AN ASSESSMENT OF CADMIUM AND CHROMIUM CONCENTRATION IN ROADSIDE DUST OF KOTA KINABALU

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DECLARATION

I hereby declare that this dissertation is the result of my own independent work and original writing, except the data and facts that already stated with its sources and origins.

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ABSTRACT

The study has been conducted in 9 sites mainly main road throughout Kota Kinabalu. The sites are Cross junction at Damai Road, Jalan Lama junction with road to Luyang, Sembulan Roundabout, Wisma Perkasa Roundabout, Tamu KPD, Perindustrian Roundabout, Masjid Bandaraya Roundabout, Anjung Selera and Kingfisher Roundabout. Each site consists of 3 replicate samples. The sampling was conducted in between the month of January and February. The dust extract was analyzed by means of flame atomic absorption spectrophotometry (AAS) using 2-5000 Polarized Zeeman Atomic Absorption Spectrophotometer at a wavelength of 228.8 nanometer for cadmium and 357.9 nanometer for chromium. Cadmium concentration for 9 site ranging between 0.01-0.1 μg/g and chromium concentration is varied between 0.4-3.8 μg/g. From the result obtained, it is clear that there are significant correlations between cadmium against chromium with Pearson correlation value of 0.692, cadmium against traffic volume with value of 0.662 and chromium against traffic volume with value of 0.584.

KAJIAN KEPEKATAN KADMIUM DAN KROMIUM DALAM DEBU JALAN DI SEKITAR KOTA KINABALU

ABSTRAK

Kajian telah dijalankan di 9 lokasi jalan utama di sekitar Kota Kinabalu. Lokasi tersebut adalah di persimpangan Jalan Damai, Jalan Lama di persimpangan Luyang, Bulatan Sembulan, Bulatan Wisma Perkasa, Tamu KPD, Bulatan Perindustrian, Bulatan Masjid Bandaraya, Anjung Selera dan Bulatan Kingfisher. Setiap lokasi terdiri daripada 3 replikat sampel. Persampelan telah dijalankan diantara bulan Januari dan Februari. Ekstrak debu telah diuji dengan alat spektrofotometri flame atomic absorption (AAS), model 2-5000 Polarized Zeeman pada panjang gelombang 228.8 nanometer untuk kadmium dan 357.9 nanometer untuk kromium. Kepekatan kadmium untuk 9 lokasi secara puratanya berada di antara 0.01-0.1 µg/g dan purata kepekatan kromium berada di antara 0.4-3.8 µg/g. Daripada keputusan yang didapati jelas menunjukkan bahawa terdapat korelasi yang signifikan antara kadmium melawan kromium dengan nilai korelasi Pearson ialah 0.692, kadmium melawan jumlah kenderaan dengan nilai korelasi Pearson 0.662 dan korelasi antara kromium melawan jumlah kenderaan dengan nilai korelasi Pearson 0.584.

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SYMBOLS

AAS	flame atomic absorption spectrometry
Cd	cadmium
Cr	chromium
Pb	plumbum
Zn	zinc
Fe	ferum
Ni	nicel
μg/g	microgram pergram
ng/ml	nanogram permililitre
ppm	part permillion
mg kg^{-1}	miligram perkilogram
10^{-6} g	microgram
nm	nanometer
ml	mililitre

CHAPTER 1

INTRODUCTION

1.1 POLLUTION

During the last few decades there has been a major concern on our environment that we live in today. The natural processes in our environment nowadays, has been disturbed with a lot of human activities until some level, the quality of life and the living organism itself has been threatened.

This kind of disturbance to the environment is called pollution. According to Environmental Quality Act (EQA), pollution is define as 'any direct or indirect alteration of the physical, thermal, chemical, biological or radioactive properties of any part of environment by discharging, emitting or depositing wastes that is potentially hazardous to public health or safety to animals, plants, birds, wildlife, fish or any aquatic life.' (Mage & Zali,1992).

Based on the above definition, we can identify several kinds of pollution such as air pollution, water pollution, soil pollution and several others. This pollution are often relate with chemical alteration to the environment. There is also physical pollution such as noise pollution and thermal pollution.

1.1.1 Motor vehicles, roadside dust and heavy metals

In large cities in the world, air and noise pollution from motor vehicles are becoming major health problems of the people (Mage & Zali, 1992). In both industrialized and developing countries, rapid industrial growth and population increase, together with rising standards of living are likely to lead to some patterns of motorization.

In Malaysia, air pollution concern has been aroused in the early 1970s, currently during the developing of industrial processes (Mage & Zali, 1992). Kota Kinabalu as a developing city itself, also packed with same problems in reducing air pollution mainly caused by motor vehicles.

Generally through readings, public always relates motor vehicles with the emission of noxious gases. These gases such as CO and NO_x can affect human health through inhalation (Hirschhorn & Oldenburg, 1991). Besides of the noxious gases, motor vehicles can also affecting environmental health through the exhaust of the vehicle parts that settled in the roadside dust.

The roadside dust also known as particles in solid form can carry many things through it dispersion. Other than solid form, particles can be present in the environment in gaseous and vapour form (Barrat, 1990). People inhale airborne particles, while the dust can be either inhaled, if it becomes suspended or ingested if it carried to human mouth or to food. Upon entering human body, these types of particles create potential health hazards. These include decrease of lung function and increased in respiratory symptoms such as cough, shortness of breath and asthma attack (Farmer, 1993). It not just can disturb the process of clear breathing but can also carry toxic substances such as heavy metals especially from vehicles exhaust into the body. In order to reach the ability to control airborne particles and settled dust, an understanding has to be developed about their origins, their characteristics, behaviour and the effects they cause.

Heavy metals are among the harmful element of pollutants. These metals in general usually include element in the lower right-hand corner of the periodic table. Heavy metals can be essential elements like iron as well as toxic metal like lead, cadmium and mercury. In general, heavy metals produce toxicity by forming complexes with organic compounds which called 'ligands' (Manahan, 1997). This complex will lose their ability to function properly. At the end the, ligands will result in malfunction or death of the affected cells.

Heavy metal originate from roadside dust that will be discuss in the next chapter are cadmium and chromium. In roadside dust, chromium often associated with use in chrome plating of some motor vehicles parts (Ndiokwere, 1984) while cadmium originates mainly during combustion of petroleum product such as lubricating oils and car tyre wear (Yassoglou et. al., 1987).

Chromium is a steel-grey, shiny, metallic and hard. Chromium (VI) compounds are highly toxic where chromium (III) compounds are essential trace element to humans and animals. Chromium (III) has a role in glucose metabolism and has an effect in the action of insulin (Manahan, 1997).

Cadmium is a soft, bluish-white metal and can be easily cut with knife. Cadmium and its compounds are highly toxic (Merian, 1991). It is a cumulative poison and can causes problems for the respiratory tract, liver and renal malfunction.

1.2 OBJECTIVES

Lead sources from motor vehicles exhaust and emission were widely studied over the years (Ndiokwere, 1984). Its effect on environment especially on vegetation and human are given a very serious interest (Pineau et al., 1994, Nasralla, 1984, Rodriguez, 1982, Nriagu, 1978). However, very little attention has been given to pollution by other heavy metals especially cadmium and chromium which are also derived from motor vehicles and other sources such as industrial and smelting process.

For this reason, analysis on roadside dust for these metals should be good indicator of motor vehicle-related pollution of the environment since most of the locations are close to buildings and schools. This may create a health risk for street traders and passers-by especially for children mostly through the possibility of ingestion either as a result of 'pica' or by oral contact with hands or playing with toys contaminated with soil or dust. Measuring heavy metals in roadside dust would also give us a better understanding on the environmental pathways of heavy metals.

Therefore this study focuses on:

1. To determine the concentration of heavy metals with a focus on cadmium and chromium in road dust.
2. To find correlation of cadmium against chromium.
3. To find correlation of each heavy metal against traffic density.

CHAPTER 2

LITERATURE REVIEW

2.1 MOTOR VEHICLE USAGE

Across the entire world, motor vehicle usage has increased tremendously. According to Mage and Zali (1992), in 1950 there were about 53 million cars on the world's roads. 4 decades later, the global motor vehicle usage has been increased to over 430 million. On average, the number has increase by about 9.5 million vehicles per year over this period. However, the rising of growth rate and increasing of urbanization and industrialization are adding acceleration to the use of motor vehicles around the globe.

According to Mage and Zali (1992), Motor Vehicle Manufacturer's of the United State Inc, 1991 had stated that world wide registrations have been growing by about 2.3 vehicles which include cars, buses and trucks per 1000 persons per year. If this trend were to continue until 2010, there would be 154 motor vehicles per 1000 person compared with 112 in 1990. Moreover the increasing use of motor vehicles in global trend will also enlarge the production of various risks to human health due to air pollution by noxious gases, heavy metals and roadside dust.

2.2 DUST

Dust is a common geological material throughout the environment. According to Concise dictionary, dust is 'finely' powdered earth or matter laying on the ground or carried about by wind while Barrat (1990) refers dust as a particulate matter smaller than 76 μm. However it must be cleared that particulate is totally different from dust. Particulate can be found in atmosphere in aerosols form however dust is a solid particle found on the earth.

According to Farmer (1993) dust formed in a variety of sizes. Particles from motor vehicles can range from 0.01-5000 μm in diameter. Most urban dust is in the range from 3-100 μm diameters and dust from motor vehicle exhausts is 3-30 μm diameters. Sizes of dust that comes from many sources such as cement kiln can be less than 30 μm in diameter whereas fly ash dust from power stations ranges from 1-2000 μm diameters. The degree of accumulation, composition and deposition of dust however depend not just on sizes and sources but also on meteorological factors such as wind and weather condition.

According to Huang (1998), there are 3 physical properties of dust. There are settling velocities, optical characteristic and absorption tendency. First, is the settling velocity of a dust depends on its size. Larger particles settle more quickly than smaller particles. Second, the optical characteristic of dust relate to the scattering, reflection and absorption of solar radiation. The degree of this characteristic depends mostly on the size, nature and the wavelength of the radiation. Third, the absorption tendency of dust refers to its ability to absorb molecules which may collide with it.

2.3 HEAVY METALS

Heavy metals are natural components of earth. They cannot be degraded or destroyed. Heavy metals as trace elements such as copper and zinc are essential to maintain the metabolism of the human body. On the other hand, at higher concentrations they can lead to poisoning. Heavy metals can enter our bodies either as essential element or toxin via food, drinking water and air.

The most dangerous characteristic of heavy metals is it tends to bioaccumulate. Accumulation process of heavy metals in living things happened faster than they are metabolized and excreted. Basically the ingestion of most metals can create toxicity in sufficient quantities. Still there are several metals that can produce toxicity at such low concentrations. Heavy metals of common concern are chromium, ferum, aluminium, cadmium, lead and mercury (Heilig, 1998).

According to Gad (1998), for toxic reactions to happened it must be assist by oxidation state and solubility. Metals can react with enzymes, cell membranes and specific cell components. These reactions can stimulate the actions of these substances and components. Because of metals are bound to some blood protein, metals can affect exact target organs or various anatomical sites. For example, leads can deposit in the bone, have an effect on the central nervous system and interfere with metabolism of haemoglobin.

There are a few important disasters with heavy metals happened in our environment. One of the most remembered cases is Minamata disaster in 1932. There was sewage containing mercury released by Chisso's chemical works into Minamata Bay in Japan. As a result, the mercury accumulates in sea creatures like fish, oyster, shrimp, crabs and others leading to mercury poisoning in the population. In 1952, the first incidents of mercury poisoning appear in the population of Minamata Bay in Japan. It had brought over 500 cases of fatalities.

2.3.1 Heavy Metals in Soils

Heavy metals in soils are originate either from the weathering of the parent material or from numerous contaminating sources. For some metals, such as lead contamination from other sources often exceeds the contribution from natural sources, whereas for less used metals this may not be occur. Although true background concentrations of metals in the environment may not be easy to obtain, below is table of probable background and typical ranges of heavy metals in soils found in some remote areas or in areas with minimum of anthropogenic effect studied by Singh and Steinnes, 1994.

Table 2.1: Probable background levels and typical concentrations of some heavy metals in soils (Singh & Steinnes, 1994)

Element	Background concentration (mg kg^{-1})	Typical range (mg kg^{-1})
As	0.1-40	0.1-50
Cd	0.01-0.2	0.01-2.4
Cr	80-200	5-1500
Cu	6-60	2-250
Hg	0.06	0.01-0.3
Ni	1-100	2-1000
Pb	12-20	2-300
Zn	17-125	10-300

2.3.2 Heavy metals in waters

Water present in streams, rivers and lakes form only about 0.002% of the total amount of water present on the surface of the earth (Garcia & Millan, 1994). However this amount is far most important to human. Two physical factors, the residence time and the pathways along which the water moves through the system are important to determine chemical composition of natural waters (Singh & Steinnes, 1994). The larger residence time, the better for reaction between water and materials in contact with it. The pathways determine which materials the water contacts during its passage through the system. In general, water following shallow pathways gets in contact with more weathered and consequently less reactive material then along deeper pathways.

The two factors dominating the chemical composition of natural fresh surface waters are the atmosphere and the mineral material in contact with the water. Trace metals, including heavy metals such as Zn, Cd and Cr are also derived from these sources. Natural fresh waters show a very wide range in their concentrations of heavy metals depending on variations in climate, geology and anthropogenic activities as presented by table below studied by Singh and Steinnes.

Table 2.2: Heavy metal composition of drinking water (Singh & Steinnes, 1994)

Metal	Median (μg^{-1})	Range (μg^{-1})
As	0.5	0.2-230
Cd	0.1	0.01-3
Cr	1	0.1-6
Cu	3	0.2-30
Hg	0.1	0.0001-2.8
Ni	0.5	0.02-27
Pb	3	0.06-120
Zn	15	0.02-100

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