THE IMPACT OF MINING ACTIVITY ON WATER QUALITY AT TASIK CHINI

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Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

The purpose of this study is to study the impact of mining activity on water quality at Tasik Chini. Six sampling stations were chosen at Tasik Chini, there are Laut Gumum, Laut Jerangking, Laut Kenawar, Laut Melai, Pulau Bali/PLKN and Tasik Chini Resort. Twenty-six parameters were analyzed based on in-situ and laboratory test and all parameters were analyzed according to National Water Quality Standard for Malaysia (NWQS) and Water Quality Index (WQI). Twelve of from the parameters which are heavy metals concentration (Na, Mg, K, Ca, Fe, Co, Ni, Cu, Zn, Cd, Pb, Sb) were analyzed by run ICP-MS test. Results indicate that low concentration found in water sample. Most of heavy metal concentration increase during wet day but still classified in Class I. Only for Fe at Pulau Balai/PLKN and Cd at Laut Kenawar during wet day classified in Class II. According to the National Water Quality Standard for Malaysia, electrical conductivity (EC), ammoniacal nitrogen (NH_3-N), Phosphate, Nitrate, total suspended solid (TSS) were classified under Class I, while pH, turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total coliform were classified under Class II. For dissolved oxygen (DO) most were classified under Class III but there are two station which are Laut Jerangking and Laut Kenawar during dry day were classified under Class IV. The temperature was within the normal ranges. According to Water Quality Index (WQI), the water at Tasik Chini was classified under Class II, meaning it is suitable for recreational and safe for body contact. Based on result, mining activity is not the main source of pollution at Tasik Chini because low concentration of heavy metal were obtained from the test. Other activities such as agriculture and longing contributed the pollution of water at Tasik Chini.

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji kesan aktivitity perlombongan terhadap kualiti air di Tasik Chini. Enam stesen persampelan telah dipilih di Tasik Chini, antaranya ialah Laut Gumum, Laut Jerangking, Laut Kenawar, Laut Melai, Pulau Balai/PLKN dan Tasik Chini Resort. Dua puluh enam parameter telah dianalisis berdasarkanujian in-situ dan ujian makmal dan kesemua parameter dianalisi mengikut Standard Kualiti Air Negara bagi Malaysia and Indeks Kualiti Air. Dua belas daripada parameter dimana merupakan kepekatan logam berat (Na, Mg, K, Ca, Fe, Co, Ni. Cu, Zn, Cd, Pb, Sb) dianalisis dengan menggunakan ujian ICP-MS. Keputusan menunjukkan bahawa kepekatan logam berat yang rendah dijumpai dalam sampel air. Kebanyakan kepekatan logam berat meningkat pada hari basah tetapi masih dikelaskan dalam Kelas I. Hanya untuk Fe di Pulau Balai/PLKN dan Cd di Laut Kenawar semasa hari kering dikelaskan dalam Kelas II. Berdasarkan Standard Kualiti Air Negara bagi Malaysia, kekonduksian elektrik (EC), nitrogen ammonia (NH_3-N), Fosfat, Nitrat, jumlah pepejal terampai (TSS) telah dikelaskan dibawah Kelas I, manakala pH, kekeruhan, permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD) dan jumlah koliform telah dikelaskan dibawah Kelas II. Bagi oksigen terlarut (DO) kebanyakannya dikelaskan dibawah Kelas III tetapi terdapat dua stesen iaitu Laut Jerangking dan Laut Kenawar semasa hari kering dikelaskan dibawah Kelas IV. Suhu adalah dalam julat normal. Menurut Indeks Kualiti Air (WQI), air di Tasik Chini dikelaskan dibawah Kelas II, ini bermakna ia sesuai untuk aktiviti rekreasi dan selamat untuk sentuhan air pada badan. Berdasarkan keputusan, aktiviti perlombongan bukan sumber utama kepada pencemaran di Tasik Chini kerana kepekatan logam berat yang rendah diperolehi dari ujian. Aktiviti-aktiviti lain seperti pertanian dan perlombongan menyumbang kepada pencemaran air di Tasik Chini.

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
Ca	Calcium
$CaCO_3$	Calcium Carbonate
Cd	Cadmium
Co	Cobalt
COD	Chemical Oxygen Demand
Cu	Copper
DO	Dissolved Oxygen
DOE	Department of Environment
EC	Electrical Conductivity
E.Coli	Escherichia Coli
EPA	Environmental Protection Agency
Fe	Iron
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
K	Pottasium
Fe	Iron
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
K	Pottasium
Mg	Magnesium
mg/L	Milligram per litre
MPN	Most Probable Number
Na	Sodium
NH_3-N	Ammonical Nitrogen
Ni	Nickel
NTU	Nephelometric Turbidity Units
NWQS	National Water Quality Standard
Pb	Lead
Sb	Tin
TSS	Total Suspended Solids
WQI	Water Quality Index
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Approximately 70 percent of earth surface covered by water. The sources are from lakes, rivers, streams, and oceans and it is very important for people for their daily routine such as cleaning, bathing, drinking, washing and so on. One of water source in Malaysia is from lake. Lake is a stagnant water area surrounding by land which connect to rivers, streams, ocean or moving water.

Tasik Chini is the main source of water to the local community around the area. They used the water from lake for their daily activities such as cleaning, washing, bathing and so on. Tasik Chini is the second largest lakes in Malaysia which consist of 12 series of lakes and connected to the Pahang River. There are some human activities give bad impact to the water quality of Tasik chini such as mining, logging, agriculture and the building of infrastructure for resort and National Service Centre near to the lake.

Water quality in lake will be affected by surrounding activity near the lake area. The quality of water is identified in terms of it physically, biological and chemical parameters. According to (Tchobanolous G. and Schorder D, 1985), water quality in lake is about the degradation of natural process of eutrophication. Social development will accelerate the eutrophication process.

Human activities near the lake which handled under control will cause lake water polluted. Water pollution is an additional of material and energy which will caused harmful to human beings, animals and aquatic life whom use the water. Term water

pollution refers to any types of aquatic contamination between two extremes which are a highly productive enriched water body and a body of water poisoned by toxic chemicals which eliminate living organism or even exclude all forms of life, (Shafi, 2005).

1.2 PROBLEM STATEMENT

The iron mine was re-activation at this lake in 2005 because of the high demand for iron. Melai is the largest mining area at Tasik Chini. According to M. B. Gazim et al. 2012, there are logging, iron ore mining, and oil palm activities carry out by local residents at Melai Village upstream of the catchment. Previously, mining was carried out by an appointed mining company, but abandoned once the Government terminated their contract. These activities give bad impact to the environment especially to the water quality of Tasik Chini due to the presence of nutrients and heavy metal.

The mining activity increase heavy metal concentration such as iron (Fe), aluminium (Al), barium (Ba), and magnesium (Mg) in water body (Fernandez, 2012). The effect of heavy metal concentration can harm the health of the lake and its inhabitants. Unwell-operated mining activity will caused increasing of heavy metal concentrations in water body.

1.3 RESEARCH OBJECTIVE

The objectives of study are:

i. To classify water quality at Tasik Chini based on National Water Quality Standard for Malaysia (NWQS) and water quality Index (WQI) on dry and wet day.
ii. To determine the effect of mining activity to water quality at Tasik Chini.

1.4 SCOPE OF STUDY

The scope of study on this research is based on mining activity near at Tasik Chini. Mining activity near Tasik Chini caused of mining runoff which can contributes heavy

metal concentration can affect the water quality at Tasik Chini. This research was conducted from September 2013 until June 2013. There are two types of test were conducted which are in-situ test and laboratory test. 9 laboratory test have been 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, alkalinity test, E-coli test, and total coliform test. For hardness test, Couple Plasma Mass Spectrometry (ICP-MS) was run.

1.5 EXPECTED OUTCOME

i. The data and result obtained useful for water quality for this research.
ii. Water quality for dry and wet day are determine.

1.6 CONCLUSION

As the conclusion, water quality at Tasik Chini effect by mining activity on dry and wet day are determine by Water Quality Standards for Malaysia (NWQS) and Water Quality Index (WQI). Mining activity is one of the effect of water quality on Tasik Chini.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Tasik Chini is chosen for study area because the activities near the lake affected the quality of water in and around the the Tasik Chini. There are many activities near the lake which can contribute to pollution of water quality at Tasik Chini such as logging, mining, agriculture, dam construction, resort, and also National Sercvice Center. It not only give a bad effect to the local community, it is also effect the ecosystem of Tasik Chini. Tasik Chini is a lake which famous with lotus blossom years ago and now overgrown with cactail.

2.2 LAKE

Lake is a body of water which have a large size and localized in a basin and it is surrounded by land. The sources of water from river, stream, or other moving of water into the lake. Lake water is an essential renewable resource for mankind and the environment and it is important for civil, industrial and recreational purpose (Sujaul, 2012).

2.2.1 Tasik Chini

Tasik Chini is second largest lake in Malaysia which located near to Pahang River. This lake was makeup a series of 12 lakes. This lake covers 12,565 acres and consists of various floura and fauna. The lake shores are inhibited by Jakun branch of the Orang Asli. Tasik Chini recently has undergone devastating situation as a lake

environment since 1984 or earlier due to development activities in the surrounding areas such as oil palm plantations and residential developments (M.B. Gasim et el. 2009). The condition of Tasik Chini become worst when a small dam was built in 1995 to retain water in the lake for tourism purposes (Mushfirah Idris & Ahmad Abas, 2005).

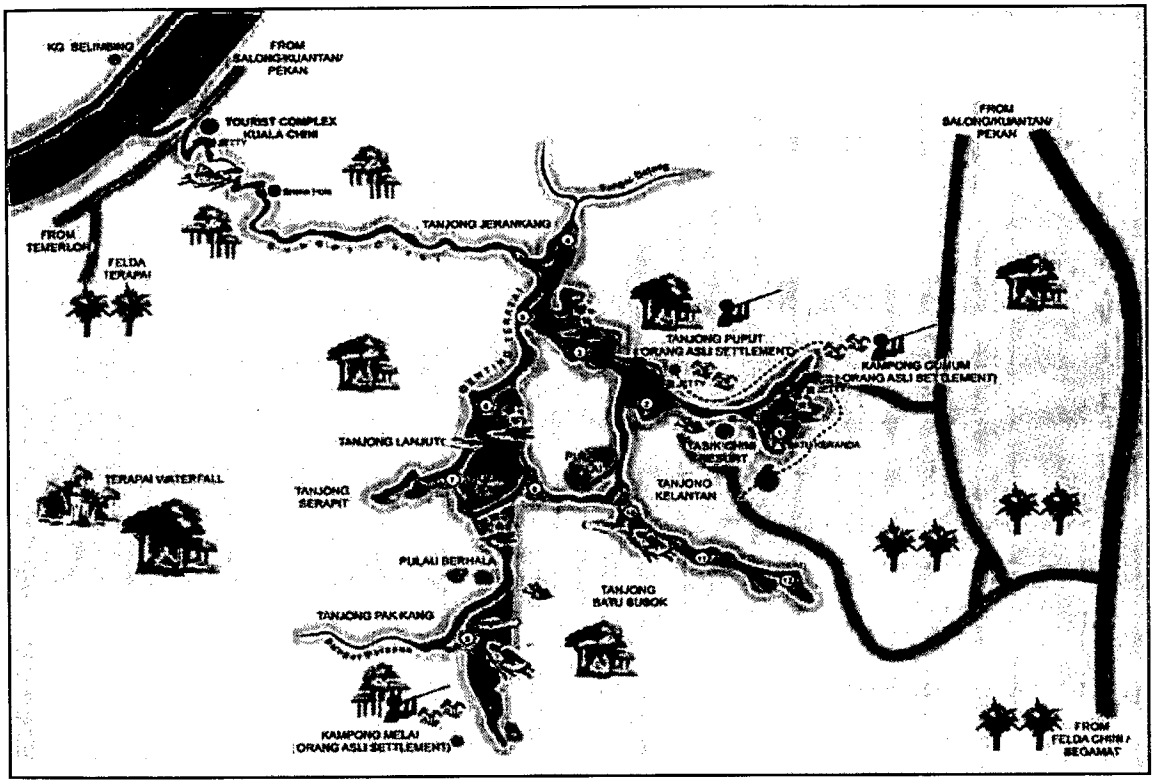

Figure 2.1: Tasik Chini Map

Source: http://www.dromoz.com/directory/place/?id=1062

2.3 MINING

Mining is known as a dirty kind of industry. It has led to the largest environmental disaster zone in the world. Not only effect to the atmospheric air but also the water resources got contaminated and turned potential to inflict harm to living organisms (Shafi, 2005). The mining activity will give bad impact to the water quality because it is contained of heavy metal concentration which can harmful the ecosystem health.

The impact of mining depends on many factors, especially the types of mining and the size of the operation. According to S. R. Warhate et al. 2006, due to lack of proper planning and negligence of regulations, an appreciable amount of environmental degradation and ecological damage to water, air and soil occurs. The mining activities increase heavy metal concentrations such as iron (Fe), aluminium (Al), barium (Ba), and manganese (Mg) in the water body (Fernandez, 2012). In Pollution Prevention and Abatement Handbook 1998, in certain mines where ores have high sulphur content, drainage from mine workings and waste heaps can become highly acidic and can contain high concentrations of dissolved heavy metals.

During mining, a large amount of waste rocks/ overburden is deposited on land in dumping yard. Overburden (OB) deposits generated from mining activities conctitute a potential risk to environment through leaching of potential toxic elements hosted by a variety of minerals present in mine-waste materials (Verma et al., 2010).

2.3.1 Background of mining activity at Tasik Chini

The environment of Tasik Chini changes since 1984 or earlier because of the development in surrounding areas through human activities such as mining, logging, oil palm plantation, and also building infrastructure for the National Service Centre. Melai and Batu Busuk are the mining area at Tasik Chini and the largest mining area is Melai.

Some of the mine, where iron ore is extracted, operate just 50m from the lake's adge (M. D. limonick, 2009). Previously, mining was carried out by an appointed mining company, but abandoned once the Government terminated their contract. The iron-ore mine was re-activation in 2005 because of high demand for iron.

2.4 HEAVY METAL

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. It usually present at low concentration in freshwaters (Le Faucheur et al., 2006).

2.4.1 Heavy metal concentration in water

The presence of heavy metal concentration in water is effect by human activities near the water body. The presence of metals in environment increases either directly via atmospheric deposition, wastewater discharge and runoff (eg Pb, Hg, Cd, Cu and Zn), or indirectly as a result of increased solubilisation and mobilisation from sediments (eg Al and Fe), (N. Riethmuller et el.).

2.4.2 Heavy metal pollution

Heavy metal pollution occur from the purification of metals and it will give bad impact to the environment. The most water pollution is from mining activities. To release heavy metals from ores, they used an acid mine because metals are very soluble in an acid solution. The heavy metal from iron ore operation will affect the environment and aquatic life in lake.

It is a same case at north-western Russia were heavy metal from iron-ore mining effluents on fish gills (Victoria Tkatcheva at el, 2003). This heavy metal pollution not only dangerous to health or the environment, it also can cause corrosion and harmful in other ways.

2.5 WATER QUALITY

According to Water Quality Standard Book, (2002), "A water quality standard is defined as the designated beneficial uses of waters segments and the water quality criteria necessary to support those uses". Water quality is refer to the physical, chemical and biological characteristic of water.

2.5.1 Physical parameter

Physical parameter have strong effect by chemical and biological parameter. Basically, turbidity, temperature and total suspended solid are physical parameter

determined in water quality study. Physical parameter can be determine by conduct in-situ test.

2.5.1.1 Turbidity

Turbidity is a measure of how particles suspended in water affect by water clarity. It is an important indicator of suspended sediment and erosion levels. Typically it will increase sharply during and after a rainfall, which causes sediment to be carried into the creek. Elevated turbidity will also raise water temperature, lower dissolved oxygen, prevent light from reaching aquatic plants which reduces their ability to photosynthesize, and harm fish gills and eggs, (Sharon Behar, 1997).

2.5.1.2 Temperature

Water temperature is affected by air temperature, stormwater runoff, groundwater inflows, turbidity, and exposure to sunlight. In considering the health of organism, it is necessary to consider their maximum temperature and optimum temperature. The maximum temperature is the highest water temperature at which organism will live for a few hours. The optimum temperature is the temperature at which it will thrive, (Sharon Behar, 1997).

2.5.2 Chemical parameter

There are nine chemical parameter were tested in this study which are pH, dissolved oxygen (DO), electrical conductivity (EC), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, nitrate, phosphorus and alkalinity.

2.5.2.1 pH

pH is a measure of a solution's acidity. In water, small numbers of water molecules (H2O) will break apart or disassociate into hydrogen ions (H+) and hydroxide ions (OH-), (Sharon Behar, 1997). pH measured in scale 1 to 14 with 1 being

acid, 7 is neutral, and 14 is alkaline. The largest variety of freshwater aquatic organism prefer a pH range from 6.5 to 8.5.

2.5.2.2 Dissolved Oxygen

Dissolved oxygen is oxygen gas molecules (O_2) present in water. Plants and animals cannot directly use the oxygen that is part of water molecule (H_2O), instead depending on dissolved oxygen for respiration, (Sharon Behar, 1997).

2.5.2.3 Electrical conductivity

According to Missouri Department of Natural Resources, "conductivity is a measure of how well water can pass an electrical current. It is an indirect measure of the presence of organic dissolved solids such as chloride, nitrate, sulphate, phosphate, sodium, magnesium, calcium, iron and aluminium. The present of this substances increases the conductivity of a body of water. Organic substances like oil, alcohol, and sugar do not conduct electricity very well, and thus have a low conductivity in water'.

2.5.2.4 Biochemical Oxygen Demand

Ndimele (2012), "BOD is an indication of the organic load and it is a pollution index especially for water bodies receiving organic effluent". According to Sujaul et al., (2012), in the dry season, the metabolic activities of various aerobic and anaerobic micro-organisms increased with the higher water temperature thus causing considerable decrease in the level of water. But during wet season the large volume of fresh water diluted the organic matter resulting in decrease of the BOD values.

2.5.3.5 Chemical Oxygen Demand

Based on W.A.Amneera et al., (2013), COD test predicts oxygen requirement during the decomposition of organic matter and the oxidation of inorganic chemicals. Normally, the value of COD is higher than that of the BOD. Theoretically, if COD concentration is higher than the water considered polluted. The value of COD and BOD

were increased with increase in the pollution load (Varunprasath, K. and A.N. Daniel, 2010).

2.5.3.6 Ammoniacal Nitrogen

Ammoniacal nitrogen is measure for the amount of ammonia in toxic pollution. It can be found in landfill leachate and waste products. Ammonia not only give a bad effect to the environment, it also can directly poison humans. The INWQS maximum threshold level for ammoniacal nitrogen in Malaysia surface water is 0.90 mg/L in order for it to be able to support aquatic life (Sujaul et al, 2012).

2.5.3.7 Nitrate

Nitrate is a required nutrient for plants. Nitrate help in algea and plant growth and contributes to lower oxygen level and high turbidity in water. The high value of nitrate concentration in drinking water can cause a diseases called methamiglobinemia. The source of nitrogen pollution in water is waste from sewage treatment plant, septic tanks and feed lot discharge. The non-point sources are from leachate of soil through runoff, animal's wastes and waste disposal in dumps.

2.5.3.8 Phosphorus

Phosphorus is a critical element in plant biochemistry. Phosphorus-containing compounds are involved in energy capture during photosynthesis, carbohydrate metabolism, and protein and nucleic acid synthesis. It is absorbed into plants in the form of phosphate through an energy-requiring process (Lunique et al, 2001).

2.5.3.9 Alkalinity

According to Environment Protection Authority (2012), "alkalinity is a measure of the buffering capacity of the water to neutralise acids resist pH change, Alkalinity within water bodies is consumed as acid is released from acid sulphate soils. Adding limestone contributes alkalinity to waters, helping to neutralise any acid released from

the sediments. Historically, alkalinity levels within this region have been between 80 and 250 mg/L as $CaCO_3$.

2.5.4 Biological parameter

The biological parameter for this study are total coliform and Esherichia coli.

2.5.4.1 Total Coliform

Total coliform and fecal coliform bacteria were used as indicator for fecal pollution in this lake. Membrane filtration technique was used to enumerate these organism (Ainon Hamzah and Yanti Hattasrul, 2008). The source of this total coliform is from human and animal wastes, domestic effluent and effect from land use at surrounding.

2.5.4.2 Esherichia Coli

Escherichia coli is naturally present in the intestinal tracts of warm-blooded animals. Since E. coli is released into the environment through deposition of fecal material, this bacterium is widely used as an indicator of fecal contamination of waterways (Satoshi Ishii and Micheal J. Sadowsky, 2008). According to Ainon Hamzah, 2008, "E. coli is not supposed to be found in drinking water. But we found high levels of it in the wells. The bacteria can be removed by boiling the water".

2.6 INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY

According to Chemistry 322L Manual, "Inductively coupled plasma mass spectrometry (ICP-MS) is an analytical technique that performs elemental analysis with excellent sensitivity. The ICP-MS instrument employs an argon plasma (ICP) as the ionization source and a mass spectrometer (MS), usually with a quadrupole mass filter, to separate the ions produced. It can simultaneously measure most elements in the periodic table and determine analyte concentrations down to the sub-nanogram per liter, or parts per trillion (ppt), level".

Inductively coupled plasma mass spectrometry (ICP-MS) was used to analyze the cations (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cu^{2+}, Co^{2+}, Fe^{2+}, Ni^{2+}, Zn^{2+}, Pb^{2+}, Sn^{2+}, Mn^{2+}, Cd^{2+}) in the samples (M.L. Meck et al, 2011). The advantage of this method is it can use to trace multi-element in water sample.

2.7 WATER QUALITY STANDARD

Water quality standard is a water quality criteria have been stated by an agency to define the usage of water. Every uses have different concern therefore different standard has provided. This standard can used in identify the source of pollution and classified the water quality parameters. In this study, DOE- Water Quality Index and National Water Quality Standard for Malaysia were used in classified the class of parameter.

2.7.1 Department of Environment – Water Quality Index

Based on Sujaul et al. (2012), "Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water". Water Quality Index (WQI) calculations involves six basic parameters, namely dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO_3-N), pH and total suspended solid (TSS), (W.A.Amneera et al., 2013).

The WQI equation based on DOE- Water Quality Index:

$$WQI = 0.22(SIDO) + 0.19(SIBOD) + 0.16(SICOD) + 0.15(SIAN) + 0.16(SISS) + 0.12(SIpH)$$

2.7.2 National Water Quality Standard

National Water Quality Standard is a standard of water quality which used as a guideline in classify the water quality parameter in water quality study. The