of algal. Lake at this class, will produce unpleasant tastes and odors because have large mats of floating algae. Hypereutrophic lakes can be categorized as extremely eutrophic, with intense algal blooms and high algal productivity. At this stage, the lake is extensive dense weed beds, also the lake depth is shallow with accumulated organic sediment, (Chin, D. A., 2006, p.199).

2.3.1 Point Source Pollution

Point sources pollution means any wastewater discharged directly towards water bodies for example, discharge pipes, where they can be easily measure. (Purohit , S. S., & Agrawal, A. K., 2004, p.23). Point sources means any discernible, confined and discrete conveyance, well discrete fissure, container rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may discharged, (Purohit , S. S., & Agrawal, A. K., 2004, p. 25).

2.3.2 Non Point Source Pollution

Non-point sources pollution, hard to identify, measure and control than point sources pollution. Non point sources pollution also known as diffuse source pollution, which come from human activities for which pollutants have no obvious point of entry receiving watercourses.(Purohit, S. S., & Agrawal, A. K., 2004, p.23). Other than that,

non point source pollutants, irrespective sources, transported through the surface runoff by rainwater or melting snow. The impact of these pollutants range from simple nuisance substances to severe ecological impacts involve of fish, birds, mammals, and on human health.

2.3.3 Agricultural Run-Off

Agricultural run-off is categorized as the non-point source pollution. These pollutants are transported through soil by rainwater and snow. Agricultural run-off consists of nitrogen and phosphorus. Run-off of nutrients especially Phosphorus will lead to eutrophication and change taste and odor of the water. Aquatic life will kill in the lake because of deoxygenation of water. In addition run-off of pesticides leads to contamination of lake. Other than that, it will cause ecological system dysfunctional by the loss of top predators due to growth inhibition and failure of reproduction.

Ploughing /Tillage will cause turbidity and sediments. These sediments contain of phosphorus and pesticides adsorbed to sediment particles. These factors make siltation at river beds and the aquatic life loss their habitat. Manure spreading is one of the fertilizers activities. It will cause contaminated of water by pathogens, metals, phosphorus and nitrogen which will lead to eutrophication (Purohit , S. S., & Agrawal, A. K., 2004, p.52).

2.3.4 Pollution at Tasik Chini

According to Suhaimi Othman, Ahmad, Mushfirah, & Lim, E. C. (2008)., Tasik Chini is classified as the mesotrophic lake based on the study about water quality at Tasik Chini by Ainon, Ratuah, Mimi, Affendi, (2006) which was conducted at 1999, have found that the lake water was contaminated by total coliform and faecal coliform which contaminated the water, therefore, the lake water is not suitable and not safe for drinking.

Recently, Tasik Chini had covered by an aquatic weed call 'cat tail' or Cabomba Furcata. In many years, the lake surface is covered by the famous lotus flower which is Nelumba Nucifera. Tasik Chini condition was worsened by the plantation of the palm oil near the Tasik Chini, (Habibah, Hamzah, & Mushfirah, 2010). The development of agricultural near Tasik Chini, caused some pollution to the lake. Agriculture activities, release nitrate and phosphate in the lake due to the used of fertilizers on the palm oil plantation. The replacement of primary forest to oil plantation and rubber plantation caused changes in hydrology, also, phenomenon of eutrophication, sedimentation and pollution.

2.4 WATER QUALITY

There are several parameters on water quality measurement which are physical, chemical and biological parameters. Based on Chin, D. A., (2006), "The interrelationships between the physical, chemical, and biological measures are complex, and alterations in the physical and or chemical condition generally results in changes in biological condition".

Analytical procedures have been developed that quantitatively measure these parameters, (Peavy et al., 1985, p.11). Water quality parameters for lake, are measured according to Malaysia Department of Environment Water Quality Index (DOE-WQI) also, will classified by using National Water Quality Standard, Malaysia (INWQS), (Othman et al, 2006).

2.4.1 Physical parameter

Physical parameter may define as characteristics of water which respond to the senses of sight, touch, taste or smell, (Peavy et al., 1985, p.14). According to Chin D.A., 2006, stated that, physical parameter which may affected the quality of aquatic life that related to flow conditions, substrate characteristics, stream habitat, riparian habitat and thermal pollution.

2.4.1.1 Temperature

Temperature is physical water quality parameter. Temperature is one of the most important parameters in natural surface water system. Most chemical reactions that occur in natural system is effect by temperature (Peavy et al, 1985, p.22). According to the previous study by Barzani Gasim et al., 2006, the temperature at Tasik Chini during wet and dry season was normal according to the climates. Other than that, temperature did not show a big difference for both seasons.

2.4.1.2 Turbidity

Turbidity is a test for water clarity, (Tschobanoglous G. and Shroeder E.D., 1985, p.56). Usually water clarity is disturbing by the suspended solid and plankton that are suspended in water column. Low levels of turbidity may indicate a healthy, well functioning ecosystem, with balance of food chain in an ecosystem. However, high levels of turbidity, gives problem towards the ecosystem. The turbidity may block the light needed by submerged aquatic plant. In addition, turbidity may raise the temperature of water bodies above normal condition because of the suspended particles have absorbs the heat from sunlight. As a result, turbidity may affect the dissolved oxygen in water.

According to the study by Bazani Gasim et al., 2007, the mean turbidity at Tasik Chini was 16.41 NTU.Turbidity in wet season is higher than in dry season. Water is acceptable for domestic use when the turbidity is within 5-25 NTU. This is according to National Water Quality Standard (NWQS) for Malaysia. However, Ministry of health has set the threshold level of turbidity for raw water is 1000 NTU. (Barzani Gasim et al., 2007).

2.4.1.3 Total suspended solid (TSS)

Total suspended solid or TTS is to test the suitability of water for public, industrial and agricultural uses, and TSS is physical characteristics of water,

(Tschobanoglous G. and Shroeder E.D., 1985, p.58). Suspended solid is important indicator of water quality. Increase of total suspended solid directly reduced dissolved oxygen content in water, hence reducing the ability of a water body to support life.

Study shows that, TSS values were higher during wet and dry season in Tasik Chini. The maximum threshold levels for Malaysian rivers according to National Water Quality Standard (NWQS) between 25 to 50 mg l^{-1}. Meanwhile, the threshold level by National Water Quality Standard (NWQS) for supporting aquatic life in fresh water is 150 mg l^{-1}. (Barzani Gassim et al., 2007).

2.4.2 Chemical Parameter

Chemical parameter may refer as the capability of solvent in water. Chemical parameters include, total dissolved solid, alkalinity, hardness, fluorides, metals, organics, and nutrients, (Peavy et al., 1985, p.23). As stated in Water-Quality Engineering Systems, by Chin D.A., 2006, chemical parameter is related to chemical compounds or combinations of compounds which considered toxicity to human and aquatic life, or have potential to occur in water environment at harmful levels.

2.4.2.1 pH

The pH of water is defined as the negative log of the hydrogen-ion activity, (Chin D.A., 2006, p.48).

$$pH = -\log_{10}[H^+]$$

ph is one of the most important chemical factor for aquatic life. If the surface water is too acidic or too alkaline will disrupts the aquatic life cycle. pH scale is from 1 to 14. A solution with pH less than 7 has more H+ activity it is considered as acidic. Meanwhile, pH more than 7 has more OH- and considered as alkaline. According to study conducted by Barzani Gasim et al, 2007, showed that, pH values were higher

during wet season than dry season. For Malaysia Rivers, the threshold level by National Water Quality Standard (NWQS) is 5.00-9.00.

2.4.2.2 Electrical conductivity (EC)

Electrical conductivity is the ability of the solution to conduct electrical current. The ion in water is transport the electrical current. Increases of the conductivity, the ions concentration are increase, (Tschobanoglous G. and Shroeder E.D., 1985, p.91). Other that EC is an alternative way to measure the presence of inorganic dissolved solid such as, chloride, nitrate, sulphate, phosphate, sodium, calcium, magnesium and iron. These substances will increase the conductivity of a water body. Inorganic dissolved solid are important to aquatic life, however, the excessive of these content will harm the aquatic life also decrease the DO level in water body.

2.4.2.3 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the amount of molecular oxygen dissolved in water and one of the most parameter which affects the health of aquatic ecosystem, (Chin D.A., 2006, p.29). According to the study by Mir Sujaul Islam et al., 2012, the DO values were low during rainy season which is from September to December 2006. The main factors that influent the value of DO were photosynthetic activities, seasonal variables and the decomposition of organic matter.

2.4.2.4 Biochemical Oxygen Demand (BOD)

BOD is the amounts of oxygen require to biochemically oxidize by organic matter in presence of water (Chin D.A., 2006, p.33). The BOD readings, tells about how much the oxygen being consumed. BOD levels during dry season were higher compared to wet season. This is due to the large volume of fresh water which diluted the organic matter in surface water which caused the BOD values decreased during the dry season. Most organic matter is biodegradable. The BOD values are usually measures of

the oxygen required for carbonaceous oxidation of a non specific mixture of organic compound rather than of pure compounds, (Tschobannoglous, G., & Schroeder, E. D., 1985, p.107). Due to the study of Said et al, 2008, the Maong River is heavily polluted by organic matters where high biological oxygen demand (BOD) levels because of the land use and activities of the area. The National Water Quality Standards has set the threshold level for Malaysia surface water is 6 mg/L.

2.4.2.5 Chemical Oxygen Demand (COD)

COD is the amount of oxygen consumed when the substance in water is oxidized by a strong chemical oxidant (Chin D.A., 2006, p.37).The National Water Quality Standard (NWQS) has set the threshold level of COD for surface water in Malaysia is 50.00 mg/L. According to previous study by Mir Sujaul Islam et al., 2012, COD level at Tasik Chini was suitable for the support aquatic life as well as for other purpose. The value of COD will increase as the pollution load increased.

2.4.2.6 Nitrogen as Ammoniacal Nitrogen

Presence of ammoniacal nitrogen in surface water may give harm towards the aquatic life and to human life indeed. Because, the ammonia (NH_3^-) contains highly toxic nature and normally ammonia is discharged from industrial waste, municipal and agricultural waste water in large volume. Based on the previous study, by Mir Sujaul et al., 2012, the highest concentration of NH3-N was during wet season which was 0.58 mg/L and the lowest value was 0.110 mg/L during dry season. On wet season, the Pahang River water backflow to Tasik Chini which caused more NH3-N thus stimulating water quality changes in lakes. The maximum threshold level according to National Water Quality Standard (NWQS) for Malaysia surface water is 0.90 mg/L in order to support aquatic life.