DETERMINATION OF HEAVY METALS IN GAMBANG LAKE WATER

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ABSTRACT

Heavy metals are a major concern in the treatment of water due to the toxic and other harmful effects these materials can produce. The objective of this study was to determine the heavy metals contains in Gambang Lake water. The water samples were collected from five sampling points around the lake. Samples were analysed using Atomic Absorption Spectroscopy (AAS) at which this instrument is possible to determine about 70 elements (mainly metal) at very low concentration. The metals analysis was done to detect lead, ferum, copper and magnesium. Based on the result, ferum recorded as the highest concentration ranged between (0.055 – 0.183) ppm, while lead recorded concentration ranged between (0.097 – 0.141) ppm and magnesium recorded concentration 0.08 ppm. Copper recorded as the lowest concentration; 0.013 ppm. Result of water quality shows that Gambang Lake is classified between classes I to II using Water Quality Standard. According to this standard, Gambang Lake has moderate quality which is suitable for daily usage and recreational.

ABSTRAK

Logam berat adalah menjadi satu kebimbangan utama dalam rawatan air disebabkan oleh toksik dan kesan bahaya lain yang boleh terhasil. Objektif kajian ini ialah untuk menentukan logam berat yang terkandung di dalam air di Tasik Gambang. Sampel air dikumpul daripada lima lokasi pensampelan di sekitar tasik. Sampel dianalisis menggunakan Atomic Absorption Spectroscopy (AAS) di mana instrumen ini berkebolehan dalam menentukan kira-kira 70 elemen-elemen (terutamanya logam) pada kepekatan yang sangat rendah. Analisis logam telah dilakukan untuk mengesan plumbum, ferum, kuprum dan magnesium. Berdasarkan keputusan itu, ferum mencatatkan kepekatan tertinggi iaitu antara (0.055 – 0.183) ppm, manakala plumbum mencatatkan antara (0.097 – 0.141) ppm dan magnesium mencatatkan 0.08 ppm. Kuprum mencatatkan kepekatan terendah iaitu 0.013 ppm. Keputusan menunjukkan bahawa Tasik Gambang diklasifikasikan antara Kelas I hingga Kelas II menggunakan Standard Kuanliti Air. Menurut piawaian ini, Tasik Gambang mempunyai kualiti yang sederhana yang mana sesuai untuk kegunaan harian dan rekreasi.

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LIST OF ABBREVIATIONS

WQI	-	Water Quality Index
BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
NH_3N	-	Ammonical Nitrogen
SS	-	Suspended Solid
DO	-	Dissolved Oxygen
EPA	-	Environmental Protection Agency
AAS	-	Atomic Absorption Spectroscopy
Fe	-	Ferum
Pb	-	Lead
Mg	-	Magnesium
Cu	-	Copper
Al	-	Aluminium
Ca	-	Calcium
Zn	-	Zinc
Cd	-	Cadmium
HNO_3	-	Nitric Acid

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water covers almost 70.9% of the Earth's surface and is vital for all known forms of life (Saraswathy et al., 2009). Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substance. Water can be classified into several types such as drinking water, safe water, wastewater and black water.

Wastewater can be defined as used water. It includes substances such as human waste, food scraps, oils, soaps and chemicals. In homes, this includes water from sinks, showers, bathtubs, toilets, washing machines and dishwashers. Businesses and industries also contribute their share of used water that must be cleaned. Wastewater also includes storm runoff. Although some people assume that the rain that runs down the street during a storm is fairly clean, it isn't. Harmful substances that wash off roads, parking lots, and rooftops can harm our rivers and lakes.

Wastewater also can be described as any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewater from different sources. It contains foreign substances such organic particles, inorganic particles, metals and others which tends to degrade the quality of water. These foreign substances in water set the physical and chemical parameters of the water. Some of them may be toxic to the aquatic ecosystem while others may constitute nutrients for aquatic microorganisms (Boukori et al., 1999).

Metals are frequently released in large quantities during different process derived from human activities and may lead to major destruction of aquatic ecosystems. Moreover, human beings located at places contaminated by heavy metals could be especially sensitive to these contaminants due to the bioaccumulation. These metals manifest themselves within the soft tissues of the body and may cause gastrointestinal, neurological, and other serious illness if left untreated. The metals can accumulate in bone, hair and in some soft tissues, such as the liver, kidney, brain or lung. Heavy metals become poison to the body when the elements deposit in soft tissue and remain there due to the body's inability to metabolize them.

Pollution is the introduction of a contaminant into the environment. It is created mostly by human actions, but can also be a result of natural disasters. Pollution has a harmful effect on any living organism in an environment, making it virtually impossible to sustain life. Pollution harms the Earth's environment and its inhabitants in many ways. The three main types of pollution are land, air and water pollution.

The water pollution in Malaysia is originated from point sources and non-point sources. Point sources that have been identified include sewage treatment plants, manufacturing and agro-based industries and animal farms. Non-point sources are mainly diffused ones such as agricultural activities and surface runoffs. According to Malaysia Environment Quality Report 2004, the Department of Environment has recorded 17,991 water pollution point sources in 2004 comprising mainly sewage treatment plants (54%), manufacturing industries (38%), animal farms (5%) and agro-based industries (3%). The distribution of the water pollution sources is shown in Figure 1.1.

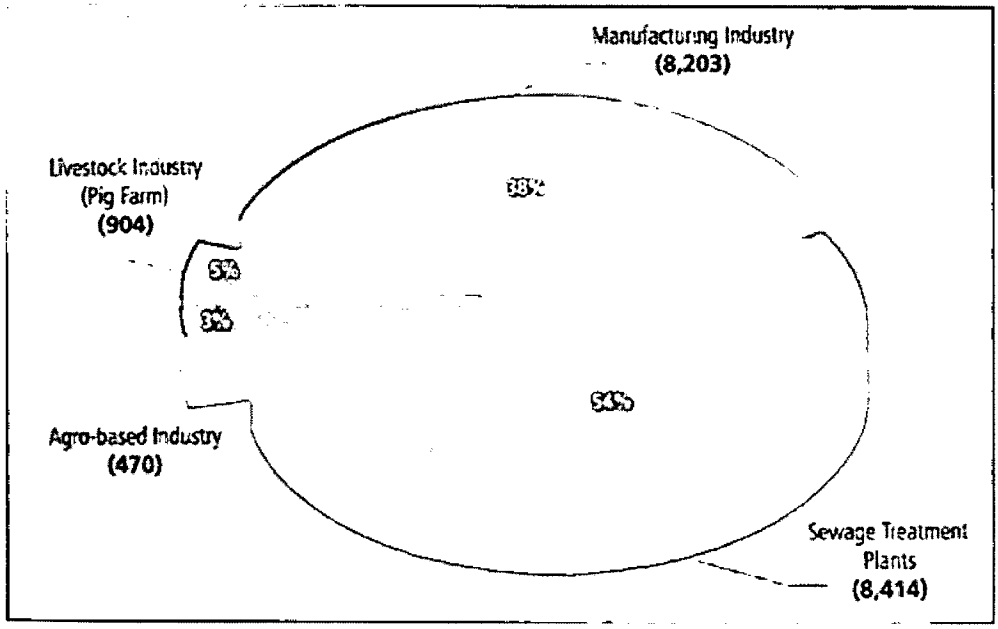

Figure 1.1: Composition of Water Pollution Sources by Sector, 2004

In Malaysia, there are some studies on heavy metals in lakes and rivers such as Bera Lake, Lake Chini, Kenyir Lake and Rompin River were conducted (Shuhaimi-Othman et al., 2007; Mushrifah and Ahmad, 2005; Ebrahimpour and Mushrifah, 2008, 2009). Lake Chini is one of the tourism attraction destinations that have wide swamp areas and can be considered as pristine. This wet land can react to

control water quality and quantity, maintain ecological system and also as a habitat for various species of flora and fauna. Heavy metals measured at Lake Chini were iron (Fe), aluminium (Al), zinc (Zn), lead (Pb), copper (Cu) and cadmium (Cd). Based on the Malaysia WQI, the water in Lake Chini is classified as class II, which is suitable for recreational activities and allows body contact.

Water quality is the physical, chemical and biological characteristic of water. For scientific and legal purposes the following definition is most often used water quality is the ability of a water body to support all appropriate beneficial uses. Beneficial uses are the ways in which water is used by humans and wildlife, drinking water and fish habitat are two examples. If water supports a beneficial use, water quality is said to be good or unimpaired. If water does not support a beneficial use, water quality is said to be poor or impaired.

Water quality index (WQI) is a weighted average of selected ambient concentrations of pollutants usually linked to water quality classes. Water quality data were used to determine the water quality status weather in clean, slightly polluted or polluted category and to classify the water in Class I, II, III, IV or V based on water quality index (Appendix A). Water quality index are calculated based on the following parameters:

i. Biochemical oxygen demand (BOD)
ii. Chemical oxygen demand (COD)
iii. Ammonical nitrogen (NH_3N)
iv. pH
v. Dissolved oxygen (DO)
vi. Suspended solids (SS)

The water quality index has been considered to give criteria for surface water classification based on the use of standard parameters for water characterization

(Couillard et al., 1985). The index is a mathematical instrument used to transform large quantities of water characterization data into a single number, which represents the water quality level. The use of WQI is a simple practise, which allows adequate classification of water quality. The determination of WQI requires a normalization step where each parameter is transformed into a 0 – 100 scale, where 100 represents the maximum quality (Sanchez et al., 2006).

As referred to Figure 1.2, atomic absorption spectroscopy (AAS) is a very common technique for detecting metals and metalloids in environmental samples. It is very reliable and simple to use. The technique is based on the fact that ground state metals absorb light at specific wavelengths. Metal ions in a solution are converted to atomic state by means of a flame. Light of the appropriate wavelength is supplied and the amount of light absorbed can be measure against a standard curve. Although the atomic absorption spectrophotometer is quite expensive, the technique is very wide-spread, but it is possible to determine about 70 elements (mainly metals) at very low concentrations. The sample is atomised at a very high temperature (2500-3000 °C) and the free atoms have line spectrum. It means that they can only absorb the energy of light at discrete energy levels according to the excitations of electrons. That makes very sensitive quantitative measurements possible.

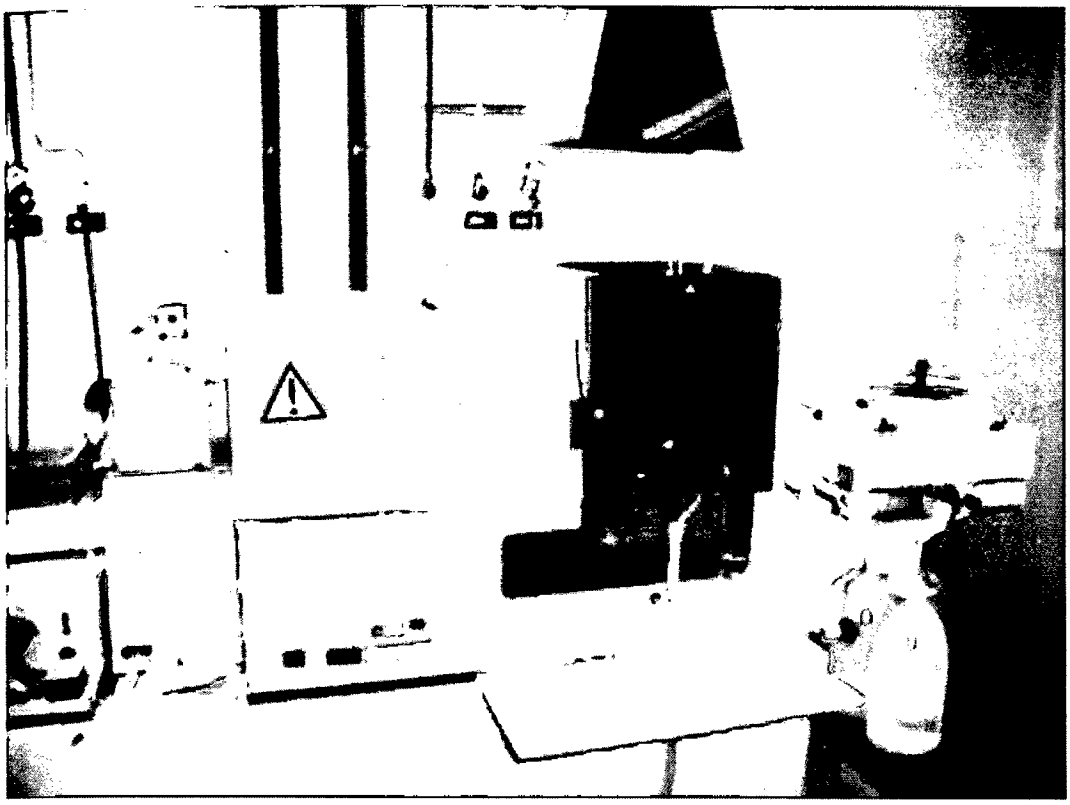

Figure 1.2: Atomic absorption spectroscopy

Figure 1.3 is the schematic diagram of atomic absorption spectrometer. Hollow cathode lamp will emit the line spectrum of the element to be analyzed. Samples are then atomized in the flame. Selection of wavelength of interest is done by the monochromator.

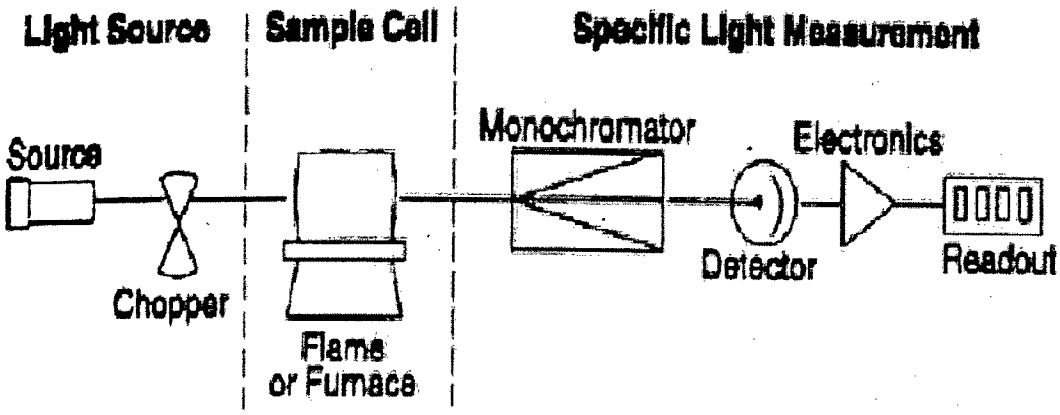

Figure 1.3: Schematic diagram of atomic absorption spectroscopy

1.1 Objective

The objective of this study is to determine the heavy metals (Fe, Pb, Cu and Mg) in Gambang Lake water.

1.2 Problem Statement

Saraswathy et al., 2009 had investigated about determination of the metals (copper, zinc, cadmium, chromium, magnesium and calcium) in tap water in residential area. In this research he applied atomic absorption spectrometry. According to his research, lead and copper level in the residential area exceeded the Environmental Protection Agency (EPA). It might due to the plumbing systems.

Therefore, this study will determine the metals (copper, magnesium, lead and iron) in Gambang Lake water. The samples will be analysed using atomic absorption spectroscopy (AAS).

1.3 Scope of Study

There are some important tasks to be carried out in order to achieve the objective of the study, which is to determine the metals in Gambang Lake water. The important scopes have been identified for this research in achieving the objectives. The scope of this study is to:

i. Identify and determine the concentration of Fe, Pb, Mg and Cu in the water.

Figure 1.4 shows the flow chart of the study of determination of heavy metals in Gambang Lake water.

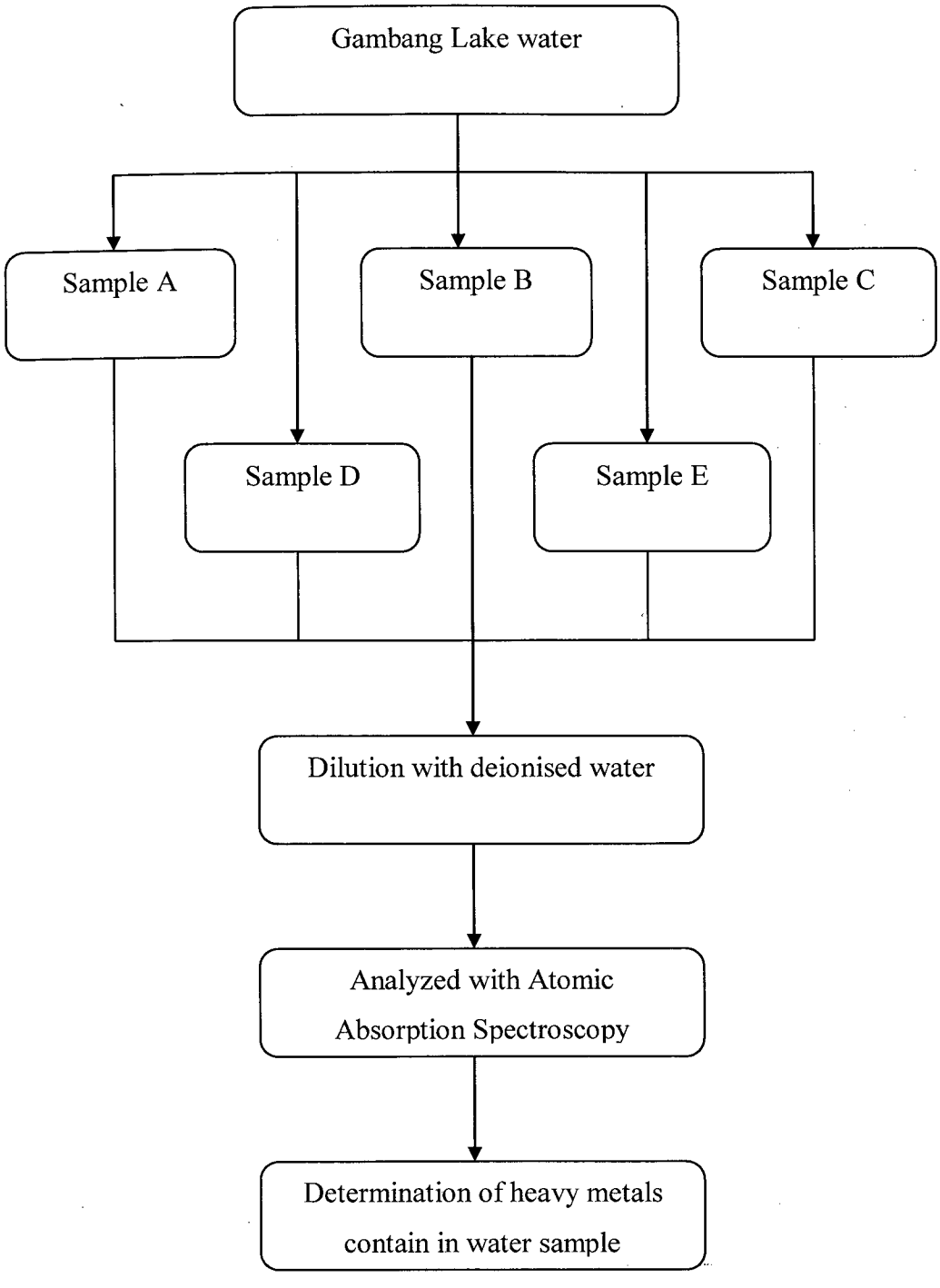

Figure 1.4: The flow chart research of determination of heavy metals in Gambang Lake water

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The study of heavy metals contamination has been done by many researchers. It involves a few types of water like water from sea, river, tap water, lake, dam and others. Most of the results have shown that heavy metals exist in these samples of water but the concentrations of their contamination are different and some of the results do not detect the existence of heavy metals in water samples.

2.2 The Study of Fe, Pb, Cu and Mg

Water and land are being increasingly stresses through the action or inaction of man leading to environmental pollution (Ibe et al., 1992). Water may be temporarily or permanently impaired in quality as a result of these actions. Water pollution arising from the presence of foreign substances which tends to degrade the quality of water (Salami, 2003) has become a serious concern today. These foreign

substances in water set the physical and chemical parameters of the waters. Some of them may be toxic to the aquatic ecosystem while others may constitute nutrients for aquatic microorganisms (Boukori et al., 1999). Thus, the determination of metals is becoming important because of the increased interest of environmental samples including water, soil and plant (Huyesin et al., 2006). Metals are frequently released in large quantities during different processes derived from human activities and may lead to major destruction of aquatics ecosystems.

2.2.1 Ferum (III)

At low concentrations, iron plays an important role in metabolic and fermentation processes, as an enzyme activator, stabilizer and functional component of proteins. Above trace levels, however, iron has other roles (Tautkus et al., 2003). Iron is a moderately toxic element when compared with other transition metals. However, the toxic doses of iron and its compounds can lead to serious problems including depression, rapid and shallow respiration, coma, convulsions and cardiac arrest (Alemdaroğlu et al., 1999).

2.2.2 Lead

Lead is trace heavy metals of great importance in environmental protection, and the development of a fast and efficient method for its determination has been the subject of numerous studies (Abdulmagid et al., 1994). Lead in water system has influenced on the quality of life seriously especially in developing country. Even small amounts of lead that enter the environment can result in elevated concentrations that can result in adverse effects. A regular absorption of small amount of lead may cause serious injuries to health such as brain damage, kidney damage and several effects in the body (Clarkson et al., 1998).

Lead is very toxic and common heavy metals. It gets into the water from the corrosion of plumbing materials. Sources including paint, mining wasters, incinerator ash, automobile exhaust, water from lead pipes and solder that are used to join copper pipes, in fittings and faucets are made from brass. Intake of lead causes delay in physical or mental development for infants and children. As for adults, it may cause damage to kidneys, brain, and nervous system (Hasbiyana et al., 2008).

2.2.3 Magnesium

Magnesium is an alkaline earth ion that is ubiquitous both in nature and in manmade products. Its concentration in different aqueous systems, industrial products, wastes and consumer products, as well as in pharmaceuticals must be determined frequently. Additionally, the activity of magnesium in blood and serum is an important clinical parameter that needs to be monitored in different situations (Capitan-Vallvey et al., 2004). The major natural sources of calcium and magnesium are soils and rocks containing limestone, dolomite & gypsum (calcium sulfate), and small amounts from igneous and metamorphic rocks (Leeden et al., 1990).

2.2.4 Copper

Soluble copper compounds in drinking water pose the greatest threat to human because although copper ions are extremely important for several biological processes, their levels in some situations are indicators of a problem or disease in many living systems or environments. Copper accumulation in the liver is a characteristic of Wilson's disease, which leads to neurological and psychiatric defects (Zamani et al., 2006).

2.3 Atomic Absorption Spectroscopy (AAS)

Atomic absorption spectroscopy (AAS) determines the presence of metals in liquid samples. Metals include Fe, Cu, Al, Pb, Ca, Zn, Cd and many more. It also measures the concentrations of metals in the samples. Typical concentrations range in the low mg/L range. Atomic absorption spectroscopy is widely used due to its low cost, but its sensitivity is usually insufficient for metals ion at ng L^{-1} concentration level (Huseyin et al., 2006).

For the determination of trace metals different spectroscopy methods are used. However, atomic absorption spectrometry is one of the most extensively used techniques for determining various elements with significant precision and accuracy. This analytical technique is remarkable for its selectivity, speed and fairly low operational cost (Tautkus et al., 2003).

CHAPTER 3

METHODOLOGY

3.1 Materials and methods

3.1.1 Location of the site

Gambang is a small town outside of Pahang's capital, Kuantan. Gambang is a transit town in Pahang, Malaysia. It is about 30 km from the state capital, Kuantan. It is located at a junction between Federal route , MEC Highway (Federal route) and Tun Razak Highway (Federal route). Figure 3.1 shows the location of Gambang Lake.

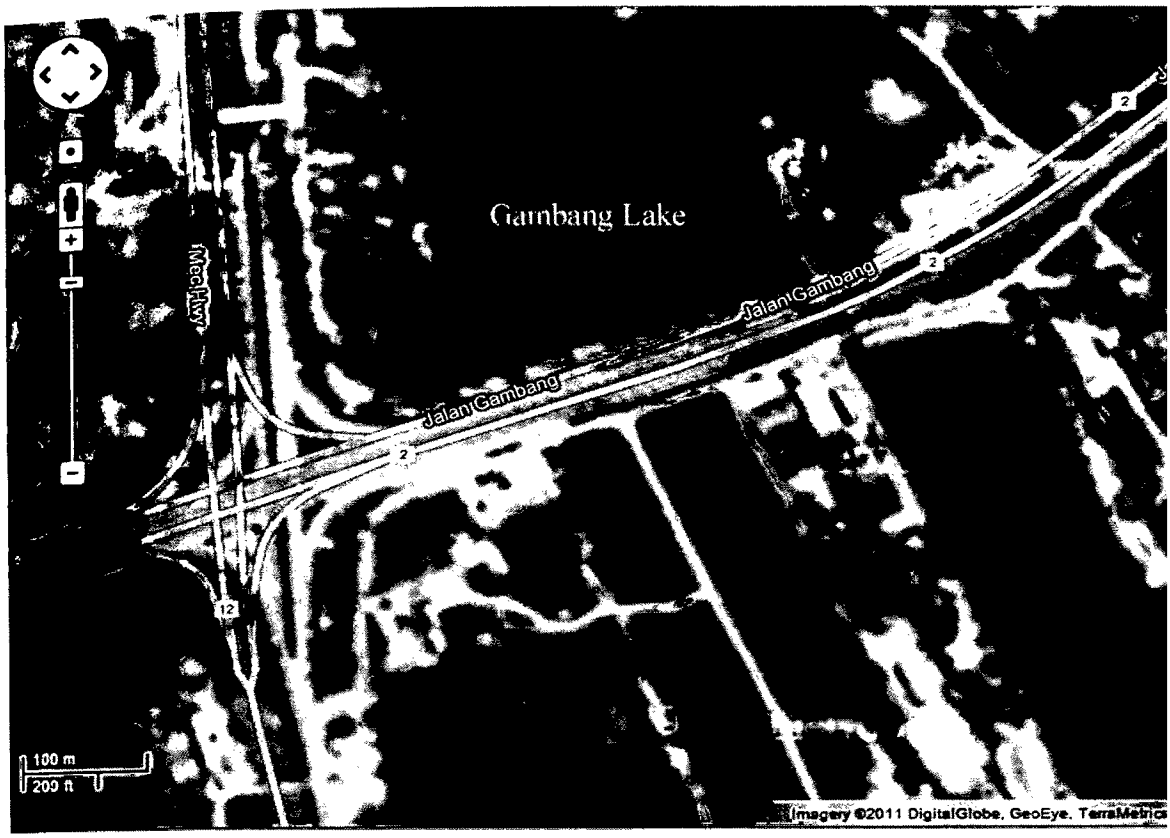

Figure 3.1: Location of Gambang Lake

The study was implemented at Gambang Lake. Gambang Lake selected as study location for this project because there is fishpond and food court. Food court presence nearby the lake perhaps indirectly contributed to contamination to water in the lake. This can be seen as in Figure 3.2.