ANALYSIS OF SURFACE WATER CONTAMINATION BY HEAVY METAL FROM DEMAK LAUT INDUSTRIAL PARK

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DECLARATION

I hereby declare that this dissertation is based on my original work except for quotation and citations which been duly acknowledged.

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ANALYSIS OF SURFACE WATER CONTAMINATION BY HEAVY METAL FROM DEMAK LAUT INDUSTRIAL PARK

ABSTRACT

Surface water is the main source of available water which is getting polluted all over the world in many ways. Anthropogenic activities are the main causes of the pollution. The main sources of toxic heavy metals were possible wastewater and effluents from major industries, especially the chemical, polymer, metal, petrochemical gas and energy, and wooden industries that generated the organic and inorganic pollutions which ultimately contaminated the river water. Therefore, the main objective of this study is to monitor the heavy metal contamination in Sungai Santubong, which is close to industrial park in Kuching, Sarawak named Demak Laut Industrial Park. This industrial park comprises of industrial of wood processing, furniture manufacturing, food processing and some machinery factory. After the construction of the barrage, this industrial park is not connected to Sungai Sarawak anymore and its discharge is directed to Sungai Santubong. River water was sampled at 10 cm and 1 m below the surface river water using Depth Sampler. Collected water samples were transferred into 200 millilitre plastic bottle and acidified to pH 2 using nitric acid. All water samples were kept in ice box at 4 °C and transported to the laboratory for analysis. Portable Data logging Colorimeter DR/890 and Atomic Absorption Spectrophotometer (AAS) were used to analyse water sample for detection of Cd, Pb and As. Reagents and quality assurance high purity chemicals and reagents were purchased from Merck and Aldrich Chemical Company. Zn and Ni have significant concentration at 10 cm and 1 m depth above surface river water. Whereas others heavy metals have no significant different at 10 cm and 1 m depth above surface river water. The concentration of Cd at 10 cm and 1 m depth from surface river water is 0.02 mg/L in level allowed based on Standard B Environmental Quality Regulation (Discharge and Industrials Effluent) 1979 where the requirement based on Standard B is 0.02 mg/L. Other heavy metals are below Standard B requirement. Only Fe and Ni have significant different concentration at 10 cm and 1 m depth above surface river water.

Key words: Surface Water Contamination, Heavy Metal, Demak Laut Industrial Park.
ANALISA AIR PERMUKAAN YANG TERCEMAR DENGAN LOGAM BERAT DARI KAWASAN PERINDUSTRIAN DEMAK LAUT

ABSTRAK

Air permukann ialah sumber utama air dunia tersedia yang mana kebanyakkannya semakin tercemar. Aktiviti-aktiviti antropogenik ialah antara punca utama pencemaran. Logam berat yang toksik adalah buangan yang banyak mencemarkan sumber air permukaan sama ada ia berpunca dari air buangan dan efluen dari industri utama, terutamanya industri kimia, polimer, logam, gas petrokimia dan industri-industri kayu yang menghasilkan pencemaran organic dan tak organik yang akhirnya mencemarkan air sungai tersebut. Logam berat paling toksik Cr, Ni, Pb dan As. Ni and Cd pula adalah karsinogenik manakala As dan Cd teratogenik. Pb akan memberi kesan kepada neurologi dan kerosakan sistem saraf pusat. Walaupun beberapa logam berat seperti Fe, Mn, Cu dan Zn adalah mikronutrien dan diperlukan oleh flora dan fauna, tetapi ia akan merbahaya jika pada kepekatan yang tinggi. Kawasan Industri Demak Laut berkedudukan di utara tambak Kuching. Di kawasan industri tersebut terdiri daripada perindustrian pemprosesan kayu, pembuatan perabot, pemprosesan makanan dan beberapa kilang pembuatan mesin. Setelah pembinaan tambak, kawasan perindustrian ini telah terpisah dari Sungai Santubong dan pelepasan sisa kumbahan diarahkan terus ke Sungai Santubong. Sampel air sungai diambil pada kedalaman 10 cm dan 1 m menggunakan depth sampler. Sampel air yang dikumpul dipindahkan ke dalam botol plastik 200 mililiter dan diasidkan kepada pH 2 menggunakan asid nitrik. Semua sampel air disimpan disimpan di dalam bekas ais dengan suhu pada 4 °C dan dihantar ke makmal untuk dianalisis. Data logging mudah alih calorimeter DR/890 untuk mengesan kandungan logam berat dalam sampel air. Manakala atomic absorption spectrophometer (AAS) digunakan untuk menganalisa sampel air untuk mengesan Cd, Pb dan As. Reagen dan bahan kimia yang berkualiti tinggi dibeli dari Merek and Aldrich chemical company. Zn dan Ni mempunyai keputusan yang signifikan pada 10 cm dan 1 m dari kedalaman di atas permukaan sungai. Manakala logam lain tidak mempunyai keputusan yang signifikan pada kedalaman 10 cm dan 1 m dari permukaan air sungai. Kepekatan Cd pada 10 cm dan 1 m dari permukaan air sungai 0.02 mg/L iaitu masih pada peringkat yang dibenarkan berdasarkan Piawai B Peraturan Kualiti Alam Sekeliling (Kumbahan dan Efluen Industri) 1979. Logam berat lain adalah masih dibawah paras Piawai B. Zn dan Ni yang mempunyai perbezaan yang signifikan pada kedalaman 10 cm dan 1 m dari permukaan air sungai.

CHAPTER 1

INTRODUCTION

1.1 Background

Having good water quality is important for healthy river and ecosystem. Several basic conditions must be met for aquatic life to thrive in the water. When these conditions are not optimal, species populations become stressed. When water qualities are poor, organisms may die. Thus, various water quality parameters need to be monitored in order to determine the health of river water for safe to use for any purpose.

Surface water is the main source of available water which is polluted all over the world in many ways. Anthropogenic activities are the main cause of the river pollution. Point source pollution includes sewage treatment, manufacturing and agro-based industries and animal farms. Non-point sources are defined as diffused sources such as agricultural activities and surface runoffs. The situation of water pollution in Malaysia is becoming more serious. As Malaysia is fast becoming an industrial country, many of rivers have become polluted due to the many wastes that have been poured out into the rivers.
Rivers are used as an outlet for the chemicals to drain away which turn harming the waters and the lives that revolve around them. The main sources of toxic heavy metals were possible wastewater and effluents from major industries, especially the chemical, polymer, metal, petrochemical gas and energy, and wooden industries that generated the organic and inorganic pollutions which ultimately contaminated the river water (Hossain et. al, 2013).

River can be readily contaminated by human activity without any obvious signs. They have long attracted scientific and environmental interests to the researchers. Among the various pollutants, heavy metals are the most toxic, persistent and abundant that can accumulate in aquatic habitats and their concentration increases through biomagnifications. The most toxic heavy metals Cr, Ni, Pb and As. Ni and Cd are carcinogenic whereas As and Cd are teratogenic. Pb will give neurological impairment and malfunctioning of the central nervous system. Although some heavy metals such as Fe, Mn, Co, Cu and Zn are essential micronutrients for fauna and flora, they also dangerous at high levels. For organism living in river, essential and non-essential heavy metal content may part of significant impact on health, reproduction and survival. Contaminants may eventually pass through the food chain to human and result in a wide range of adverse effects.
Heavy metals are chemical elements mostly with density greater than 4 g/cm³ found in all kinds of soils, rocks and water in terrestrial and freshwater ecosystems. The very low general level of their content in soils and plants as well as the definite biological roles of most of them makes them microelements. They occur in typical background concentrations of these metals relative to their normal background values. When these occur, heavy metals are considered serious pollutants because of toxicity, persistence and non-degradable conditions in the environment, thereby constituting threat to human beings and other forms of biological life (Adeleken and Abegunde, 2001).

In Malaysia, rivers as an important water source which is not only for drinking but also for irrigation, industrial use, washing purpose and etc. As an important as water sources, rivers also pose risk polluted by manmade activities especially from industrial discharge and the most of imported pollution discharge into river water is heavy metals, which threaten the aquatic life as well as the ecological system in the river.

Similar to West Malaysia, Sarawak especially at Kuching Division also has industrial development which is very important in economic growth. In Kuching, the industrial development has also been heavily concentrated in the eastern sector of Kuching, with the development of Demak Laut and Sama Jaya industrial estate. Demak Laut Industrial Park is likely to continue to expand to joining areas to the north and west, as it is strategically located near the Senari Port. The existing industries will also potentially attract other related industries to locate to the area. It comprises of
industrial of wood processing, furniture manufacturing, food processing and some machinery factory.

**Figure 1.1:** Demak Laut Industrial Park Phase I

After the construction of the barrage, this industrial park is not connected to Sungai Sarawak anymore and its discharge is directed to Sungai Santubong. The receiving river acts as transporting agents which eventually brings all these pollution loads into Sungai Santubong. For analysis purposes of this study, all pollution sources were assumed to discharge their wastewater into Sungai Santubong.
1.2 Problem Statement

Rivers play an important role in assimilating or carrying off industrial and municipal wastewater, manure discharges and runoff from agricultural fields, roadways and streets beside constitute the main water resources in inland parks for drinking, irrigation and industrial purposes. As known, rivers are most vulnerable to pollution due to their easy accessibility for disposal of wastewater.

Industrial wastewater often cause river to being polluted with heavy metal and it is difficult to detect and clean compare to solid waste from residential. In 2009, as reported by Statistic Department of Malaysia, the readings or average concentration for all the five heavy metals which are mercury, cadmium, arsenic, lead and zinc increased when compared to previous year (Statistic Department of Malaysia, 2009). The source of heavy metal in rivers came from land surface runoff, rainfall precipitation and factory waste outlet point discharge (Idris and Ahmad, 2012). The major industries that discharges are chemical, polymer, metal, petrochemical gas and energy, and wooden industries. Most of these types of industries have generated the organic and inorganic pollutants which ultimately contaminated the river water (Hossain et. al, 2013).
Urban and industrial activities are introducing heavy metals into marine environment. When the concentration of heavy metal exceed the standard it will have toxin effects on living organisms which will cause decrease of survival, growth and species diversity (Sany et. al, 2011). Although some of heavy metals are required as micronutrients, it can be toxic when present higher than the minimum requirement (Idris and Ahmad, 2012). High concentration of Al can cause hazard to brain function such as memory damage and convulsion. In additional, there are studies suggested that Al is linked to the Alzheimer disease. Cd is harmful to both human and aquatic ecosystems. Cd is carcinogenic, embryotoxic, teratogenic and mutagenic and may cause hyperglycemia, reduced immunopotency, and anemia, as it interferences with our metabolism. Furthermore, Cd in body has been shown to result in kidney and liver damages and deformation of bone structures.

Cr is essential nutrient for animal and essential to ensure human and animal lipids effective metabolism but Cr is carcinogenic. Cr is the most toxic form and having equivalent toxicity to cyanides. It can cause skin ulcer, convulsion, kidney and liver damage. Moreover, it can generate all types of genetic effects in the intact and in the mammals in vivo. It has also been reported that intensive to Cr compound may lead to lung cancer in man.

Fe is an essential element in several biochemical and enzymatic processes. It involved the transport of oxygen to cells. However, at high concentration, it can increase the free radicals production, which is responsible for degeneration diseases and ageing. Pb
could accumulate in kidney, liver, bone and brain. Chronic intoxication can lead to encephalopathy mainly in children. Ni is an essential element to both plant and human, but high exposure to this metal can lead to cancer in organs of breathing system, cardiovascular and kidney disease. Zn is an essential element to human and plant. Recent studies indicated that Zn is also involved in bone formation. However, elevated intake of Zn can cause muscular pain and intestinal haemorrhage.

1.3 Study Objectives

i. To determine the presence of heavy metal in surface river water.
ii. To determine the concentration of heavy metal in surface river water.
iii. To compare the current concentration of heavy metal in surface water with Malaysia Standard.

1.4 Study Justification

The objective of this study is to determine the presence of heavy metal in surface river water of Sungai Santubong due to industrial activities at Demak Laut Industrial Park. Surface river water commonly polluted by point source and non point source pollutant. Rubbish is a common surface river water pollutant but through rubbish trap it easy to remove from surface river water. Some of pollutant such as heavy metal is not easy to remove from surface river water. Industrial discharge to river is a major source of presented of heavy metal at river water whether at surface river water or at water sediment.
The significant of this study is to determine the concentration of heavy metal in surface river water at Sungai Santubong and compare current concentration of heavy metal on surface river water with International Water Quality Standard, Malaysia. Water quality is important to balance the ecosystem in that area. Some of living organisms are sensitive to presented of heavy metal even in small amount and certain organism can accumulate the heavy metal in adipose tissue or muscle.
CHAPTER 2

LITERATURE REVIEW

2.1 Source of Surface Water Contamination

Industrial waste is a major point source of water pollution and likely to know that the source of this pollution is a common cause of deterioration of water quality. Unlike pollution from industrial and sewage treatment plants, nonpoint source (NPS) pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters. Nonpoint source pollution is the leading remaining cause of water quality problems. Effluent can enter surface water through runoff from over application from irrigators, overflowing ponds, intensive grazing next to watercourses and cattle directly standing in waterways, food court outlets and industrial estate activities. Effluent discharge to surface water, affects water quality and their living organism. Differences among species in sensitivity to a single chemical can vary an order of magnitude and possibly up to seven orders of magnitude. Moreover, the sensitivity of a species can vary from a toxicant to another one (Sai’idi, 2010). More seriously, contaminated water destroys aquatic life and reduces its reproductive ability.
2.2 Industrial Waste Discharged Into River

Rapid expansion of industrial activity has significantly accelerated the risk of environmental pollution with heavy metals and the common dumping site is water body. Anthropogenic inputs from the natural are the basis of environmental management. Heavy metals discharge into river both natural and anthropogenic sources are distributed between bed sediments and aqueous phases. The input of waste into river not always impact negatively on aquatic environment because of the self-purification property of the water (Reza et al., 2010). However the untreated waste may contain toxic compounds. Once pollutants enter the water bodies, they can get dissolved or suspended in water or deposited in bed.

2.3 River Water Contaminated By Heavy Metal

Water pollution is a complex process that leads to changes in water composition especially in aquatic flora and fauna. Many result in a poor condition, water quality for economic and recreational use, being dangerous to human health. Importance of trace metal concentration evidence in natural waters and/or environment is growing for the pollution monitoring studies. Traces of metal ions have important roles in a wide spectrum of function for life. Some of these toxic trace metal levels are high, such as poisoning by Fe, Pb and Ni will affect the central nervous system. Heavy metals presence in nature usually is not dangerous for the nervous system. Heavy metals presence in nature usually is not dangerous for the environment because they are
present only in very small quantities. Heavy metals are pollutant in environment only if heavy metal present in large quantities.

Some of chemical discharged from industrial wastewater almost contain certain metals which are able to accumulate in the environment following their release, either within sediments or in some cases can accumulate in living organism in that area (Brigden et. al, 2009). Continuous discharges of these chemicals are likely to lead to ever increasing levels in receiving levels in the receiving environment. The toxic discharged of heavy metal into river are not accumulated through the food chain but may also either limit the number of living organism or reduce the production of organisms. Indirectly this pollution will affected and significantly weaken biodiversity (Damodharan, 2013).

2.4 Harmful Effects Resulting From Heavy Metals Contamination of Surface and Ground Waters

Trace amount of metals are common in water and these are normally not harmful to our health. In fact, some metals are essential to sustain life. Calcium, magnesium, potassium and sodium must be present for normal body functions. Cobalt, copper, iron, manganese, molybdenum, selenium and zinc are needed at low levels as catalyst for enzyme activities (Salem et.al, 2000). Drinking water containing high levels of
these essential metals, or toxic metals such as aluminium, arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver, may be hazardous to our health.

A number of effects result from heavy metal contamination which can affect both the environment and health as well. Environmental effects from these heavy metal contaminations can include contamination concentration at the bottom of water bodies, interference with proper nutrient uptake, crop and atmospheric contamination, impaired drinking, surface and ground waters, interference with proper soil functioning, adverse effects in wildlife and fish populations and the propagation of concentrated amounts of metals throughout the food chain.

Human health effects are highly dependent on ingested dosage but can range from excessive shyness, to changes in sensory perception, to simple stomach ailments, nausea vomiting and diarrhoea, to blood, lung, kidney, brain, pancreas and bone complications or diseases as well as immune and nervous system impairments and even death. Heavy metal pollution is highly dangerous to young children, as well as unborn foetuses.

Exposed to low level of arsenic for an extended period of time it may cause a dislocation of skin, the appearance of corns or warts, decreased nerve conduction velocity and various forms of cancer affecting skin, lung, digestive tract, liver, bladder and kidneys. Arsenic also has potential to affect the lymphatic and blood systems. One