UNIVERSITI PUTRA MALAYSIA

CADMIUM CONCENTRATION AND NEUROBEHAVIORAL PERFORMANCE AMONG PRIMARY SCHOOL CHILDREN IN TANJUNG KARANG, SELANGOR

NURUL IZZATY BINTI ZAABA

CADMIUM CONCENTRATION AND NEUROBEHAVIORAL PERFORMANCE AMONG PRIMARY SCHOOL CHILDREN IN TANJUNG KARANG, SELANGOR

BY

NURUL IZZATY BINTI ZAABA

Thesis submitted in fulfillment of the requirement for the degree of

Bachelor Science (Environmental And Occupational Health)

Faculty Of Medicine And Health Sciences

Universiti Putra Malaysia

Serdang, Selangor

2012/2013

ACKNOWLEDGMENT

Praise to Allah SWT for all his blessings and guidance of this project can be completed. Special gratitude to Prof. Dr. Zailina Hashim as my supervisor for this project, for her invaluable advice, guidance and inspired me throughout this project. Appreciation is also extended to all teachers and students who cooperate in the data collection throughout this project.

Special appreciation to my parent and my family for their blessing, inspiration, and financial support in completing this research. Thank you to my Academic Advisor, Prof. Madya Dr. Shamsul Bahri Mohd Tamrin for his invaluable advice and guidance throughout this project

Special gratitude to Dr. Saliza Mohd Elias as Final Year Project Coordinator for Bachelor Science of Environmental and Occupational Health. My appreciation also to my friends, Miss Nur Naqibah Lukhman, Miss Nurul Husna Miswon, Miss Nurul Aida Muhamad, Miss Raihana Chokeli and Miss Vivien How .

My gratitude to all my coursemates and all lecturers in the Department of Environmental and Occupational Health for their support. Finally, special thank you goes to all involved in this study either directly or indirectly. Thank you.

ABSTRACT

CADMIUM CONCENTRATION AND NEUROBEHAVIORAL PERFORMANCE AMONG PRIMARY SCHOOL CHILDREN NEAR PADDY FIELD IN TANJUNG KARANG, SELANGOR

Nurul Izzaty Zaaba

Department of Environmental and Occupational Health,
Faculty of Medicine and Health Sciences,
Universiti Putra Malaysia.

Introduction: Cadmium is a widespread toxic mineral found in the environment (air, water, soil and food) and as a pollutant coming from agricultural sources. Fertilizer is a major source of cadmium and it is found in plants grown in such soils. **Objective:** The aim of this study was to determine the relationship between urinary cadmium concentrations with neurobehavioral performance of primary school children who live and study near paddy field in Tanjung Karang, Selangor. **Method:** This is a cross-sectional comparative study design. A total of 80 primary school children as exposed group and 60 school children as unexposed group were randomly selected from the class name list. Questionnaires were filled by parents in order to obtain background information of the children. Urinary cadmium concentration determined using Flame Atomic Absorption Spectrophotometer and neurobehavioral performance measured using WHO Neurobehavioral Core Test Battery (NCTB). **Result:** The results showed that the urinary cadmium concentration for exposed group was not significant higher than unexposed group. **Conclusion:** Results showed that all of the children studied had urinary cadmium concentration below 1 µg/L which is the acceptable level whereby they were not at risk. There was no significant difference between urinary cadmium concentration and neurobehavioral performance score between the two study groups. However, there was significant relationship between urinary cadmium concentration and Reaction Time Test score.

Keyword: Urinary cadmium concentration, neurobehavioral performance, school children

ABSTRAK

KEPEKATAN KADMIUM DAN PRESTATSI NEUROTINGKAHLAKU DI KALANGAN PELAJAR SEKOLAH RENDAH BERDEKATAN SAWAH PADI DI TANJUNG KARANG ,SELANGOR

Nurul Izzaty Zaaba

Jabatan Kesihatan Persekitaran dan Pekerjaan,
Fakulti Perubatan dan Sains Kesihatan,
Universiti Putra Malaysia.

Pengenalan: Kadmium adalah bahan toksik yang terdapat di alam sekitar (udara, air, tanah, makanan) dan bahan pencemar yang berpunca daripada sumber pertanian. Baja adalah sumber utama kadmium dan dijumpai dalam tumbuhan yang ditanam. **Objektif:** Tujuan kajian ini adalah untuk mengenalpasti hubungan kepekatan kadmium dalam urin dan prestasi neurotingkahlaku di kalangan pelajar sekolah rendah yang berdekatan dengan sawah padi.**Kaedah:** Ini adalah kajian perbandingan pada satu masa. Sejumlah 80 orang pelajar sekolah rendah yang berdekatan dengan kawasan padi dipilih sebagai kumpulan terdedah dan 60 orang pelajar sekolah rendah yang jauh dari kawasan sawah padi dipilih sebagai kumpulan kawalan. Borang soal selidik telah diisi oleh ibubapa/penjaga untuk mendapatkan maklumat latar belakang mereka. ,Kepekatan cadmium dalam urin telah dikenalpasti menggunakan mesin AAS dan Ujian Teras Bateri Neurotingkahlaku (NCTB) untuk neurotingkahlaku. **Keputusan:** Keputusan ujian menunjukkan bahawa paras kepekatan kadmium dalam urin bagi kumpulan terdedah lebih tinggi berbanding secara signifikan dengan kumpulan kawalan. **Kesimpulan:** Keputusan menunjukkan kesemua pelajar sekolah yang dikaji mempunyai antara paras kepekatan kadmium dibawah paras selamat iaitu 1 µg/L, dan mereka tidak berisiko. Tiada perbezaan signifikan antara kepekatan kadmium dalam urin dengan keseluruhan NCTB prestasi di antara dua kumpulan kajian. Walaubagaimanapun, terdapat hubungan bererti antara kepekatan kadmium dalam urin dengan skor Ujian Masa Tindakbalas/Pergerakan.

Kata Kunci: Kepekatan kadmium, Ujian Neurotingkahlaku, pelajar sekolah

CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF APPENDICES

LIST OF ABBREVIATIONS

P	Significant value
r	Correlation
Cd	Cadmium
U-Cd	Urinary Cadmium
SD	Standard Deviation
IQR	Interquartile range
et. al.	And others
NCTB	Neurobehavioral Core Test Battery
AAS	Atomic Absorption Spectrophotometry
SOP	Standard operating procedure
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Children who live and attend school near paddy field are more likely to be highly exposed to heavy metal in environment and therefore at higher risk of experiencing chronic health effect on nervous system. The potential health risks associated with exposure of children to heavy metal have received increased attention with the passage of the new federal emphasis on children's health .There is currently a renewed emphasis on protecting vulnerable subpopulations, especially children, and understanding children's exposure to neurotoxin chemicals.

Agriculture is one major important factor and best contribute to overall economic growth and modernization in Malaysia. Agriculture growth and productivity increases are crucial to sustained economic development. In agriculture, there are need to use fertilizer in order to improve plant growth. The use of

pesticides and fertilizer in agriculture has been one of the most important factors leading to increased yields and reduced product prices.

Cadmium is a widespread toxic mineral found in the environment (air, water, soil and food) and as a pollutant coming from agricultural sources. Fertilizer is a major source of cadmium exposure from the plant's absorption of these metals in the soil (Satarug et al., 2004). Some sources of phosphate in fertilizers contain cadmium in amounts of up to 100 mg/kg, (Abbas,2007) which can lead to an increase in the concentration of cadmium in soil .

Cadmium is found in soils where certain fertilizers have been used, and in plants grown in such soils (Satarug et al., 2004). High levels of cadmium in surface soils usually result from cadmium particles settling from the air. Once released into the air the cadmium will be absorbed through the contact point of the body by inhalation and it will distribute throughout the body. Cadmium and its compound are classified by the International Agency for Research on Cancer (IARC) as group 1, carcinogenic to human (Satarug *et al*., 2004). Cadmium can accumulate in the body over time and can be measured in urine, blood, nails or hair. (Jiang et al., 2000). Concentration of cadmium in urine may indicate the short term exposure of the cadmium in the body.

Cadmium concentrations in healthy persons without excessive cadmium exposure are generally less than 1 μg/L in either blood or urine. The neurotoxic effects described are due to damage of both peripheral and central nervous system. The highly toxic heavy metals, such as cadmium, are environmentally and occupationally widespread pollutants with mutagenic, carcinogenic, and teratogenic effects. This metal belongs to the most harmful factors due to their tendency to accumulate in tissues and organs and to transfer along food chains, high reactivity, and the ability to stimulate reactive oxygen species (ROS) formation and to produce injury in cell functions.

Cadmium neurotoxicity can involve both peripheral and central nervous systems. Symptoms of fatigue, mental irritability, headache, muscle weakness, dizziness, syncope and hyposmia were reported in patients or workers acutely or chronically exposed to cadmium (Baldi et.al.,2001).Other symptoms are a decrease of motor speed, attention, memory vision for skills (Stellern et.al.,1993) and a presence of neurophysiological and neurobehavioural abnormalities. Children exposed to cadmium diminished intelligence were described especially with respect to verbal, psychomotor, cognitive and perceptual skills (Marlowe et.al., 1993). In a cohort studies, Thatcher et al (1994) reported that the concentration of cadmium in hair was inversely related to adjusted IQ. Marlowe et al, (1995) have reported associations between hair cadmium and children's performance on visual motor tasks.

1.2 Problem Statement

The widespread use of fertilizer in paddy field has led to frequent exposure in adult and children. Even the use of fertilizer may cause adverse health effects particularly in children. The effects particularly affect children because of they are all active at this phase and their organ and system especially their cognitive function are in developing stage (Eskenazi et al.,2010), and contributes to neurological problem among children then affects their neurobehavioral performance (Leroyer et al.,2001)

Once cadmium accumulated in our body it is can cause several health effects divided by acute (14 days or less), intermediate (15 days to 365 days) and chronic health effects (365 days and more) (Faustman et al., 2000). Heavy metals are primarily neurotoxic and produce well-defined muscarinic, nicotinic and cholinergic neurosymptoms involving both central and peripheral nervous systems. Increase in both central and peripheral neurologic symptoms are also found in many studies on moderate exposure.

Increased symptom prevalence may provide early evidence of neurologic dysfunction, before clinically measureable signs are evident (Rourke et al., 2001). Few study have investigates the health effect in humans of low level chronic exposure to heavy metal.

WHO currently considers children's exposure to be characterized by three pathways: diet, drinking water, and residential use. Other studies reported that children in agricultural communities receive additional exposures from living near agricultural areas and because of their parents' occupation. Thus, children in agricultural communities have a more complex aggregate exposure profile than other children, as well as the potential for exposure to fertilizer compounds (Murakami et al., 2004).

In tropical country like Malaysia, crops such as rice and vegetables are particularly susceptible to the negative impacts of chemical use. This is attributed to the often indiscriminate and intensive use of fertilizer associated with these crops.

A 2005 study of children born to farm workers in California's Salinas Valley found that infants with the greatest exposure to heavy metal had more abnormal reflexes than infants of non-agricultural workers .Studies conducted by investigators at Oregon Health & Science University showed that preschool children from agricultural communities scored lower in the acquisition of test performance, response speed and latency in neurobehavioral performance tests (Chatham et al., 2011).

1.3 Study Justification

The study area selected is primary school which is near to paddy field. The population involve is primary school children who study and live there. High risk populations can be defined as groups which are either more highly exposed to an environmental agent or more susceptible to its effect. Children live in or near to agricultural areas appear to meet both of these criteria; children are considered potentially vulnerable to developing organs systems, and are likely to receive greater exposures than other children. Although there has been significant attention to the health effects of heavy metal on human health, there has been little focus on the vulnerable children population near paddy field.

The data collection was done on January 2013. In January, usually for every year the paddy field workers start the new plantation that the water starts flow to the block of the paddy field. All the seeds were plant and the fertilizer was added to initiate growth of the paddy. At the end of January, control the growth of the weed was done and spray of pesticide to control the growth of any unwanted insect or pest.

Recently, special attention has been given to children who are considered a group particularly at risk for exposures because of their dietary patterns and unique behaviours. Children here have little knowledge of their chemical toxicant exposure and, thus, little control over when and whether they are exposed. Heavy metal like

cadmium, have the potential to affect the health as well as to the function of the nervous system in humans. If the rate of exposure is relatively constant, a single urinary biomarker measurement may be representative of typical or chronic exposure.

Improved understanding of this relationship is important for investigations of health effects potentially related to chronic heavy metal exposure. However, in Malaysia, these studies are quite limited.

Children are the future generation to develop our country hence their health are important especially in their neurobehavioral performance that affect their learning process. The cadmium concentration level can be detected either high or low and some control measure can be done to decrease the exposure towards children.

1.4 Conceptual Framework

Figure 1.1 shows that the conceptual framework of the study. It was used to assist and guide researcher in implementing the study. The aim of this study is to determine the relationship between the urinary cadmium concentration with neurobehavioral performance score among primary school children (Year 4 and 5) and to compare between those who live and study near paddy field with those who live away from paddy field in Tanjung Karang, Selangor.

From the framework, cadmium is one of the heavy metal that exist either naturally or man-made near paddy field in Tanjung Karang, and it will be released to the atmosphere, and deposit to soil as sedimentation.The usage of this material will give an exposure to the school children nearby. The exposure can occur from three ways that is inhalation (breathing air), ingestion (contaminated food) and very rare through direct contact (eyes or skin), and result in disturbance to human body. These exposures will give and adverse health effect to human system especially central nervous system.

This research was focused on the effect to nervous system, where the exposure level has been monitored by determining individual urinary cadmium concentration by using AAS (Flame Atomic Absorption Spectrometry), while the effect on nervous system were evaluated by using Neurobehavioral Core Test Battery (NCTB).

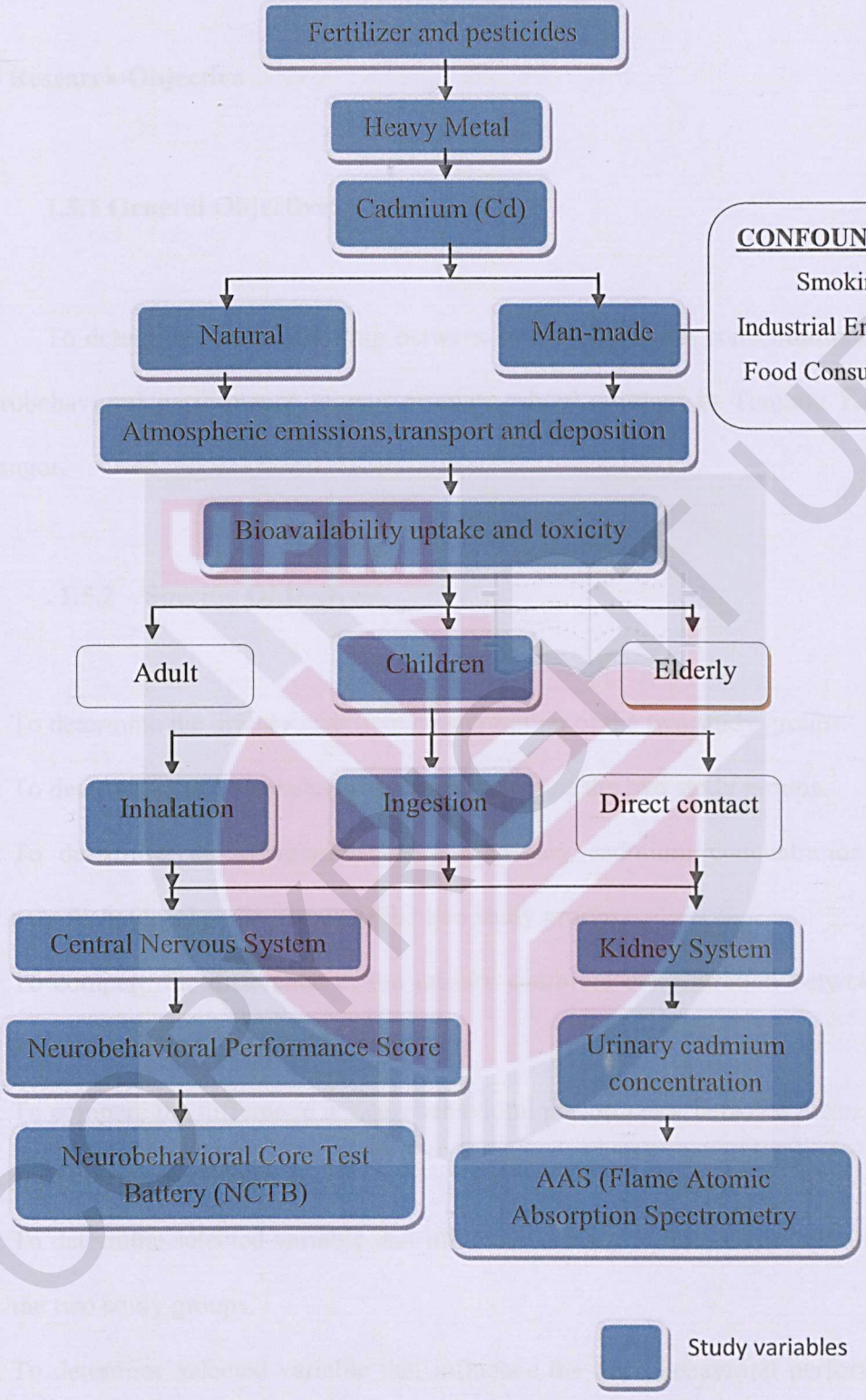


Figure 1.1: Conceptual Framework of the study

1.5 Research Objective

1.5.1 General Objective:

To determine the relationship between urinary cadmium concentrations with neurobehavioral performance among primary school children in Tanjung Karang, Selangor.

1.5.2 Specific Objectives:

i. To determine the urinary cadmium concentration of the two study groups.
ii. To determine the neurobehavioral performance of the two study groups.
iii. To determine the correlation between urinary cadmium concentration with neurobehavioral performance of the two study groups.
iv. To compare the difference in the urinary cadmium concentration between the exposed with the unexposed group.
v. To compare the difference in neurobehavioral performance between the exposed with the unexposed group.
vi. To determine selected variable that influence urinary cadmium concentration of the two study groups.
vii. To determine selected variable that influence the neurobehavioral performance of the two study groups.

1.6 Hypothesis

i. There is significant relationship between urinary cadmium concentration and neurobehavioral performance of the two study groups.

ii. Urinary cadmium concentration among the exposed group is significantly difference from the unexposed group.

iii. Neurobehavioral performance among the exposed group is significantly difference from the unexposed group.

iv. The distance from house to paddy fields significantly influence the urinary cadmium concentration of the two study groups.

v. Urinary cadmium concentrations significantly influenced the neurobehavioral performance of the two study groups.

1.7 Definition Of Term

1.7.1 Conceptual definition

a) Urinary-Cadmium (U-Cd)

Urine cadmium is defined as a fluid excreted by kidneys that contain many of the body's waste products included heavy metal named as cadmium.

b) Primary School Children

Primary school children is which children within age between 7 to 12 years old that schools focused to develop children's knowledge and understanding (Boyle et al.,2011) .

c) NCTB (Neurobahavioral Core Test Battery)

Neurobehavioral test are used to assess exposure-response relationship for evaluating nervous system effect in population exposed to exogenous substance (Rourke et al., 2001).

1.7.1 Operational definition

a) Urinary cadmium concentration (U-Cd)

U-Cd can be measured by taking spot urine samples from each respondents by provided disposable polypropylene urine container and the respondents must be fill the container as much as their can. Then the samples were analyze using AAS (Atomic Absorption Spectrometry).

b) Primary School Children

Primary school children involved was children between the age group of 10 -11 years old suitable for the use of neurobehavioral performance and live near paddy field in Tanjung Karang, Selangor. .

c) NCTB (Neurobahavioral Core Test Battery)

A series of test which capable to measure potential adverse health effect to nervous system and detect neurological impairment. The test are Benton Visual Retention Test, Digit Span Test, Digit Symbol Test, Santa Ana Manual Dexterity Test, Time Reaction/Movement Test,Trial making Test and Persuit Aiming Test.

CHAPTER 2

LITERATURE REVIEW

2. 1 Heavy metal

The main threats to human from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the WHO. Heavy metals have been used by humans for thousands of years. Although several adverse effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries, though emissions have declined in most developed countries over the last 100 years (Boyle et al., 2003).

Among possible target organs of heavy metals, the kidney and central nervous system appear to be the most sensitive ones. Neurotoxic effects of heavy metals are also well documented, especially for mercury and lead, with numerous reports of neurobehavioral changes after occupational exposure and of developmental effects in children with pre- or early postnatal exposure (Cynthia et al. 2010). However, experimental studies suggest that other metals such as cadmium and arsenic could also interfere with the nervous system and that all metals may influence the dopaminergic system in different ways (Faustman et al. 2000).

2.2 Cadmium

Cadmium (Cd) is a soft, malleable, bluish white metal found in zinc ores, and to a much lesser extent, in the cadmium mineral greenockite. In 2011, US production of cadmium was estimated at 600 metric tons, down approximately 40% from the production levels 20 years ago (Traina, 1999).

Cd is a rare element in the Earth's crust with an average concentration of ~0.1mg/kg. In 1983, the atmosperic emission of this metal from human activities was 7570 tonnes, which represents 85-90% of the total (natural and anthropogenic) emission on a worldwide scale (Viaene et al., 1999).

This element is most abundant naturally-occurring isotope is non-radioactive. It is found in nature in mineral forms and is obtained for commercial uses principally from cadmium ore, called greenockite, which is commonly found in association with zinc ore. Cd is one of the most toxic environmental heavy metals because of its long half-life and multifaceted deleterious effects (Burbure et al.,2003).

Phosphorus is one of the key nutrients needed by plants to grow. Many soils, particular in developing countries, are deficient in phosphorus, leading to stunted growth, drying of the leaves, slow ripening processes, and poor filling of grain. In many developing countries, the amount of phosphorus applied to crops (from manure or mineral fertilizers) is well below the quantity being removed by crops and erosion, leading to a progressive impoverishment of the soil and reduction of yields.

While phosphorus is important for plants, and hence for people, cadmium contained in phosphorus sources can be detrimental. In fact, the quantity of cadmium contained in a phosphate fertilizer depends on the source of the rock from which it was made. This content varies from almost zero to over 300 mg/kg. With current processes, much of the cadmium in the rock passes into the phosphate fertilizers produced from it.

Phosphorus fertilizers contain cadmium (Cd) as a contaminant at levels varying from trace amounts to as much as 300 mg Cd kg-1 of dry product, and therefore represent a major source of Cd input into agricultural systems. Phosphorus (P) is an essential nutrient for crop production and growth. For soils deficient in P, application of organic or inorganic fertilizers is needed to achieve optimum crop yields. Although P fertilizers represent the major anthropogenic input of P to agricultural soils, both inorganic P fertilizers and organic P sources, such as sewage sludge and manure, may contain Cd (Murakami et al., 2004).

2.3 Cadmium Exposure in Children

Children are thought to be more susceptible to contaminants exposure than adults due to a variety of factors including physiology, metabolism, food consumption patterns and activity patterns. Children's respiratory rate, heart rate and metabolism are significantly different from adults (Fenske et al., 2005) as are food consumption patterns. Children's activities place them at risk of exposure to chemical toxicant when in a contaminated environment through object and hand-to-mouth behavior and close contact with the ground and children have a greater skin surface area per kilogram body weight than adults (Kippler et al., 2012). These factors can result in different sources and levels of exposure for children than adults in the same scenario. Only one study reported a significant association between neurobehavioral performance and heavy metal levels (Kippler et al., 2012).

Therefore, a number of neurobehavioral tests have been used to identify these more subtle adverse health effects of a wide range of toxicants heavy metal in both adults and children (Bellinger et al., 2000).

Heavy metal can cause a wide range of health problems, ranging from acute and persistent injury to the nervous system, injury to reproductive systems, birth defects, cancer and kidney damage (Buchet et al., 2003), but primarily it damages the nervous system.

Some studies concluded that children living with parents who work with agricultural pesticides, or who live in close proximity to pesticide-treated farmland, have higher exposures than do other children living in the same community (Fenske et al., 2005). Another study suggested that children living in agricultural areas may be exposed to higher levels of chemical exposure than other children because it tracked into their homes by household members, by pesticide drift, or by playing in nearby fields (Eskenazi et al., 1999). Coronado et al., (2011) confirmed the hypothesis that the take-home exposure pathway can contribute to residential contamination in agricultural homes where young children are present.

2.4 Sources of Cadmium

Cd emissions have increased dramatically during the 20th century, one reason being that cadmium-containing products are rarely recycled, but often dumped together with household waste (Bellinger et al.,, 2001).

Food is the main source of cadmium intake for non-occupationally exposed people. Crops grown in polluted soil or irrigated with polluted water may contain increased concentrations, as in meat from animals grazing on contaminated pastures (Galal, 1991). Food is the main source of non-occupational exposure to cadmium, with dietary daily intakes, as stated above, in the range 10–35 μg. The intake from drinking-water is usually less than 2 μg/day. Smoking will increase the daily intake of cadmium. There are many ways of Cd exposure to human. For the non-occupationally exposed population, cigarette smoking is considered to be a major source of exposure.

2.5 Pathogenetic Mechanism of Cadmium

Several hypothesis have been suggested to explain the molecular mechanisms of the neurotoxic action of the Cd ion, competition with Zn or Ca, interaction with nucleic acids, second messenger systems, enzymes, receptors or translocating proteins, effects on neurotransmitter concentrations and reuptake, disruption of membrane dynamics including the function of Ca channels and damage to glial cells resulting in accelerated lipoperoxidation that influences neuronal function. Reports,

in several cases, have described demyelinating polyneuropathy or some symptoms related to polyneuropathy. Perinatal exposure to Cd induces anxiety and learning ability of offspring.

2.6 Route of Exposure

Children can be exposed to heavy metal through a variety of pathways, including dietary and non-dietary ingestion, inhalation of indoor and outdoor air, dermal contact with contaminated surfaces, and use of medications and personal care products (Faustman et al., 2000). Because children's activities often occur in or near their residences, realistic risk assessments must necessarily involve characterization of children's exposure in residential settings (Kippler et al., 2012). Additionally they have lower metabolic capacities compare with adults (Gimeno et al., 1996). Exposure to cadmium during critical periods of brain development may contribute to poorer intellectual development, deficit in working memory and attention problems (Chatham et al., 2011).

Study of long term sequel of acute exposure to heavy metal reveal that 6-12 year-old-children who had been hospitalized for acute heavy metal poisoning before the age of 3 exhibited significantly more impairments in verbal learning and motor inhibition tasks than control children (Rourke et al., 2001).

Routes of exposure or exposure pathway describe the way the chemical enters the body. Hazardous chemicals may enter the body by absorption through the respiratory tract via inhalation, absorption through the skin via dermal contact (very rare) and absorption through the digestive tract via ingestion such as eating or smoking with contaminated hands or in contaminated work areas.

For the general population, the two main sources are diet which is from contaminated water and crops grown on contaminated soil and tobacco smoking. A single cigarette is determined to have 1-2 μg of Cd and 10% of inhaled Cd is absorbed by the lungs (Faustman *et al.*, 2000). Below are the routes of exposure against Cd.

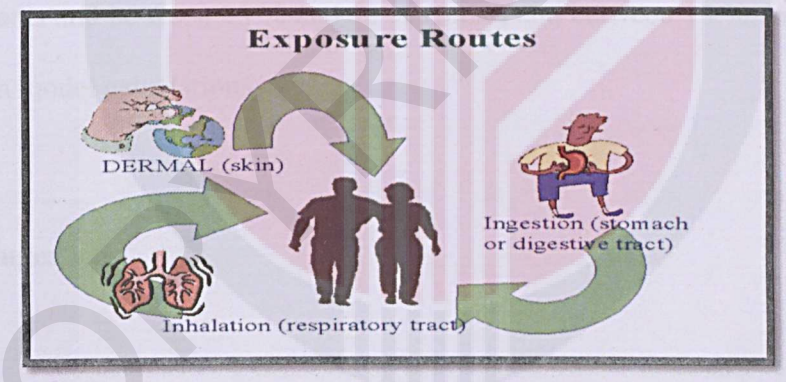


Figure 2.1 : Routes of exposure

2.6.1 Inhalation

A hazardous substance can enter the body by inhaling an airborne substance or contaminant in the form of gas, fumes mists, vapors, dusts, or aerosols. Once inhaled, contaminants can be deposited in the lungs and/or transported into the blood (Coronado et al., 2011).

Cd and inorganic Cd compounds have low volatility and exist in air mainly as particles or bound to particles. Consequently, the absorbed fraction depends, among other things, on the size of the particles and their solubility in the lungs. For cadmium oxide, the fraction is between 50 % (fume) and 30 % (dust) in animal experiments and between 25 % and 50 % (fume) and between 10 % and 30 % (dust) in human model calculations.

2.6.2 Ingestion

Absorption through ingestion defined as the act of swallowing something through eating, drinking, contaminated sources or mounting objects such as smoking. A hazardous substance can enter the body by this way (Faustman *et al.*, 2000). A small amount of the Cd in food and water about 1-10% will enter our body through the digestive tract. If our body do not have enough iron or other nutrients in diet, they are likely to take up more Cd from food than usual.

For the non-smoking population, food is the main intake source for Cd (daily intake about 10 to 60 µg cadmium) (Galal, 1991). Cadmium absorption in the gastrointestinal tract is influenced by various factors, such as age, composition and trace element content of the food, the calcium and iron balance, and also by the damage to the gastrointestinal mucosa caused by high Cd concentrations. It is about 5 % on average (Faustman *et al*., 2000).

2.6.3 Dermal absorption

Dermal absorption is defined as absorption through the skin via dermal contact which is touching. Satarug *et al*., 2004 carried out in vitro penetration tests on human cadaver skin with an 80-mesh filtered soil, to which Cd chloride ($^{109}CdCl_2$) (13ppb) was added, and a Cd chloride-containing aqueous solution (116ppb). Whereas after 16 hours uo to 12.7% (water) and 0.6 (soil) of the applied dose had been absorbes through the skin, only 0.6% and 0.07%, respectively had been recovered in the acceptor solution.

2.7 Other effects and symptoms

Once cadmium entered our body in short-term of expsoure it's can cause presence symptoms such cough, nose and throat irritation, headache, excessive sweating, fever, muscle shivering, nausea, vomiting, restlessness, chest pain, abdominal cramps and pain, muscle pain (Jiang et al., 2000). There is conflicting data that chronic cadmium exposure may cause mild anemia.

2.8 Biological Indicator to Detect Cadmium

Cadmium can be measured in blood, urine, hair or nails. However, cadmium levels in hair and nails are not useful as an indication of when or how much cadmium taken in, partly because cadmium from outside of our body may attach to the hair and nails. Most of the cadmium that enters our body goes to our kidney and liver and can remain there for many years. A small portion of the cadmium that enters our body leaves slowly in urine and feces. Basically our body can change most cadmium to a form that is not harmful, but too much cadmium can overload the ability of our liver and kidney to change the cadmium to harmless form (Buchet et al., 2003).

Cadmium concentrations in biological materials such as urine and blood are frequently used for estimating exposure level. Some reports from animals and from humans have shown a relationship between urinary cadmium excretion and total

body burden (Buchet *et al.*, 2003). The level of Urinary-cadmium (UCd) is a better indicator of body burden in those occupation-exposed people than other urinary metals (Burbure *et al.*, 2003).

Biological monitoring in urine, as opposed to blood, has several obvious advantages such as the ease of sample collection, the high concentration of analytes, and the greater amount of sample available for analysis (Buchet et al., 2003). Many studies have focused on exposures in young children, particularly pesticide exposures. Pesticides can cause a wide range of health problems, ranging from acute and persistent injury to the nervous system, injury to reproductive systems, birth defects, cancer and kidney damage, but primarily it damages the nervous system.

Urinary Cd has been shown to accurately reflect the amount of cadmium in the body. The amount of cadmium in urine shows both recent and past exposure (Leroyer *et al.*, 2001). Urinary Cd is a useful indicator because it is considered to be mainly in equilibrium with body burden before renal damage occurs. The level of urinary heavy metals could be associated with the level of body burden at a certain time, and it is an important indicator in health analysis (Galal, 1991).A first phase of very short duration (0-15 days) is observed during which cadmium level in urine increases rapidly to reach a value of about 15 μg/g creatinine. This is followed by a second phase (15-120 days) during which cadmium level in urine increase more slowly. After 120 days there is apparently a rapid increase of the cadmium level in urine (third phase).

CHAPTER 3

METHODOLOGY

3.1 STUDY LOCATION

For the exposed group, this study was conducted in primary school near the paddy field in Sawah Sempadan, Tanjung Karang, Selangor (Figure 3.1), as it represented the typical geographic and socio-economic distribution among children in Tanjung Karang. While for the unexposed group, the children were selected from a school located far from agriculture area and not expose to pesticides and fertilizers. Tanjung Karang is an estate located in the state of Selangor, and an area under Kuala Selangor Municipal Council (MPKS).

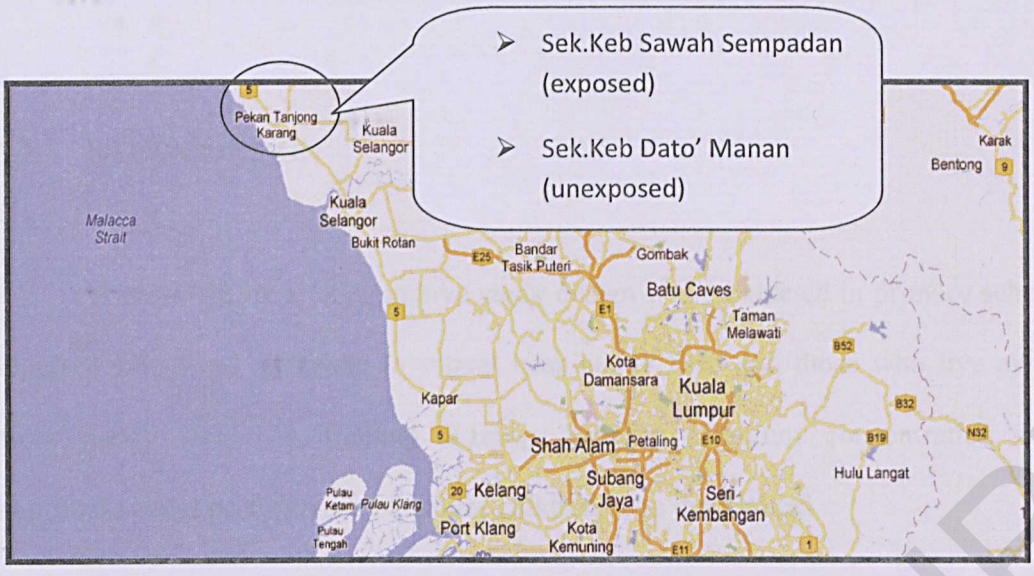


Figure 3.1: Location of Tanjung Karang

Table 3.1: Timeline of Paddy Cultivation in Tanjung Karang, Selangor

Months	Activities
November	Cut rice straw and doing the weedicide
	The rice straw will be burn before plant new paddy
	Ploughing using tractor and leveling the paddy field
December	Herbicide will be used to do weed control in field
	Balance the soil pH
	Pesticide used to control pests in the field
	Ploughing using tractor and leveling the paddy field
January	Irrigate and remove water from paddy field block
	Sow seed uniformly
	Fertilizing
February & March	Fertilizing, maintaining and pest control
April	Ripening of paddy
May	Harvesting of paddy

(Source: Pejabat Pertanian Kuala Selangor Utara, 2009)

3.2 STUDY DESIGN

A cross-sectional comparative study design was conducted in primary school children who lived and went to school near paddy field and those who live away from paddy field, in Tanjung Karang. Urinary cadmium concentration and neurobehavioral performance of school children were determined.

3.3 SAMPLING

3.3.1 Sample Population

The sampling method used was convenience sampling. The study populations were primary school children, with age group of 10-11 years old (Year 4 and 5), who live and went to school located near (<100m) the paddy field. While the unexposed populations were the primary school children who live more than 5 km the agriculture area.

3.3.2 Sample Frame

The students in Year 4 and 5 were selected randomly from the name lists obtained from the teachers. However, only those children who fulfill the inclusion criteria (healthy and approved by parents) were included in the study.

Inclusion criteria

- Primary school children who live and went to school near paddy field, with age group of 10-11 years old (Year 4 and 5).
- Primary school children who got an approval from their parents or guardian to participate in the study.
- Primary school children who were healthy .

3.3.3 Study Sample

In this research, the respondents involved consist of 89 primary school children that live and study near agriculture area while 89 primary school children act as unexposed group as they live and study far from agriculture area.

Rubinson & Neutens (1987) formula is used to calculate the sample size. This formula used because the research wants to compare between exposed children and unexposed group. The total of respondents for exposed and control group will be doubled to get the total respondents. The sample size calculation are as below:

$$N = (z/e)^2(p)(1-p)$$

Where:

N = sample size

z = standard score for significant level

p = estimation incident for population

For 95% significant level = 1.96, e = 0.1

Calculation for Exposed and Unexposed Primary School Children Group:

The value p=0.253 is based on study by Boyle et al. (2011).

$N = (1.96/0.10)^2(1-0.253)\ (0.253)$

N = 74.061

N = 74, minimum sample size for exposed primary school children group, also 74 respondents for the unexposed primary school children group.

The value is rounded up to 20% to account and backup any missing data during data collection process. The calculation is follows:

20% x 74.061

=14.812

=15

=15 + 74

=89 respondents

Total respondents for exposed and unexposed primary school children,

N= 89+89

N= 178

3.4 STUDY INSTRUMETATION AND DATA COLLECTION

3.4.1 Questionnaire

The questionnaire is one of the tools to get information from the children. Questionnaires were used to determine the background information of each respondent. The questionnaire consists of four sections (26 questions) which are socio-demographic information, knowledge on fertilizer and pesticides, residential area and health status of the children. Since Bahasa Malaysia is our national language and the language is understood by most of citizens, the questionnaire was in Malay language as to facilitate the respondents to understand the questions. If the questionnaire was incomplete, the mothers were contacted to obtain the missing information.The questionnaire were pre tested before the actual data collection.

3.4.2 NCTB (NEUROBAHAVIORAL CORE TEST BATTERY)

Neurobehavioral performance batteries which consist of seven tests are a well-recognized method of assessing potential health effects associated with heavy metal exposure. Specifically, the functional domain tested including attention and response speed, auditory memory, manual dexterity, perceptual motor speed, visual perception and memory, and steadiness. The materials needed were test performances form sheets, stopwatch, pencils without eraser and eraser. It has seven

tests and time needed to complete all tests around 45-50 minutes for each respondent. There are several steps in usage of this instrument. Firstly, training was given for the researcher who is going to do the test, next was the preparation of instruments and respondents, and after that actual test was conducted. The room where testing was done were free from any distractions, with adequate lighting and comfortable. One concern was that the tests needed to be acceptable to the children and their parents (i.e., painless, not too time-consuming, and appropriate for the age group).

✓ **Instrumentation**

a) Pencil without eraser

b) Eraser

c) Stopwatch

d) WHO Neurobehavioral Core Test Battery which are:

Table 3.2: Neurobehavioral Tests and Its Purpose

TEST	PURPOSE
1.Benton Visual Retention	Visual Perception/Memory
2. Reaction Time /Movement	Attention/Response Speed
3.Santa Ana Manual Dexterity	Manual dexterity
4. Trail Making	Motor and Visual Coordination/ Steadiness
5. Persuit Aiming	Motor Steadiness
6. Digit Symbol	Perceptual Motor Speed
7. Digit Span	Auditory Memory

3.4.2.1Benton Visual Retention Test

The Benton Visual Retention test is an individually administered test that measures visual perception and visual memory. It can also be used to help identify possible learning disabilities. The respondents were showed 10 geometrical designs,one at a time , and then asked to determined which from the A,B, C and D answer are the same design with the geometrical design has been shown in one minutes.Then, the answer is recorded on the NCTB form.

3.4.2.2 Digit Symbol Test

The Digit Symbol Test of psychomotor performance and its computer based alternative, the symbol digit test of complex scanning and visual tracking, constitute the most widely used and sensitive tests in human behavioral neurotoxicology research. These tests present nine symbols, each paired with a number between 1 and 9 in a matrix or 2 x 9 table. Below the matrix is a similar matrix but with only the number (digit symbol) or symbol (symbol digit), and the respondent must add the missing member of each pair, as quickly as possible just in 90 seconds.

3.4.2.3 Digit Span Test

The Digit Span Test is a simple test of attention in which a series of numbers between 1 and 9 are read to a respondent who must, after the series is completed, repeat the series orally. The test is then repeated with new numbers, but respondent are to repeat them backwards that is, reverse of the order in which they were read. The last series where the respondent can repeat had been considered as the final result.

3.4.2.4 Pursuit Aiming Test

The Pursuit Aiming Test requires the subject to use a pencil and place one dot inside the centre of each circle following the pattern given on the printed pursuit aiming test sheet. This task is to be performed as quickly as possible for 60 seconds.

3.4.2.5 Reaction Time / Movement Time Test

The Reaction Time / Movement Time Test of response speed presents a visual or auditory stimulus to which the respondent is to respond as quickly as possible by transferring their finger from bottom to top button. The respondents need to respond if the green LCD appears. The result is recorded in the form.

3.4.2.6 Santa Ana Dexterity Test

In this test a plastic base plate with pegs fitted in rows of 12 was used. Each peg was to be removed turned 180 degrees and replaced in its slot. The objective is to turn as many pegs as possible in 30seconds. The test is repeated twice with the dominant hand and twice with the non-dominant hand. The number of pegs successfully turned is recorded as the test score.

3.4.2.7 Trail Making Test

This test used to measures attention, visual conception and psychomotor function. The worksheet contains 2 pages, the first page contain numbers only and the second one contains numbers and letters inside circles. The respondent task is to draw a line connecting numbers to numbers in the first page and letters to numbers in the correct order in the second page from the number 1 to the letter A, to number 2 to the letter B and so on. The time in second is recorded after the respondent completed the task.

3.4.3. URINARY CADMIUM CONCENTRATION LEVEL

The individual urine sample has been collected in 50mL polypropylene plastic bottle that deionized (free from heavy metals) and previously washed with 5% nitric acid. Spot urines was requested, thus, they were provided with the collection materials the day of sample collection and urine samples were marked with ID number. Then, they returned their urine samples to the study researchers. Samples were stored and cooled as soon as possible and transported in cool box to the laboratory for analysis of markers of cadmium. Urine samples were preserved at cool box with temperature maintained $4^{o}C$ and before stored, the samples were wrapped with aluminum foil to avoid them from vapourized and contamination. Upon arrival, the samples were stored at -20^{o} C.

Each sample was acidified with 100µl of 65% (v/v) HNO^3 and then returned to the fridge. Before the dilution, each sample was shaken strongly before being dilute with the deionized water. 1ml of the urine sample was diluted with 9ml of deionized water. The result was showed on the computer's screen. We determine the cadmium concentration by using Flame AAS machine.

3.4.4 Flame Atomic Absorption Spectrometry (AAS)

Urinary cadmium concentrations were measured using the SHIMADZU AA6800/PERKIN ELMER 3300 Model of the Flame Atomic Absorption Spectrometry (FAAS). It is ideal for laboratories analyzing a limited number of elements and requiring excellent detection limits. The minimum detection of cadmium in urine by AAS was 0.1µg/L (Thatcher *et al.*, 1994).

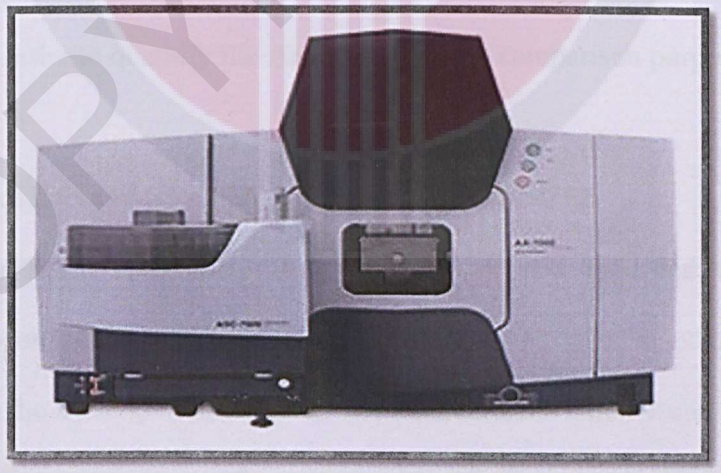


Figure 3.2 :Flame Atomic Absorption Spectrometry (AAS)

3.5 DATA COLLECTION PROCEDURE

Permission was obtained from Ministry of Education to carry out research at schools in Tanjung Karang, Selangor .Then the permission letter was given to the headmasters'. Consent letter were distributed to the students, to get their parents/guardian permission. After the parents/guardian gives their permission, the questionnaire was brought back to be filled in by their parents.

The Neurobehavioral Core Test Battery (NCTB) which consists of seven types of test was carried out and 50ml urine sample were obtained from each respondent. Then, the sample was analyzed using the Flame AAS Machine SHIMADZU AA6800/PERKIN ELMER 3300.

The data collection approaches for both exposed and unexposed group were conducted in the same procedures .NCTB data were computed through the following formula (3.6) in order to quantify the standard score for comparison purposive.

3.6 COMPUTATION OF STANDARD SCORE FOR NCTB

The raw score (raw data) from NCTB test was modified to make it comparable to score which was collected from other studies. The standard score for NCTB requires the computation of mean and standard deviation from all subjects from each test .The standard score formula are shown below:

$$\text{Standard Score} = [(\text{raw score} - \text{mean})/ \text{SD}] \times 10 + 50$$

3.7 DATA ANALYSIS

All the data was analyzed using Statistical Package of The Social Sciences (SPSS 19.0) and Microsoft Excel 2007.The data analysis used as follows:

Table 3.3: Data Analysis Use in the Research

SPECIFIC OBJECTIVE	STATISTICAL ANALYSIS
To determine the urinary cadmium concentration of the two study groups.	Descriptive statistics
To determine the neurobehavioral performance of the two study groups.	Descriptive statistics
To determine the correlation between urinary cadmium concentration with neurobehavioral performance of the two study group	Spearman-rho correlation
To compare the difference in the urinary cadmium concentration between the exposed with the unexposed group	Mann-Whitney U
To compare the difference in neurobehavioral performance between the two study groups.	Independent T-test and Mann Whitney U
To determine selected variable that influence urinary cadmium concentration of the two study groups.	Multiple Linear Regression
To determine selected variable that influence the neurobehavioral performance of the two study groups.	Multiple Linear Regression

3.8 QUALITY CONTROL

To ensure that data collection was reliable and valid, quality control on the instrument and procedure during data collection are as following:

3.8.1 Questionnaire

Pre-test of questionnaire were conducted to 10% of the total respondents. The validity and reliability of the questionnaire were then determined using SPSS (α= 0.749). The pre-tests was carried out before data collection. The purpose of pre-tests is to ensure that every questions ask in questionnaire could be understood and answered by the respondents.

3.8.2 Standard Operating Procedure for Urine Collection

Urine samples were kept in a sterile polypropylene container to avoid from contamination which might affect the result. The polpropylene container and all the apparatus were washed with 65% Nitric Acid to avoid contamination with heavy metal and were kept in cool box at 4°C-8°C during transportation and stored at -20°C.

3.8.3 NEUROBAHAVIORAL CORE TEST BATTERY (NCTB)

Safety Operating Procedures that have been taken were the researcher was trained thoroughly to control error variance, the room must be ensured to be comfortable, free from distracting noise and intrusions, having adequate lighting, suitable table and seats (researcher and respondent can sit either face-to-face or a 90% angle in regard to each other). Besides than that, other SOP that were included in this study were giving pre-test before actual tests being done and also usage of pencil without its own eraser.

The respondents were told exactly the same thing as the standard procedure. The SOP was also used in analysis using standard method by World Health Organization.

3.9 STUDY ETHIC

This study was conducted by considering ethical issues as stated by medical ethical committee from Faculty of Medicine and Health Sciences, Universiti Putra Malaysia:

i. The research proposal has been reviewed and endorsed by the ethical committee.

ii. Permission letter from Ministry of Education was obtained before carrying out the research.

iii. The individual consent from respondents was requested before involving them in the study.

iv. The respondent has been given some explanation about the whole of the study activities involved.

v. The respondent has been given some explanation about the explanation about the purpose of the urine taken and explanation about the method of urine sampling.

vi. Standard Operating Procedure has been followed in order to run the NCTB test.

vii. The respondent has been given some explanation about the NCTB test that will be held to them in term of the purpose of the test, the procedure taken , and also respondents' in this study.

3.10 STUDY LIMITATIONS

The limitations of the study are:

i. The NCTB test duration is 30-40 minutes, therefore the respondent did not cooperate fully.

ii. Permission from parents and cooperation of the respondents.

iii. Information bias can occur when respondents were required to recall the activity and previous history when they are needed to give the information.

CHAPTER 4

RESULT

4.1 Study Location

This study was conducted at Kampung Sawah Sempadan, Tanjung Karang, Selangor which is the largest paddy producer in Selangor after Kedah and Perak. It has approximately about 2,300 hectares of paddy field at this village. It is a part of the Barat Laut Paddy Project within the north of Selangor state which is in the southeast part of Malaysia. Global Positioning System (GPS) coordinates for the area is 3.730467°N, 101.029567°E. Fertilizer applications are limited to the farmers' perception, or at best, based on general recommendations provided by agricultural agencies.

Paddy cultivation has become the identity of the community in the Tanjung Karang vicinity as rice is their main crop production. It is a reality that the Malay community livelihood is still dependent on agriculture sources as their main source of income. It has a population of 39,857 people and comprises of 90% Malays, 8% Chinese and the rest are Indians. The Chinese are live in the urban area and involved in business or retailing. The Malays and Indians live in the rural areas performed agricultural activities, particularly rice cultivation.

Sekolah Kebangsaan Sawah Sempadan, a rural area school, is located about 5km from Pekan Tanjung Karang. This school was constructed in year of 1964 and able to accommodate about 360 students from standard one to standard six. It was chosen as the exposed group based on the location of the school which was located about 100 to 200 meters from paddy-planting area. Due to this factor, the students were believed to have high risk of pesticide exposure from paddy agriculture activities.

For unexposed group, students from Sekolah Kebangsaan Dato' Manan were selected to be in this study, and the school was constructed in the year of 1980. It is slightly bigger in size compared to Sekolah Kebangsaan Sawah Sempadan which has about 450 students. Based on the observation, the school was far from agriculture areas.

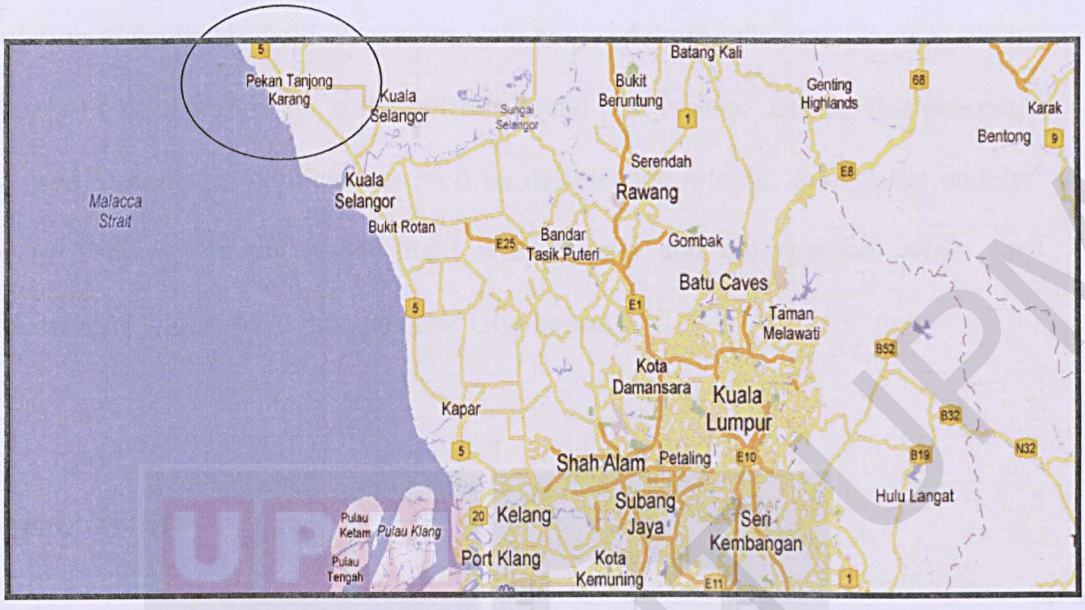


Figure 4.1: Map of the study location

4.2 Process of Paddy Cultivation

From the Agriculture Department of Kuala Selangor, the paddy cultivation process carried out twice a year, with each cycle of paddy cultivation takes around 6 months to harvest the final product. Paddy cultivation process includes several steps such as preparation of the soil, irrigate paddy block, planting the seed, fertilizing/pesticide control and harvesting.

The farmers used pesticides for the land preparation in which they used herbicide to control the growth of weed. In the process of irrigating the paddy block,

they used herbicide to control weed growth and also rodenticide to control the rat population in the paddy field. Pesticides were not used during the seed planting and it will only be used widely for soil fertilization and pest control. During this process, they used insecticide, herbicide as well as mollucicide widely. Insecticide widely used in Tanjung Karang paddy field was Avisect and chlorpyrifos, while for herbicide they widely used Paraquat and Glyphosate.

4.3 Study Sample

This study aimed to determine the urinary cadmium concentration and neurobehavioral performance of the primary school children, who were highly exposed to heavy metal.

In order to get a valid sample of data, the sample of students were taken from two selected schools after considering their location and the surrounding areas. The students involved in this study were controlled based on their age which they must be in the range of 10-11 year old (Year 4 & 5). From this two selected schools, 140 students were involved, where for the exposed group, 80 students were participated meanwhile 60 students participated as unexposed group. The response rate was more than 80%, thus it increase the power of the study.

4.4 Socio-demographic of Study Group

Personal variable between the two groups were tested to compare the difference between exposed and unexposed group, namely gender, number of siblings, Body Mass Index (BMI), transportation, housing area, total household income parents occupation and parents education. All the children were between Year 4 and 5, Malay ethnic and all their fathers smoked.

In determine any significant value present, all continuous data variables (body mass index (BMI) and number of siblings) have been tested with statistical analysis of Mann-Whitney U test since they were not normally distributed according to the Shapiro-Wilk. Selected continuous variables such as BMI and number of siblings would give values for median and inter-quartile range. Both BMI (p= 0.098) and number of siblings (p =0.296) variables, shows no significant difference between the two study groups (Table 4.1).

Table 4.1 : Respondents' socio-demography information

Variable	Median (IQR)		z	P
	Exposed	Unexposed		
	N=80	N=60		
Number of siblings	4.00	4.00	-1.045	0.296
	(2.00)	(2.00)		
BMI	15.384	16.569	-1.655	0.098
	(4.6000)	(4.600)		

N = 140
IQR=Interquartile Range

Chi-Square Test was performed towards the categorical data (Table 4.2). Variables such as gender, parents education level, total household income, parents occupation, transport used, housing area as well as the distance of study group's house to school were taken into account. Among them, only transportation, father's Occupation, gender and both parents' education level shows there were no significant differences between study groups. The rest of variables show there were significant difference between the study groups.

Gender is one of the factors that might affect the result; hence, match the gender between two groups studied was the appropriate method to control for confounder and bias. Study group total household income was obtained as an indicator of their health status.

The respondent parents' education level was obtained to reflect on the perceived knowledge of respondent on pesticide exposure and health effect from the exposure. The result showed that there was no significant difference between father's educational level among exposed and unexposed group, meanwhile mother's educational level showed significant difference.

Frequency for certain variables were also been measured to gather information of studied children's background. Most of the respondent father's work as general workers/ normal staff, whereas half of the mothers' works as housewife. Professional/expert had the lowest number of parents' occupation, and this is because the school is in rural area, and surrounded by agriculture area. Thus, most of them seem to have average salary of RM1000-RM2000. Another features observed is the medium of transportation used by the children as they going to school where most of the children come to school by riding motorcycle. In order to identify significant cofounder, house location of each student was also asked in the questionnaire and most of the study groups were found stayed near to roadside.

Table 4.2: Respondents' socio-demography information

Variables	Exposed n (%)	Unexposed n (%)	χ^2	P
Gender			0.197	0.657
Male	33(41.3)	27(45.0)		
Female	47(58.8)	33(55.0)		
Father's education level			1.517	0.824
Primary School	17(21.2)	11(18.3)		
PMR	11(13.8)	9(15.0)		
SPM	48(60.0)	36(60.0)		
STPM/Diploma	4(5.0)	3(5.0)		
Degree/Master/PHD	-	1(1.7)		
Mother's education level			7.361	0.118
Primary School	13(16.2)	7(11.7)		
PMR	20(25.0)	7(11.7)		
SPM	42(52.5)	37(61.7)		
STPM/Diploma	5(6.2)	8(13.3)		
Degree/Master/PHD	-	1(1.7)		
Total Household income			15.220	0.009*
<1000	29(36.25)	6(10.0)		
1000-2000	38(47.5)	39(65.0)		
2001-3000	8(10)	6(10.0)		
3001-4000	2(2.5)	6(10.0)		
4001-5000	1(1.3)	1(1.7)		
>5000	2(2.5)	2(3.3)		
Father's occupation level			9.132	0.058
Professional/Expert	-	2(3.3)		
Assistant Staff	3(3.8)	3(5.0)		
General worker/Normal Staff	19(23.8)	25(41.7)		
Business/Self-employee	51(63.8)	27(45.0)		
Jobless/Pension	7(8.8)	3(5.0)		

Mother's occupation level			16.656	0.005*
Professional/Expert	1(1.2)	2(3.3)		
Assistant Staff	1(1.2)	10(16.7)		
General worker/Normal Staff	8(10.0)	8(13.3)		
Business/Self-employee	12(15.0)	4(6.7)		
Jobless/Pension	7(8.8)	1(1.7)		
Housewife	51(63.8)	35(58.3)		
Transportation			4.44	0.217
Bicycle	20(25.0)	15(25.0)		
Motorcycle	24(30.0)	25(41.7)		
Car	11(13.8)	10(16.7)		
House Location			47.559	<0.001**
Paddy Field	40(50.0)	-		
Residential Area	13(16.3)	33(55.0)		
Road	25(31.3)	23(38.3)		
Jungle	2(2.5)	4(6.7)		
Distance of house to school			7.177	0.028*
<1000m	40(50.0)	17(28.3)		
1000-2000m	30(37.5)	35(58.3)		
>2000m	10(12.5)	8(13.3)		

N=140

*Significant at $p<0.05$

**Significant at $p<0.001$

4.5 Reported Sign and Symptom of Study Group

The findings showed there was significant differences on some symptoms reported between exposed with unexposed group which were cough (p= 0.029) and excessive sweat (p=0.029). Watery eye, breathing difficulties, and watery nose showed no significant difference between both groups. These symptoms might appear due to chemical exposure in agriculture, and further examination by medical doctor is needed to confirm these symptoms. Table 4.3 shows the distribution of the reported signs and symptoms of the two study groups.

Table 4.3 : Comparison of sign and symptoms among study groups

Symptoms	Exposed	Unexposed	χ^2	P
	n(%)			
Watery Eye				
Yes	28(35.0)	11(18.3)	0.479	0.29
No	52(65.0)	49(81.7)		
Breathing Difficulties			1.414	0.234
Yes	20(25.0)	10(16.7)		
No	60(75.0)	50(83.3)		
Excessive Sweat			4.739	0.029*
Yes	28(35.0)	11(18.3)		
No	52(65.0)	49(81.7)		
Watery nose			2.24	0.636
Yes	5(6.3)	5(8.3)		
No	75(93.8)	55(91.7)		
Cough			4.739	0.029*
Yes	28(35.0)	11(18.3)		
No	52(65.0)	49(81.7)		

N=140; *Significant at p<0.05

4.6 Urinary cadmium Concentration

A total 80 (exposed group) and 60 (unexposed group) children responded to the study. The raw data then were analyzed according to Shapiro-Wilk test to determine their pattern of distribution. Since, both exposed and unexposed group were not normally distributed, the Mann Whitney U test then were performed to determine the significant difference between both groups. The median of exposed group was slightly higher than control group. Based on the result, there was no significant difference of urinary cadmium concentration between exposed and unexposed group (p = 0.180) (Table 3.3).

Table 4.4: Comparison of urinary cadmium concentration between study group.

Variable	Median (IQR)		z	p
	Exposed	Unexposed		
Urinary cadmium concentration (µg/L)	0.100 (0.11)	0.000 (0.52)	-1.342	0.180

N=140

4.7 Neurobehavioral Performance

Seven NCTB test were performed and normality test was carried out to determine the distribution of data for both groups.

To observe the neurobehavioral performance of the samples, a set of seven NCTB test were performed for both exposed and unexposed group. Based on the result obtained, six of the scores were not normally distributed, hence, Mann – Whitney U test was used to determine if there is difference in NCTB score between the two groups. Out of six, five of them show there were no significant difference between exposed and unexposed group for the test of Benton Visual Retention Test ($p = 0.796$), Digit Span Test ($p = 0.261$), Santa Ana Manual Dexterity Test ($p = 0.650$), Pursuit Aiming Test ($p = 0.693$) and Trail Making Test ($p = 0.975$). Only Reaction Time /Movement Test shows significant difference between exposed and unexposed group ($p = 0.025$).

It was also found that only Digit Symbol Test was normally distributed and there was no significant difference in Digit Symbol Test between the exposed and the unexposed group. (Independent T-Test, $p = 0.837$).

Table 4.5 : Comparison of neurobehavioral performance between both groups

Variable	Median (IQR)/Mean(SD)		z^a/t^b	P
	Exposed	Unexposed		
Benton Visual Retention Test[a]	52 (12)	50 (14)	-0.258	0.796
Digit Span Test[a]	50 (10)	50 (10)	-1.123	0.261
Santa Ana Manual Dexterity Test[a]	51 (14)	51 (12.50)	-0.454	0.650
Reaction Time / Movement Test[a]	52 (14)	70.5 (108.25)	-2.247	0.025*
Pursuit Aiming Test[a]	48 (15)	47 (13.50)	-0.394	0.693
Trail Making Test[a]	48 (9)	47 (9)	-0.032	0.975
Digit symbol Test[b]	50.08 (1.0164)	50.43 (1.0164)	-0.206	0.837
Total NCTB score	351.08	365.93	-0.516	0.606

N=140
[a]Man-Whitney U test
[b] Independent T-test
*Significant at $p<0.05$

4.8 Correlation between Urinary Cadmium Concentration and Neurobehavioral Performance among Study Groups

In order to identify the correlation between urinary cadmium concentration and neurobehavioral performance, Spearman's rho test was conducted. Based on this bivariate test (non-parametric) correlation test, there was no significant correlation between urinary cadmium concentrations with the entire neurobehavioral performance scores except with Reaction Time test as shown in Table 4.6.

Table 4.6: Correlation between Urinary Cadmium Concentration and Neurobehavioral Performance of Study Groups

Variable	Urinary Cadmium Concentration (µg/L)					
	Exposed n=80		Unexposed n=60		Both Group N=140	
	r	p	r	p	r	p
Benton	0.150	0.186	-0.172	0.190	0.082	0.335
Digit Span Test	0.130	0.250	0.007	0.956	0.048	0.577
Santa Ana	-0.101	0.374	0.064	0.626	0.016	0.847
Reaction Time	0.229	0.041	0.104	0.430	-0.168	0.047*
Trail Making Test	0.030	0.795	0.023	0.862	0.024	0.780
Pursuit Aiming Test	-0.146	0.197	0.054	0.680	-0.017	0.844
Digit Symbol Test	-0.88	0.437	0.208	0.111	0.088	0.301

N=140
*Significant at p<0.05

4.9 Selected Variables Which Influenced Urinary Cadmium Concentration among Study Groups

Multiple Regression Linear (MRL) (enter method) were used to determine which variable influenced the neurobehavioral performance score other than urinary cadmium concentration while adjusting for all the confounders. In this test, the dependent variable was urinary cadmium concentration while independent variable were transportation, house location, distance from house to school, parents occupation, parents' education, and total household income data. From the overall selected variables, all the variables do not influence the urinary cadmium concentration for all children. (Table 4.7).

Table 4.7: Selected Variables Which Influenced Urinary Cadmium Concentration among Study Groups

Independent Variable	Regression Coefficient (ß)	t	p	F	p
(Constant)	-2.59	-0.543	0.588		
Transportation	0.071	0.792	0.430		
House Location	-0.017	-0.208	0.835		
Distance from house to school	-0.144	-1.040	0.300		
Father's Education	0.041	0.766	0.445	0.585	0.824
Mother's Education	0.002	0.041	0.967		
Father's Occupation	0.035	0.522	0.602		
Mother's Occupation	0.003	0.075	0.940		
Total Household Income	0.005	1.109	0.270		
BMI	0.006	0.555	0.580		
Gender	0.071	0.891	0.375		

N=140;
Regression Method= Enter

4.10 Selected Variables Which Influenced Total NCTB Performance among Study Groups

Multiple Linear Regression was carried out to determine the risk factor of the total NCTB performance among the exposed group. In this test, the dependent variable was total NCTB performance while independent variable were urinary cadmium concentration, parents' education, parents' occupation, total household income and number of siblings in the children's family

4.11 Selected Variables Which Influence Each NCTB Test among Study Groups

Multiple Linear Regression (enter method) analysis was used to identify independent variables which significantly influence NCTB test performance. Among the 7 NCTB tests that have been analyzed, only Reaction Time /Movement Test showed significant relationship between the predictor factors of neurobehavioral performance due to heavy metal exposure. The rest of NCTB test shows no significant relationship between the test performance and the independent variables selected.

4.12 Selected Variables Which Influence Reaction Time/Movement Test

Multiple Linear Regression Analysis was carried out to identify independent variable which significantly influenced Reaction Time/ Movement Test score among the exposed group. In this test, the dependent variable was Reaction Time /Movement Test score while independent variables were urinary cadmium concentration, parents' education, parents' occupation, total household income and number of siblings in the children's family.

Table 4.8 : Selected Variables Which Influenced Reaction Time Movement Test among Study Groups

Independent Variable	Regression Coefficient (ß)	T	p	F	P
(Constant)	47.095	9.272	<0.001		
Urinary cadmium concentration (µg/L)	-2.650	-1.395	0.165		
Father's Education	-2.650	-2.294	0.023*	1.918	0.072
Mother's Education	3.237	2.531	0.013*		
Father's Occupation	1.769	1.221	0.224		
Mother's Occupation	-1.026	-1.263	0.209		
Total Household Income	-0.001	-0.926	0.356		
Number of siblings	0.416	0.712	0.478		

N=140
Regression Method= Enter

***Significant at p<0.05**

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

5.1.1 Socio-demography background

A total of 80 respondents from school near paddy field selected as exposed group, while 60 respondents far from agriculture area as unexposed group participated in this study. The primary school children near paddy field were selected as exposed group due to their exposure to agricultural sources. While school children far from agriculture area, were selected as unexposed group. The urinary cadmium concentration was found to be below standard value. Primary prevention of exposure provides the best hope of mitigating the impact of this preventable disease. Children exposed to cadmium may diminish their intelligence and described especially with respect to verbal, psychomotor, cognitive and perceptual skills (Marlowe et al.,

1993). In cohort studies, (Thatcher et al, 1994) reported that the concentration of cadmium was inversely related to adjusted IQ score.

The respondents were selected based on the inclusive criteria such as age from 10 to 11 years old, healthy children and get an approval from their parents. Matching process is very important when comparing between two study groups. The matching of the group includes age, ethnicity and fathers smoking. This is because the confounding factors may influence the study. In this study, smoking was the major confounding factors because these variables might influence the neurobehavioral performance. Therefore, we reduce the bias by controlling their age range, same ethnicity (Malay) and all the fathers are smoked.

Boyle et al., (2011) found that children who resided in an agricultural community displayed poorer response speed and latency abilities compared with children from non agricultural communities in the United States. Children of agricultural workers are considered to have a higher risk of exposure to pesticides compared to the general populations because of the close proximity of their homes to the fields where pesticides are applied and from take-home exposure (Fenske, et al., 2005). The primary reason children are believed to be more vulnerable to neurotoxic chemical is because of their increased absorption and decreased elimination through the gastrointestinal tract.

The children of farmworkers are also potentially heavily exposed to heavy metal because they accompany their parents to the fields, live in housing contaminated by pesticide drift from nearby fields, and occasionally work in the fields themselves. A recent California Department of Health Services pilot project suggests a potential for higher residential exposure to some pesticides for children of farmworkers versus children of non-farmworkers.

Heavy metal are thought to pose a considerably higher risk to children due to behavior (e.g.,increased hand-to-mouth activity) and potentially longer-term exposure over a working lifetime, overall higher activity levels and faster metabolism, and smaller body weight per exposure (Galal, 1991). Body Mass Index was measure because toxicants has been reported to reduce food intake and the concentration of certain toxicants may remain higher in obese people in longer time (Faustman et al., 2000). Gender-related behavioral disparities during infancy and childhood have been reported and related to differences in early exposure to chemicals (Kippler et al., 2012). Differences between males and females in patterns of exposure, gastrointestinal absorption of chemicals, metabolism, and detoxification have also been documented. Thus, the internal cadmium dose is generally higher in women than in men due to a higher gastrointestinal absorption at low iron stores.

There is also concern about the impact of neurotoxicants on the developing central nervous system (Bellinger et al., 2001). There were respondents who reported

suffer health problems, such as watery eye, breathing difficulties, excessive sweat, watery nose and cough. Acute organophosphate exposure causes increased salivation tearing, blurred vision, nausea, vomiting, abdominal cramps, urinary and fecal incontinence bronchial secretions, cough wheezing, and sweating. In even more severe acute intoxication, dyspnea, bradycardia, heart block, hypotension, pulmonary edema, paralysis, convulsions, or death may occur (Fenske et al, 2005).

Heavy metal can cause both acute and chronic damage to children's nervous systems. Children acutely exposed to neurotoxic heavy metal are susceptible to symptoms of poisoning much like adults, ranging, depending on exposure levels, from headache and nausea to convulsions and death. Few pesticides have been evaluated for their ability to cause chronic, permanent damage to immature, developing nervous systems. Children also spend a lot of time outdoor and more likely to come into contact with particulate cadmium that concentrate in this breathing zone. Children also have greater hand-to-mouth activity, increasing opportunities for direct ingestion of cadmium residues in dirt or dust.

The primary reason children are believed to be more vulnerable to neurotoxic insecticides is because of their increased absorption and decreased elimination through the gastrointestinal tract. Infant kidneys, for example, are immature and cannot excrete foreign compounds such as drugs as quickly as adult kidneys.

5.1.2 Urinary Cadmium Concentration

In this study, it is found that, there is no significant difference between exposed and unexposed group. Children can be exposed to heavy metal through a variety of pathways, including dietary and non-dietary ingestion, inhalation of indoor and outdoor air, dermal contact with contaminated surfaces, and use of medications and personal care products. Because children's activities often occur in or near their residences, realistic risk assessments must necessarily involve characterization of children's exposure in residential settings (Jedrychowski et al., 2009). In order to evaluate the degree of exposure of the children, urine can be utilized as a biomarker to detect the presence of cadmium.

The individual urine sample has been collected in 50mL polypropylene plastic bottle that deionized (free from heavy metals) and previously washed with 5% nitric acid. Spot urines was requested, and stored at -20°C until analysis. Urinary cadmium concentrations were measured using the SHIMADZU AA6800/PERKIN ELMER 3300 Model of the Flame Atomic Absorption Spectrophotometer (FAAS). The minimum detection of cadmium in urine by AAS was 0.1µg/L (Thatcher *et al.*, 1992).

Biological monitoring in urine, as opposed to blood, has several obvious advantages such as the ease of sample collection, the high concentration of analytes,

and the greater amount of sample available for analysis (Buchet et al., 2003). Urinary cadmium has been shown to accurately reflect the amount of cadmium in the body. The amount of cadmium in urine shows both recent and past exposure (Leroyer *et al.*, 2001). Urinary cadmium is a useful indicator because it is considered to be mainly in equilibrium with body burden before renal damage occurs (Leroyer *et al.*, 2001). The level of urinary heavy metals could be associated with the level of body burden at a certain time, and it is an important indicator in health analysis (Jiang et al., 2000). Cadmium concentrations in healthy persons without excessive cadmium exposure are generally less than 1 µg/L in either blood or urine. The ACGIH biological exposure indices for blood and urine cadmium levels are 5 µg/L and 5 µg/g creatinine, respectively, in random specimens.

5.1.3 Neurobehavioral Performance and Comparison Between Exposed with Unexposed Group

NCTB testing is a non- invasive method use to evaluate the performance of the central nervous system in an individual or group with similar exposures. Test batteries consists of tasks that measure performance of particular neurologic function ,such as ability to learn, reaction time, memory , and coordination. It used widely to detect the dysfunction of nervous system that caused by neurotoxin agent.

The NCTB consists of seven test, which are made up of the Benton Visual Retention Test,Digit Symbol Test,Digit Span Test ,Pursuit Aiming Test, Reaction Time /Movement Test, Santa Ana Manual Dexterity Test and Trial Making Test.

Previous studies showed that the widely usage of NCTB as neurobehavioral assessment due to neurotoxicant exposure support this study in using NCTB as the tools to determine the neurological effects. Another study showed NCTB has been used to evaluate pesticide effects on cognitive and psychomotor function (Cynthia et. al.,2010).

According to the table 4.11, it shows there was no significant difference in score between exposed and unexposed group. Exposure to cadmium during critical periods of brain development may contribute to poorer intellectual development, deficit in working memory and attention problems (Catham et al., 2011). Study of long term sequel of acute exposure to pesticide reveal that 6-12 year-old-children who had been hospitalized for acute pesticide poisoning before the age of 3 exhibited significantly more impairments in verbal learning and motor inhibition tasks than control children (Cynthia et al., 2010).

Similar findings were reported in previous study, where organophosphate poisoned populations have shown a consistent pattern of deficits when compared to a unexposed or non-poisoned population on measures of neurobehavioral performance (Bellinger et. al., 2001).A study on exposure to organic solvent and the neurobehavioral performance showed that the high exposure group had lower performance than both the low and moderate exposure groups on the entire neurobehavioral performance test (Coronado et. al., 2011).This findings was supported by the previous study by Rourke et al (2001), stated that study exposure to heavy metal are associated with less optimal cognitive and motor development.

A prospective study of children intoxicated with cadmium before age 3, found that such children had learning impairments and difficulty in restraining and controlling their active behaviour (Cynthia et al., 2010). Other studies had found

associations between prenatal heavy metal with mental and motor development delays, attention and attention deficit hyperactivity disorder problems, pervasive development disorder problems, smaller head circumference and higher blood pressure .

5.1.4 Correlation Between Urinary Cadmium Concentration with Neurobehavioral Performance

Based on the result there was no significant relationship between urinary cadmium concentration and neurobehavioral performance test except for Reaction Time test which show significant difference. This show that the concentration of cadmium in urine does not significantly affect the neurobehavioral performance score among the school children.

The exposure of children to metals is of interest because of their possible environmental exposure, their origins in areas where the potential for exposure to environmental sources is high, and the possible interaction of such toxic chemicals which children are exposed (Burbure et al., 2003). The biological half-lives of these metals vary, and the amounts excreted can reflect a combination of recent and past exposures.

Children exposed to cadmium diminished intelligence were described especially with respect to verbal, psychomotor, cognitive and perceptual skills (Marlowe et.al., 1993). In cohort studies, Thatcher et al., (1994) reported that the concentration of cadmium in hair was inversely related to adjusted IQ. Marlowe et al, 1995 have reported associations between hair cadmium and children's performance on visual motor tasks.

Exposure to cadmium during critical periods of brain development may contribute to poorer intellectual development, deficit in working memory and attention problems (Chatham et al., 2011). Study of long term sequel of acute exposure to pesticide reveal that 6-12 year-old-children who had been hospitalized for acute pesticide poisoning before the age of 3 exhibited significantly more impairments in verbal learning and motor inhibition tasks than control children (Cynthia et al. , 2010).

5.1.5 Selected Variables Which Influenced Urinary Cadmium Concentration among Study Groups.

Multiple Linear Regression (enter method) was carried out to identify if there is any independent variable which may significantly influenced the urinary cadmium concentration. In this test, the dependent variable was urinary cadmium concentration while independent variable were transportation, housing area, distance from house to school, parents occupation, parents' education, and total household income data. From the overall selected variables, none of the variable show significant association in influencing urinary cadmium concentration of study groups.

Cadmium is found in soils where certain fertilizers have been used, and in plants grown in such soils (Satarug et al., 2004). High levels of cadmium in surface soils usually result from cadmium particles settling from the air. Once released into the air the cadmium will be absorbed through the contact point of the body by inhalation and it will distribute throughout the body. If parents or other family member work in paddy field, chemicals may be brought into the home on work boots, work clothing, or on the skin. Several studies have demonstrated that children of exposed workers have significant higher exposures to workplace chemicals than unexposed children (Kippler et al., 2012).

Furthermore, the occupation of their parents as a farmer needs them to live at the agricultural area with their family. Typically, they possibly live in the area for extended period which make the location of housing area as one of the factor contribute to the exposure of neurotoxicant chemical among children.

5.1.6 Selected Variables Which Influenced Neurobehavioral Performance among Study Groups.

Multiple Linear Regression analysis shows that there were several variables found to be the confounders influencing the neurobehavioral performance score of study groups.

Among the seven tests conducted only Reaction Time /Movement Test show significant relationship with both fathers and mothers education. Heavy metal contamination on skin and clothes is inevitable especially during outdoor activities. Thus, an appropriate hygiene practice is highly recommended to reduce any potential take-home route of exposure and parents play an important role in minimizing their risk.

5.2 Conclusion

In conclusion, results showed that all of the children studied had urinary cadmium concentration below 1 μg/L which is the acceptable level whereby they were not at risk. Thus, there was no significant difference between urinary cadmium concentration and neurobehavioral performance score of these children. However, there was significant relationship between urinary cadmium concentration and Reaction Time Test.

Thus, there was no relationship between urinary cadmium concentrations with neurobehavioral performance of study group. Urinary cadmium concentrations among exposed group were higher than unexposed group and inversely correlated with neurobehavioral performance score.

In general, children of agricultural workers are at greater risk of cadmium exposure because their homes are usually close to fields where application may occur and from take-home exposure on clothing. Thus, it points out the need for additional larger studies aimed at determining whether low-level cadmium exposures produces deficits in standardized test performance in children of agricultural workers. It also illustrates the importance of proper pesticide and fertilizer application and improved hygiene in pesticide applicators to prevent exposures in their children. Thus, future studies in Malaysia is recommended to investigate about this important heavy metal

from checking the environment (air, water and food) for cadmium and the contribution that relates to the human health exposure and risk. Further research should address their risk for adverse health outcomes due to combined exposures to neurotoxins in both pesticides and fertilizer.

5.3 Recommendation

Personal hygiene should be the first prevention step to be practiced among individual. These practices shall include the proper procedures for hand washing, bathing and clothes cleaning. Heavy metal contamination on skin and clothes is inevitable especially during outdoor activities. Thus, an appropriate hygiene practices is highly recommended to reduce any potential take-home route of exposure.

During fertilizer and pesticide application, try to avoid exposure by wearing protective clothing, take bath and change clothes when doing any outdoor activities, in order to minimize the exposure to heavy metal, and most importantly enhance their awareness on the effects of heavy metal to the health among school children, or simply by staying away from the application site. They should wash their hand before consuming food and drinks. Farmworkers must read the label directions thoroughly and make sure to keep kids and pets out of the area for as long as possible after the application, and parents play an important role in educate their children.

REFERENCES

Abbas S. T, Sarfraz M, Mehdi S. M, Hassan G. and Obaid U. R. (2007). Trace elements accumulation in soils and rice plants irrigated with contaminated water. *Soil and Tillage Research* 94(2): 503–509.

Aceto M, and Malandrino . (2002). Heavy metals in agricultural soils from Piedmont, Italy. Distribution, speciation and chemometric data treatment. Chemosphere, 49 Wong S C, Li X

Baldi, I., Filleul, L., Mohammed, B., Fabrigoule, C., Dartigues, J., Schwall, S., and Brochard, P. (2001). Neuropsychologic effects of long-term exposure to pesticides:Results from the french phytoner study. *Environmental Health Perspectives, 109*(8), 839-844.

Bellinger D, Abelsohn A and Adams H. (2001) Environmental pollutant exposures and children's cognitive development. In: Sternberg RJ, Grigorenko EL, editors. Environmental effects on cognitive abilities. Mahwah, NJ: Lawrence Erlbaum Associates, p. 157–88.

Boyle, C.A., Boulet, S., Schieve, L.A., Cohen, R.A., Blumberg, S.J., Allsopp, M.Y., Kogan, and Moure.D. (2011). Trends in the prevalence of Developmental Disabilities in US Children, 1997-2008. *Official Journal of the American Academy of Pediatrics, 127(6),* 1034-1042. doi:10.1542/peds.2010-2989

Buchet JP, Heilier JF, Bernard A, Lison D, Jin T, and Wu X,(2003). Urinary protein excretion in humans exposed to arsenic and cadmium. Occupational and Environmental Health 76:111–120

Capel ID, Pinnock MH, Dorrell HM, Williams DC, and Grant EC. (2001) *Comparison of concentrations of some trace, bulk, and toxic metals in the hair of normal and dyslexic children.* Clinical Chemistry.; 27(6): *879-81.*

Chatham S. K., Mann, M., Schwartz, A. W., and Landrigan, P. J. (2011). First, do no harm: Children's environmental health in schools. *American Educator, 35*(4), 22-31.

Chuan M C, Shu G Y, and Liu J C. (1996). Solubility of heavy metals in a contaminated soil: effects of redox potential and pH. *Water, Air, and Soil Pollution*, 90(3): 543–556.

Cocker, J., Mason, H. J., Garfitt, S. J., and Jones, K. (2002). Biological monitoring of exposure to organophosphate pesticides. *Toxicology Letters, 134*(1–3), 97-103. doi:10.1016/S0378-4274(02)00168-6

Coronado, G. D., Holte, S., Vigoren, E., Griffith, W. C., Barr, D. B., Faustman, E., and Thompson, B. (2011). Organophosphate pesticide exposure and residential proximity to nearby fields: Evidence for the drift pathway. *Journal of Occupational and Environmental Medicine, 53*(8), 884-891. doi:10.1097/JOM.0b013e318222f03a

Cynthia A., Ricco, and L. Avila, (2010). Pesticide poisoning in a preschool children: A case study eximine neurocognitive and neurobehavioral effects. *Applied Neuropsychology.* 17: 153 – 159

Burbure C, Buchet JP, Bernard A, Leroyer A, Nisse C,and Haguenoer JM. (2003). Biomarkers of renal effects inchildren and adults with low environmental exposure to heavy metals. *Toxicology Environmental Health* 66:783–799.

Eskenazi, B., Bradman, A., and Castorina, R. (1999). Exposures of children to organophosphate pesticides and their potential adverse health effects. *Environmental Health Perspectives, 107*(SUPPL. 3), 409-419.

Eskenazi, B., Huen, K., Marks, A., Harley, K. G., Bradman, A., Barr, D. B., and Holland, N. (2010). PON1 and neurodevelopment in children from the chamacos study exposed to organophosphate pesticides in utero. *Environmental Health Perspectives, 118*(12), 1775-1781. doi:10.1289/ehp.1002234

Faustman, E.M., Silvernagel, S.M., Fenske, R.A., Burbacher, T.M., and Ponce, R.A., (2000).Mechanisms underlying children's susceptibility to environmental toxicants. *Environmental Health Perspectives*. 108 (suppl 1), 13–21.

Fenske, R. A., Bradman, A., Whyatt, R. M., Wolff, M. S., and Barr, D. B. (2005). Lessons learned for the assessment of children's pesticide exposure: Critical sampling and analytical issues for future studies. *Environmental Health Perspectives, 113*(10), 1455-1462.

Galal G. H. (1991) Dietary intake of pesticide residues, cadmium, mercury and lead. *Food Additives and Contaminants*, 8:793–806.

Gimeno-Garcfa E, Andreu V, and Boluda R, (1996). Heavy metals incidence in the application of inorganic fertilizers and pesticides to rice farming soils. *Environmental Pollution*,92(1): 15-25.

Holmgren, G.G., Meyer, M.W., Chaney, R.L., and Daniels, R.B., (1993). Cadmium, lead, zinc, copper and nickel in agricultural soils of the United States of America. *Journal of Environmental Quality* 22, 335e348.

Jedrychowski, W., Perera, F., Jankowski, J., Mrozek-Budzyn, D., Mroz, E., Flak, E.,Edwards, S., Skarupa, A., and Lisowska-Miszczyk, I., (2009). Gender specific differences in neurodevelopmental effects of prenatal exposure to very low-lead levels: the prospective cohort study in three-year olds. *Early Human Development* .85, 503–510.

Jung M C and Thornton I. (1997). Environmental contamination and seasonal variation of metals in soils, plants and water in the paddy fields around a Pb-Zn mine in Korea. *Science of the Total Environment* 198(2): 105–121.

Kashem M A, and Singh B R, (2001). Metal availability in contaminated soils: II. Uptake of Cd, Ni and Zn in rice plants grown under flooded culture with organic matter addition. *Nutrient Cycling in Agroecosystems*, 61(3): 257–266.

Kippler, M., Tofail, F., Hamadani, J.D., Gardner, R.M., Grantham-McGregor, S.M., Bot-tai, M., and Vahter, M., (2012). Early-life cadmium exposure and child developmentin 5-year-old girls and boys: a cohort study in rural Bangladesh. Environmental Health Perspectives 120, 1462–1468.

Leroyer A, Hemon D, Nisse C, Auque G, Mazzuca M, and Haguenoer JM. (2001). Determinants of cadmium burden levels in a population of children living in the vicinity of nonferrous smelters.

Marlowe M, Cossairt A, Moon C, Errera J, MacNeel A, Peak R, Ray J, and Schroeder C. (1995) Main and interaction effects of metallic toxins on classroom behavior. *Abnormal Child Psychology*. 13(2): *185-98*.

Marlowe M, Errera J, and Jacobs J. (1993) Increased lead and cadmium burdens among mentally retarded children and children with borderline intelligence. *Abnormal Mental Deficiency*. 87(5): *477-83*.

Minetti A, Reale CA. (2006) Sensorimotor developmental delays and lower anxiety in rats prenatally exposed to cadmium. *Application Toxicology*. 26(1): *35-41*.

Mueller M., (1994). Distribution of cadmium in the food chain (soil-plant-human) of a cadmium exposed area and the health risks of the general population. *The Science of To Abollino Q*

Murakami, H., Ae, N., Sugiyama, M., and Ishikawa, S., (2004). Phytoremediation of cadmium-contaminated paddy fields by a rice cultivar with high cadmiumaccumulation properties. NIAES Annual Report 2004, 5e6.

Oliveira Ribeiro C A, Vollaire Y, Sanchez-Chardi A and Roche H. (2005). Bioaccumulation and the effects of organochlorine pesticides, PAH and heavy metals in the eels (*Anguilla anguilla*) at the Camargue Nature Reserve, France. *Aquatic Toxicology* 74(1): 53–69.

Pejabat Pertanian Kuala Selangor Utara. (2009). Aktiviti-aktiviti penanaman padi kawasan Tanjong Karang. Retrieved from http://padiksu.blogspot.com/2009/01/-86/laporan padi-selangor.html.

Rastogi S.K., Tripathi S., and Ravishanker D. (2010) .A study of neurologic symptoms on exposure to chemical toxicants in the children of agricultural workers. *Indian Occupational Environmental Medical Journal* 166:1431

Rourke, B. P., and Finiayson, M. A. (2001). Neuropsychological significance of variations in patterns of performance on the trail making test for older children with learning disabilities. *Abnormal Psychology*.

Sanborn M, Cole D, Abelsohn A, Weir E (2001): Identifying and managing adverse environmental health effects of pesticides. *Journal of Work Environmental Health* 166:1431

Satarug, S., Baker, J.R., Urbenjapol, S., Haswell-Elkins, M., Reilly, P.E., Williams, D.J., and Moore, M.R., (2004). A global perspective on cadmium pollution and toxicity in non-occupationally exposed population. Toxicol. Lett. 137, 65–83.

Stellern J, Marlowe M, Cossairt A, and Errera J. (1993) Low lead and cadmium levels and childhood visual-perception development. *Perceptual Motor Skills*. 56(2): *539-44*.

Thatcher RW, Lester ML, McAlaster R, and Horst R. (1992) Effects of low levels of cadmium and lead on cognitive functioning in children. Environmental Health. 37(3): *159-66*.

Thatcher R.W., McAlaster R, and Lester M.L. (1994). Evoked potentials related to hair cadmium and lead in children. Ann N Y Academy Science. 425: *384-90*

Traina, S.J., (1999). The environmental chemistry of cadmium. In: McLaughlin, M.J., Singh, B.R. (Eds.), Cadmium in Soils and Plants. Kluwer Academic Publishers, Dordrecht, pp. 11e37.

Viaene M.K, Roels H.A, Leenders J, De Groof M, Swerts L.J, Lison D, and Masschelein R. (1999) . *Cadmium: a possible etiological factor in peripheral polyneuropathy*. Neurotoxicology. 20(1): *7-16*.

World Health Organization, WHO. (1986). Operational guide for the WHO Neurobehavioral Core Test Battery. Retrieved from http://whqlibdoc.who.int/hq/1987/1985-86/78520

World Health Organization, WHO. (2004). *The WHO recommended classification of pesticides by hazard and guidelines to classification*: 2004. World Health Organization. ISBN 92 4 154663, Retrieved from http://www.who.int/ipcs/publications/pesticides_hazard/en/

APPENDICES

APPENDIX 1

(Schedule of Study for Research Project)

ATTACHMENT 1 – GANTT CHART

	2012				2013					
PLANNING/MONTH	SEPT	OCT	NOV	DEC	JAN	FEB	MAC	APR	MAY	JUNE
Propose title for the project										
Submit the proposal										
Title presentation										
Attach supervisor										
Permission letter to selected company										
Submission on methodology										
Proposal presentation										
Pre- tested questionnaire										
Resubmission of proposal										
Ethical Clearance										
Receive approval letter from company										
Visit the company for project sources										
Give and collect the consent letter from respondents										
Collect data										
Analyze data										
Preparing the complete thesis										
Submission of final thesis and presentation										

APPENDIX 2

(Informed Consent)

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

BORANG KEBENARAN IBU BAPA/PENJAGA

TAJUK KAJIAN:

Kepekatan kadmium dan neurotingkah laku dalam kalangan pelajar sekolah rendah di Tanjung Karang, Selangor.

Penyelidik: Nurul Izzaty binti Zaaba

Saya ..... No Kad Pengenalan .....
..... Dengan ini secara sukarela bersetuju untuk mengambil bahagian dalam penyelidikan klinikal * (pengajian klinikal, soal selidik kajian atas / dadah percubaan) yang dinyatakan di atas.

Saya telah dimaklumkan tentang maklumat penyelidikan klinikal dari segi metodologi, kesan buruk dan komplikasi yang mungkin (rujuk kepada Bahagian Maklumat). Saya faham bahawa saya mempunyai hak untuk menarik diri daripada penyelidikan ini pada bila-bila masa tanpa memberi apa sahaja alasan. Saya juga faham bahawa kajian ini adalah sulit dan semua maklumat yang diberikan mengenai identiti saya akan kekal sulit dan rahsia.

Saya ingin untuk * tahu / tidak ingin tahu mengetahui keputusan ujian yang dilakukan ke atas sampel saya.

* Potong di mana perlu

Tandatangan ..... Tandatangan .....
(Responden) (Saksi)

Tarikh: ..... Nama: .....

I/C No: .....

Saya mengesahkan bahawa saya telah menerangkan kepada responden sifat dan tujuan penyelidikan klinikal tersebut di atas.

Tarikh ..... Tandatangan .....
(Penyelidik)

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

BORANG KEBENARAN RESPONDEN

TAJUK KAJIAN:

Kepekatan kadmium dan neurotingkahlaku dalam kalangan pelajar sekolah rendah di Tanjung Karang, Selangor.

Penyelidik: Nurul Izzaty binti Zaaba

Saya ..... No Kad Pengenalan .....
..... Dengan ini secara sukarela bersetuju untuk mengambil bahagian dalam penyelidikan klinikal * (pengajian klinikal, soal selidik kajian atas / dadah percubaan) yang dinyatakan di atas.

Saya telah dimaklumkan tentang maklumat penyelidikan klinikal dari segi metodologi, kesan buruk dan komplikasi yang mungkin (rujuk kepada Bahagian Maklumat). Saya faham bahawa saya mempunyai hak untuk menarik diri daripada penyelidikan ini pada bila-bila masa tanpa memberi apa sahaja alasan. Saya juga faham bahawa kajian ini adalah sulit dan semua maklumat yang diberikan mengenai identiti saya akan kekal sulit dan rahsia.

Saya ingin untuk * tahu / tidak ingin tahu mengetahui keputusan ujian yang dilakukan ke atas sampel saya.

* Potong di mana perlu

Tandatangan ..... Tandatangan .....
(Responden) (Saksi)

Tarikh: ..... Nama: .....

I/C No: .....

Saya mengesahkan bahawa saya telah menerangkan kepada responden sifat dan tujuan penyelidikan klinikal tersebut di atas.

Tarikh ..... Tandatangan .....
(Penyelidik)

APPENDIX 3

(Subject Information Sheet)

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

LAMPIRAN MAKLUMAT RESPONDEN

Sila baca maklumat berikut dengan teliti, sila bertanya untuk membincangkan apa-apa soalan yang anda ada dengan penyelidik anda.

TAJUK KAJIAN

Kepekatan kadmium dan neurotingkahlaku pelajar sekolah rendah di Tanjung Karang, Selangor.

PENGENALAN

Kajian ini adalah mengenai kesan pendedahan logam berat iaitu kadmium yang berpunca daripada sumber pertanian. Baja adalah sumber terbesar kadmium dan dijumpai dalam tanah tanaman pertanian. Kadmium boleh mengurangkan neurokognitif kanak-kanak yang bersekolah berhampiran dengan sawah padi. Kanak-kanak adalah golongan yang tinggi risiko terhadap pendedahan logam berat yang digunakan kerana sistem pertahanan badan dan anggota badan masih berkembang. Akibat pendedahan yang berlebihan, terdapat beberapa kesan terhadap kesihatan sebagai contoh peluh yang berlebihan, hidung berair, mata berair, masalah pernafasan, dan batuk.

APA YANG ANDA HARUS LAKUKAN?

Anda hanya perlu menandatangai surat kebenaran jika berminat untuk memberi kebenaran kepada anak anda untuk menyertai dalam kajian ini. Anda hanya perlu menandatangani borang peserta responden selepas membaca dan memahami huraian ini. Borang peserta mesti dikembalikan kepada penyelidik sebelum menjalankan apa-apa ujian. Selepas itu, anda akan mengikuti satu siri ujian akan dijalankan oleh penyelidik. Hanya ikut arahan yang diberikan oleh pengkaji.

SIAPAKAH YANG TIDAK PERLU TERLIBAT DALAM KAJIAN?

Sepanjang kajian ini dijalankan, hanya pelajar yang memenuhi syarat kajian sahaja akan mengikuti kajian ini. Antara yang tidak dibenarkan untuk mengambil bahagian dalam kajian ini adalah pelajar yang mempunyai masalah kesihatan dan tidak mendapat kebenaran ibubapa/penjaga.

APA AKAN FAEDAH KAJIAN:

(A) KEPADA ANDA?

Faedah kajian yang akan diperoleh selepas kajian ini diadakan adalah memperoleh maklumat dan pengetahuan mengenai pendedahan racun yang digunakan dengan kesan yang diperoleh terhadap neurotingkahlaku pelajar yang bersekolah berhampiran dengan sawah padi. Hasil daripada kajian ini dapat memberikan maklumat kepada penjaga mengenai fenomena yang berlaku supaya kesihatan dan masa depan mereka lebih terjamin di masa akan datang.

B) PENGKAJI?

Maklumat dan hasil daripda kajian ini dapat membantu penyelidik dalam mengumpul bukti pendedahan logam berat (kadmium) kepada kesihatan pelajar yang bersekolah dan tinggal berhampiran kawasan tanaman padi, di Malaysia. Selain itu, hasil kajian juga dapat membantu penyelidik mempromosi kesihatan untuk meningkatkan taraf kesihatan dalam kalangan mereka. Akhirnya, kajian ini membantu penyelidik dalam menyelesaiakan tugas sebagai pelajar tahun akhir.

ADAKAH TERDAPAT SEBARANG RISIKO?

Kajian ini tidak akan timbul sebarang risiko kemalangan, jangkitan, kecederaan, dan sebagainya. Semua proses penyelidikan akan dijalankan di kawasan yang selamat. Semua proses mengambilan adalah mengikut peraturan yang disediakan. Semua proses penyelidikan akan dijalankan dengan selamat.

APAKAH KELEMAHAN KAJIAN?

Kelemahan kajian ini adalah ujian mengambil masa kira-kira 30 hingga 45 minit setiap pelajar untuk menghabiskan semua ujian-ujian yang disediakan.

ADAKAH MAKLUMAT DAN IDENTITI SAYA AKAN KEKAL SULIT?

Semua maklumat mengenai responden telah dijamin rahsia dan sulit. Tiada maklumat individu dari semua aspek akan dibincangkan.

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

SIAPAKAH YANG PERLU SAYA HUBUNGI JIKA SAYA ADA SOALAN TAMBAHAN SEMASA PROSES PENYELIDIKAN?

Sebarang masalah atau soalan semasa kajian ini boleh diajukan kepada penyelidik, Nurul Izzaty binti Zaaba untuk berjumpa secara langsung atau melalui telefon bimbit, 017-3657254.

Terima kasih di atas kerjasama yang diberikan.

NURUL IZZATY BINTI ZAABA

Penyelidik

BS (Kesihatan Persekitaran dan Pekerjaan)

Universiti Putra Malaysia

APPENDIX 4

(Questionnaire)

UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

ID Responden :

JABATAN KESIHATAN DAN PEKERJAAN

FAKULTI PERUBATAN DAN SAINS KESIHATAN

UNIVERSITI PUTRA MALAYSIA

KEPEKATAN KADMIUM DAN NEUROTINGKAHLAKU DALAM KALANGAN PELAJAR SEKOLAH RENDAH DI TANJUNG KARANG, SELANGOR.

Alamat Responden :

_____

_____

No Telefon : (R) : _____

(HP): _____

ARAHAN SOALAN:

1. Borang soal selidik ini mengandungi empat (4) bahagian iaitu:

   Bahagian A: Maklumat peribadi kanak-kanak dan keluarga
   Bahagian B: Pengetahuan tentang racun serangga
   Bahagian C: Maklumat kawasan perumahan
   Bahagian D: Maklumat taraf kesihatan kanak-kanak

2. Anda diminta menjawap semua soalan yang ada dalam buku soalan ini.

3. Untuk menjawap anda perlulah menandakan (√) pada ruangan kotak yang disediakan.

   [√]

4. Borang soal selidik ini hendaklah diserahkan semula kepada pengkaji setelah selesai menjawab semua soalan.

Bahagian A :Maklumat Peribadi Kanak-Kanak Dan Keluarga

1. Umur: _____tahun
2. Tinggi kanak-kanak: _____cm Berat kanak-kanak: _____kg
3. Tarikh lahir: _____hari _____bulan_____tahun
4. Bilangan adik-beradik:_____(orang)
5. Tahun Persekolahan:_____
6. Jantina: ☐ Lelaki ☐ Perempuan
7. Bangsa: ☐ Melayu ☐ Cina ☐ India ☐ Lain-lain
8. Tahap pendidikan bapa:

Sekolah rendah ☐ PMR/SRP ☐ SPM ☐ STPM/Diploma ☐

Ijazah/Master/PHD ☐

9. Tahap pendidikan ibu:

Sekolah rendah ☐ PMR/SRP ☐ SPM ☐ STPM/Diploma ☐

Ijazah/Master/PHD ☐

10. Adakah anak anda diberi susu badan sejak lahir?

☐ Ya ☐ Tidak

11. Jika ya ,sila nyatakan tempoh penyusuan: Dari_____ Hingga _____

12. Tempoh kanak-kanak tinggal di alamat sekarang:_____tahun_____bulan

13. Adakah antara ahli keluarga anda yang merokok?

☐ Bapa
☐ Ibu
☐ Ahli keluarga lain

14. Apakah jenis aktiviti(hobi) yang biasa anda lakukan?

Sila nyatakan: _____

15. Ketika bermain di luar rumah ,adakah anak anda memakai seperti berikut:

Sila pilih satu sahaja jawapan sahaja [√] di kotak yang disediakan.

Media/Kekerapan	**Selalu**	**Kadang-Kadang**	**Tidak Pernah**
Kasut			
Selipar			
Tudung/ Topi			
Baju lengan panjang			
Baju lengan pendek			
Seluar pendek			
Seluar panjang			
Lain-lain (Nyatakan: _____)			

16. Adakah anak anda membasuh tangan dengan betul setiap kali sebelum makan?

☐ Ya ☐ Tidak

17. Berapa kerap anak anda mandi dalam sehari?

☐ Sekali sehari
☐ 2 kali sehari
☐ >3 kali sehari

18. Adakah kanak-kanak dibenarkan bermain di kawasan sawah padi?

☐ Ya ☐ Tidak

Bahagian B : Pengetahuan tentang Racun Serangga

19. Adakah anda mempunyai ahli keluarga yang bekerja di sawah padi?

☐ Ya ☐ Tidak

20. Adakah anak anda faham apa itu racun serangga?

☐ Ya ☐ Tidak

21. Adakah anda menggunakan sebarang racun makhluk perosak di rumah anda?

☐ Ya ☐ Tidak

22. Di manakah anda menyimpan racun makhluk perosak yang telah digunakan?

☐ Bilik stor
☐ Belakang rumah
☐ Lain-lain (nyatakan)
.....

Bahagian C: Maklumat Kawasan Perumahan

23. Apakah kenderaan yang digunakan oleh anak anda untuk ke sekolah?

Nyatakan:.....

24. Jarak lokasi sekolah dari rumah

☐	<100 meter dari rumah
☐	>100-500 meter dari rumah
☐	>500-1000 meter dari rumah
☐	>1000 meter dari rumah

25. .Sila pilih lokasi kawasan perumahan anda

☐	Berdekatan dengan sawah
☐	Berdekatan dengan jalan raya
☐	Berdekatan dengan kawasan perumahan
☐	Berdekatan dengan hutan

Bahagian D :Maklumat Taraf Kesihatan Kanak-Kanak

Berikut merupakan soalan-soalan mengenai taraf kesihatan anak anda, sila pilih 'YA' atau 'TIDAK'. Sekiranya anda ragu-ragu , sila tandakan 'TIDAK'.

25. Dalam masa 3 bulan yang lepas, pernahkah anak anda kerap mengalami masalah kesihatan berikut(sila tanda √ di tempat yang berkaitan)

Simptom	Ya	Tidak
Susah bernafas		
Mata berair		
Hidung berair		
Pening kepala		
Peluh Berlebihan		
Batuk		

26. Pernahkah anda berjumpa doktor perubatan disebabkan oleh simptom-simptom yang dihuraikan di atas?

☐ Ya ☐ Tidak

~ Borang soal selidik tamat ~

Terima kasih atas kerjasama yang anda berikan.
Sekian.

APPENDIX 5

(Neurobehavioral Core Test Battery form)

APPENDIX I

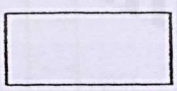
UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

BENTON VISUAL RETENTION TEST

JAWAPAN

1.	A	B	C	D	6.	A	B	C	D
2.	A	B	C	D	7.	A	B	C	D
3.	A	B	C	D	8.	A	B	C	D
4.	A	B	C	D	9.	A	B	C	D
5.	A	B	C	D	10.	A	B	C	D

JAWAPAN BETUL



UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

DIGIT SPAN TEST

---

1. Digits Forward Test

Arahan : Sila dengar dengan teliti nombor-nombor yang akan dibaca dan anda dikehendaki mengulangi balik sebutan secara ke hadapan.

a. 5-8-2

b. 6-4-3-9

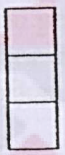
c. 4-2-7-3-1

d. 6-1-9-4-7-3

e. 5-9-1-7-4-2-8

f. 5-8-1-9-2-6-4-7

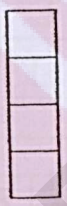
g. 2-7-9-8-6-2-5-8-4



6-9-4

7-2-8-6

7-5-8-3-6

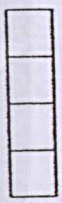


3-9-2-4-8-7

4-1-7-9-3-8-6

3-8-2-9-5-1-7-4

7-1-3-9-4-2-5-6-8



2. Digits Backwards Test

Arahan : Sila dengar dengan teliti nombor-nombor yang akan dibaca dan anda dikehendaki mengulangi balik sebutan secara ke belakang.

a. 2-5

b. 6-2-9

c. 3-2-7-9

d. 1-5-2-8-6

e. 5-3-9-4-1-8

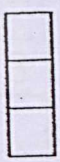
f. 8-1-2-9-3-6-5

g. 9-4-3-7-6-2-5-8

5-8

4-1-9

4-9-6-8

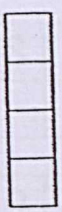


6-1-8-4-3

7-2-4-8-5-6

4-7-3-9-1-2-8

7-2-6-1-9-6-5-3



UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

DIGIT SYMBOL TEST

Markah : _____

Arahan : Sila perhatikan dengan teliti petak-petak di bawah.
Setiap nombor digit (1-9) di bahagian petak atas mempunyai simbol masing-masing di bahagian bawah petak.
Anda dikehendaki mengisi petak di bahagian bawah dengan simbol-simbol yang sesuai dengan nombor digit yang berada di dalam petak bahagian atas.
Tempoh masa yang diberikan ialah 90 saat.

No. Digit	1	2	3	4	5	6	7	8	9
Simbol	—	⊥	□	L	U	0	∧	X	=

2	1	3	7	2	4	8	1	5	4	2	1	3	2	1	4	2	3	5	2

3	1	4	6	3	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3

7	2	8	1	9	5	8	4	7	3	6	2	5	1	9	2	8	3	7	4

6	5	9	4	8	3	7	2	6	1	5	4	6	3	7	9	2	8	1	7

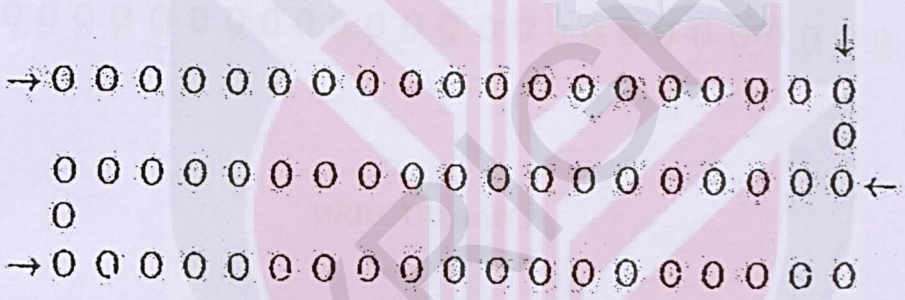
9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

PURSUIT AIMING TEST

Arahan : Anda dikehendaki meletakan **satu titik** atau **bintik** di bahagian dalam setiap simbol **'O'** yang diberikan dengan mengikut arah setiap anak panah seperti yang ditunjukan di bawah.
Tempoh masa yang diberikan adalah **60 saat.**

LATIHAN

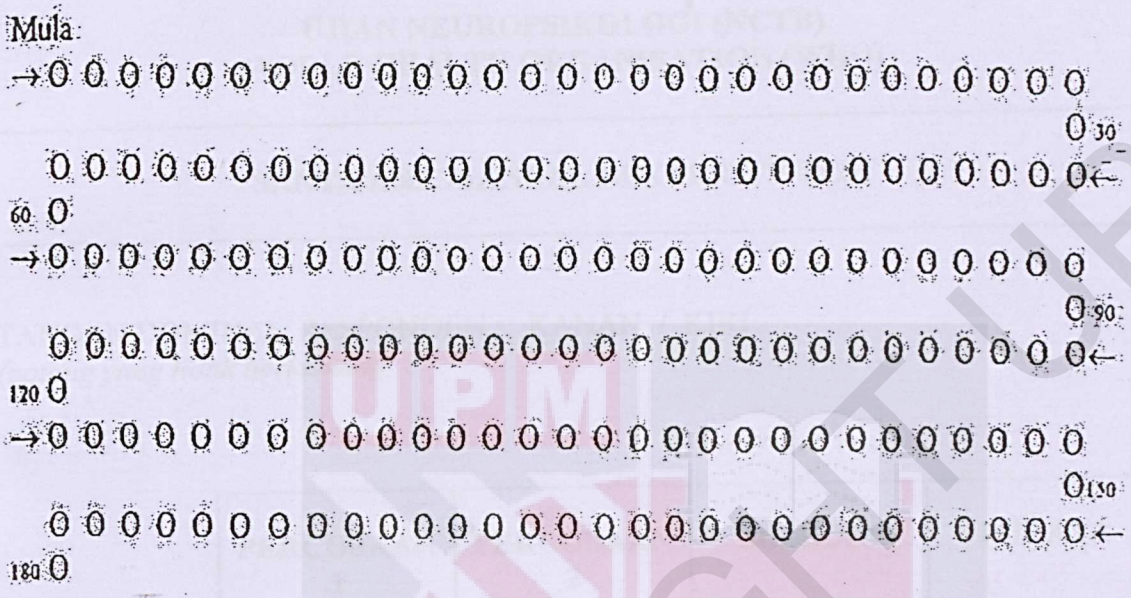


Titik/bintik yang betul : Percubaan 1 ☐ 2 ☐ Jumlah betul ☐

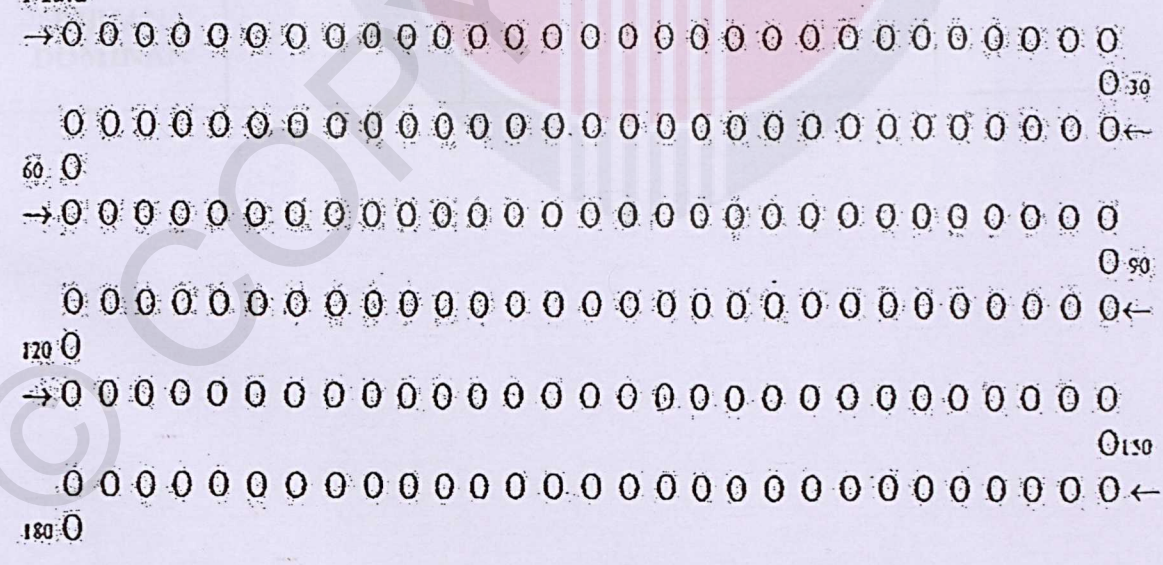
Titik/bintik yang salah : Percubaan 1 ☐ 2 ☐ Jumlah salah ☐

JUMLAH BESAR ☐

PERCUBAAN 1



PERCUBAAN 2



UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

SANTA ANA MANUAL DEXTERITY TEST

TANGAN DOMINAN RESPONDEN : KANAN / KIRI
(potong yang tidak berkenaan)

	PERCUBAAN 1	PERCUBAAN 2	JUMLAH	PURATA
TANGAN DOMINAN				
TANGAN BUKAN DOMINAN				

UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

TIME REACTION / MOVEMENT TEST

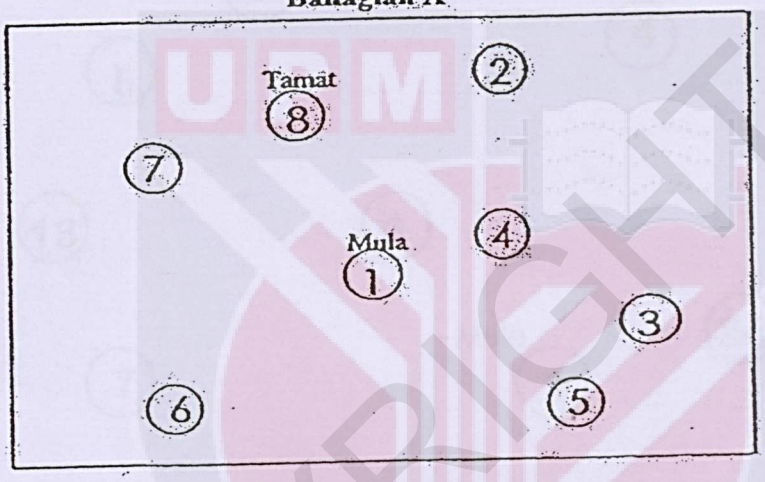
	REACTION (RT)	MOVEMENT (MT)
Trial 1		
Trial 2		
Trial 3		
AVERAGE		

UJIAN NEUROPSIKOLOGI (NCTB)
WORLD HEALTH ORGANISATION (WHO)

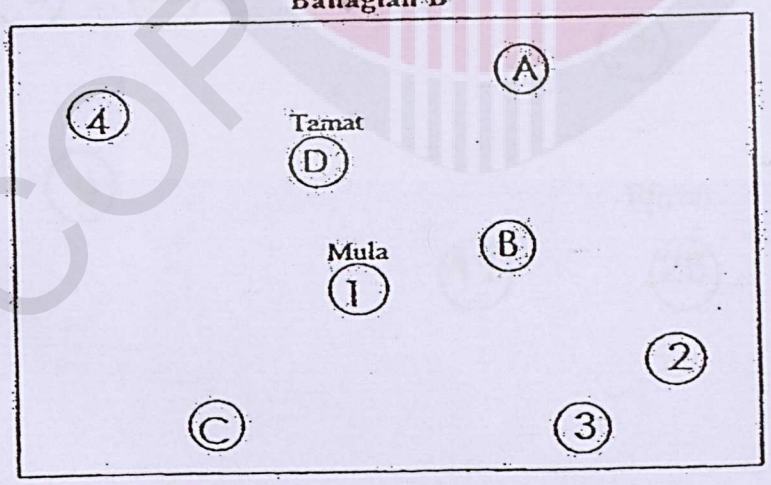
TRAIL MAKING TEST

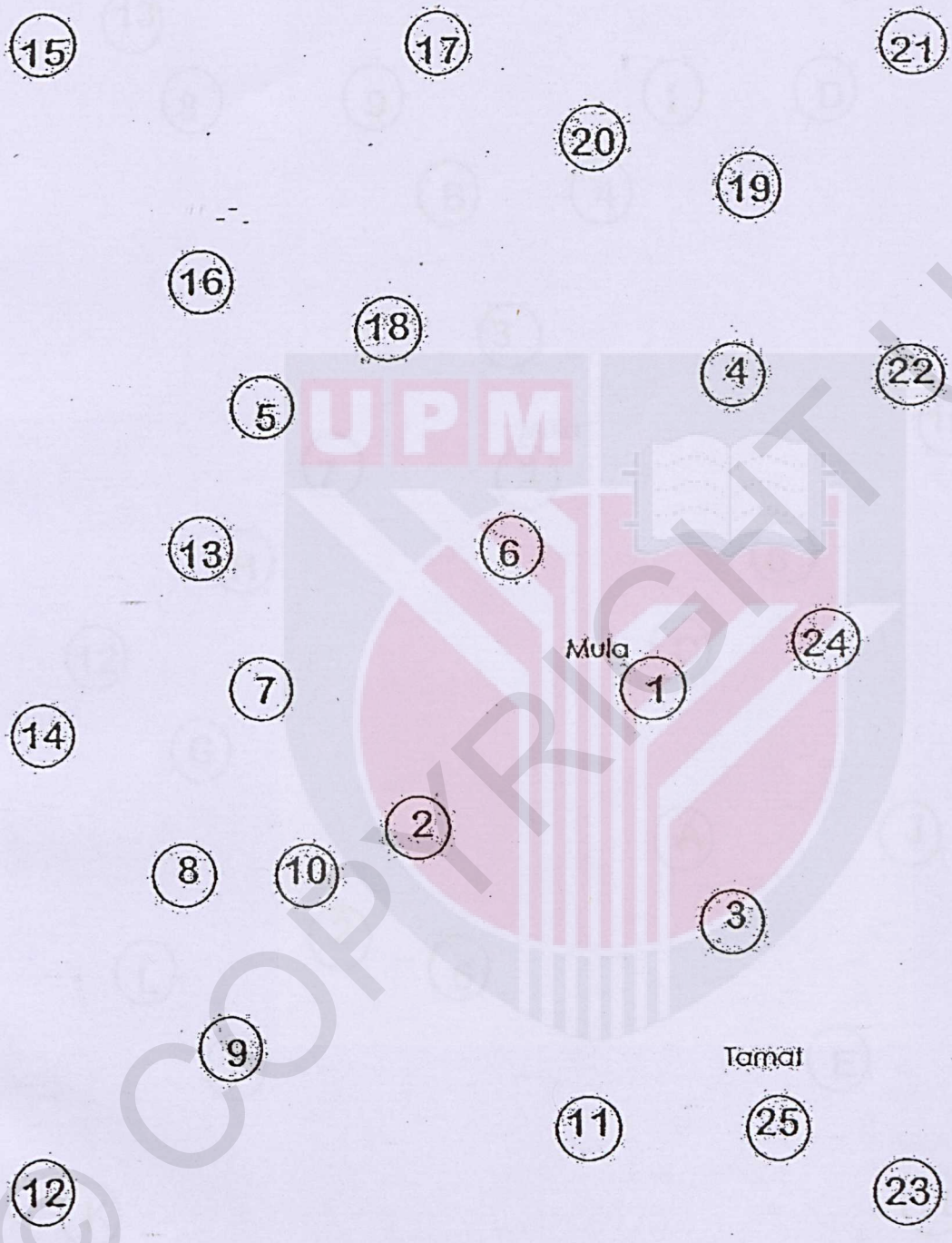
PERCUBAAN

Bahagian A

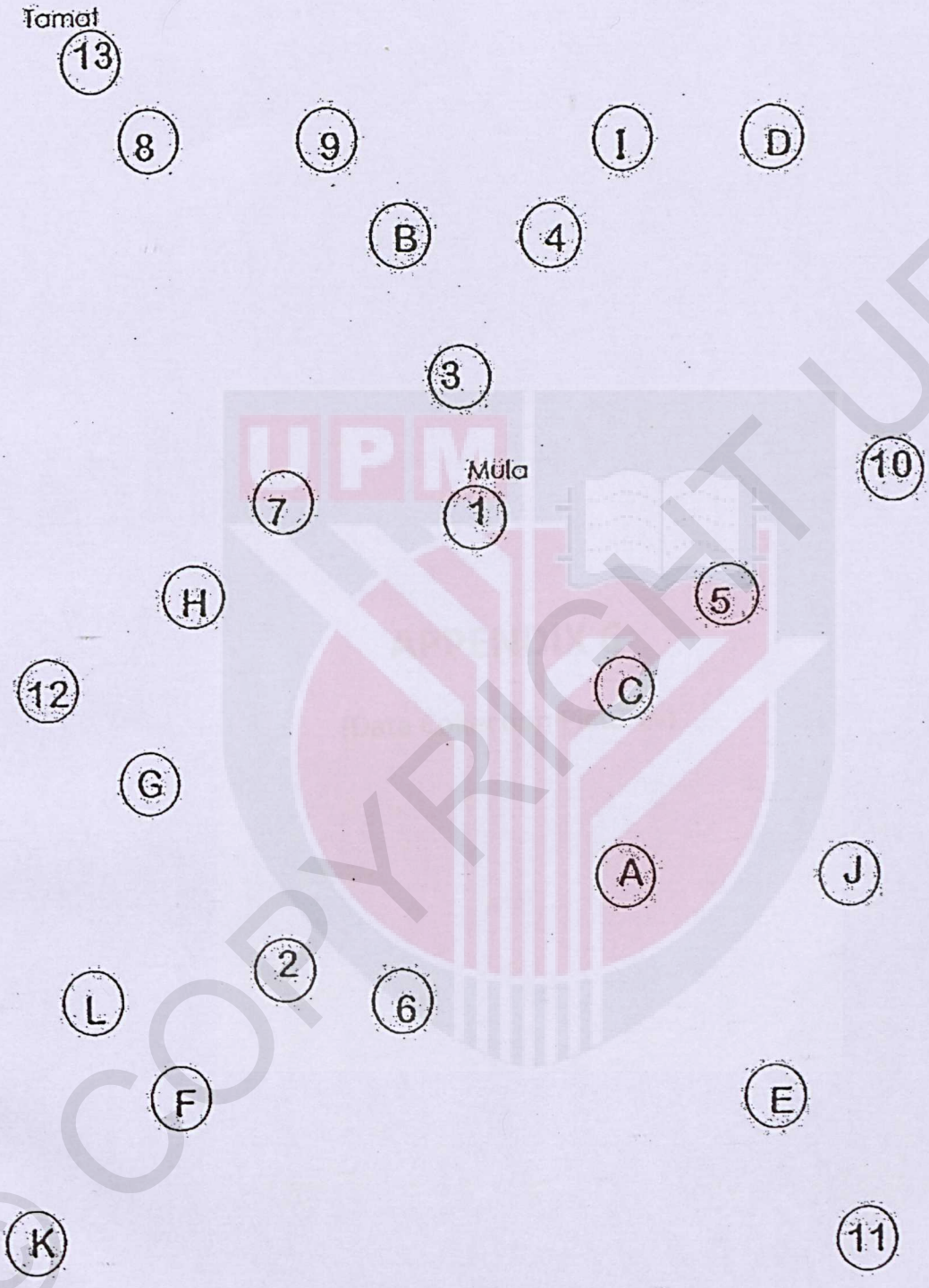


Bahagian B





BAHAGIAN A



BAHAGIAN B

APPENDIX 6

(Data Collection Pictures)

Location of school near paddy field (Sek.Keb. Sawah Sempadan)

Collection of urine from respondents

Instruction given by researcher to respondent in doing Reaction Time/ Movement Test