UNIVERSITI PUTRA MALAYSIA

HEALTH RISK ASSESSMENT OF LEAD EXPOSURE IN DRINKING WATER AMONG RESIDENTS OF FELDA PALONG, NEGERI SEMBILAN

BY
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ABSTRACT

HEALTH RISK ASSESSMENT OF LEAD EXPOSURE IN DRINKING WATER AMONG RESIDENTS OF FELDA PALONG, NEGERI SEMBILAN

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Introduction: Lead in drinking water is a major public health concern. Lead can cause several adverse health effects to human health. This cross-sectional study was conducted in Felda Palong, Negeri Sembilan. **Objective:** The main objective of this study was to determine the risk of lead exposure in drinking water among residents of Felda Palong, Negeri Sembilan. **Method:** Sixty (60) respondents were involved in this study after considered some criteria. Water samples were taken from each respondent house (first flushed and fully flushed) and were analysed with Graphite Furnace Atomic Absorption Spectrometer (GFAAS) to determine lead (Pb) concentration. The demographic information, the amount of water consumption and body weights of each respondent was obtained through questionnaires. The health risk level was calculated by Chronic Daily Intake (CDI) and Hazard Index (HI) **Result:** The mean ± SD of lead concentration in water samples were 3.22 ± 4.9 µg/L (first flushed water samples) and 2.02 ± 2.24 µg/L (fully flushed water samples. Spearman Rank Order Correlation test showed that is no significant correlation between lead concentrations in fully flushed water samples and pH. Meanwhile, Wilcoxon Signed-Rank test showed there was a significance difference between lead concentration levels of first flush and fully-flush water sample with Z = -2.15 and p value <0.05. Only 10% of first flush water samples were exceeded the upper safe limit of National Standard for Drinking Water Quality (NSDWQ), mainly in Felda Palong 4, 5, 7 and 8. This is possibly due to the using of metal and PVC pipes that containing lead for household water distribution system which caused lead leaching into tap water. **Conclusion:** As for the health risk level, the hazard index (HI) value shows that the risk of lead in drinking water in FELDA Palong is within an acceptable risk (HI < 1).

Keywords*:* **Lead level, drinking water, health risk assessment, hazard index, pH level, Felda Palong**

ABSTRAK

KAJIAN RISIKO KESIHATAN TERHADAP PENDEDAHAN PLUMBUM DIDALAM AIR MINUM DI KAWASAN FELDA PALONG, NEGERI SEMBILAN

NOR ZAHIDAH BINTI ZUKFALI

Pendahuluan: Dikalangan masyarakat, plumbum didalam air minum menjadi perhatian utama dalam kesihatan. Plumbum boleh menyebabkan beberapa kesan kesihatan kepada manusia. Kajian keratan rentas ini telah dijalankan di Felda Palong, Negeri Sembilan. **Objektif:** Objektif utama kajian ini adalah untuk mengenalpasti risiko kesihatan terhadap pendedahan plumbum dalam air minum di kalangan penduduk yang tinggal di kawasan Felda Palong, Gemas Negeri Sembilan. **Methodologi:** Sebanyak 60 orang responden telah memenuhi kriteria dipilih untuk menyertai kajian ini. Sampel air telah diambil untuk setiap rumah responden (air yang mula-mula keluar dari paip dan air yang keluar dari paip selepas 3 minit), dan dianalisis menggunakan alat GFAAS untuk mengenalpasti kehadiran plumbum di dalam air minum. Borang soal selidik telah diberikan bagi mengetahui latar belakang responden, kadar air minum dalam sehari dan berat responden. Dengan maklumat yang ada, risiko kesihatan setiap respondent dikira menggunakan rumus yang sedia ada. **Keputusan:** Nilai min ± SP bagi kepekatan plumbum dalam sampel air ialah 3.22 ± 4.09 µg/L (air yang mula-mula keluar dari paip) dan 2.02 ± 2.24 µg/L (air yang keluar dari paip selepas 3 minit). Ujian hubung kait Spearman menunjukkan, tiada hubung kait antara kepekatan plumbum dan nilai pH dalam sampel air. Manakala, Ujian Wilcoxon pula menujukkan ada perbezaan nilai kepekatan plumbum antara air yang mula-mula keluar dari paip dan air yang keluar dari paip selepas 3 minit ($Z = -2.15$, $p<0.05$).Kajian menunjukkan sebanyak 10% sampel air (air yang mula-mula keluar dari paip) melebihi piawaian selamat air minum. Ini mungkin disebabkan oleh penggunaan paip jenis besi dan PVC yang mengandungi plumbum bagi sistem pempaipan di rumah yang menyebabkan plumbum larut dalam air paip. **Kesimpulan:** Bagi kiraan risiko kesihatan, risiko pendedahan plumbum bagi setiap responden adalah diterima.

Kata kunci: Nilai plumbum, air minum, kajian risiko kesihatan, index hazard, nilai pH, Felda Palong

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

Pb	Lead
mg/l	microgram per litre
µg/dl	microgram per decilitre
HNO3	Nitric Acid
ATSDR	Agency for Toxic Substances and Disease Registry
CMAJ	Canadian Medical Association or its licensors
CEPA	California Environmental Protection Agency
CEHA	Centre of Environmental Health Activity
FELDA	Federal Land Development Authority
GFAAS	Graphite Furnace Atomic Absorption Spectroscopy
GIS	Geographical Information Systems
IWA	International Water Association's
PTWI	Provisional Tolerable Weekly Intake
PVC	Polyvinyl Chloride
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is a major part of living things in the world. In some organism, water consists up to 90% of their body weight. About 60 % of the human body is water and 83% of our blood is water, which helps to digest food, transport waste and control body temperature (Raihan, 2008). Humans must replace 2.4 litre of water every day through drinking and from foods.

In Malaysia, most of the water supply originates from rivers and streams, while ground water contributes to only 1% of water supply (Pillay and Chu, 2001).

Water supply management is not centralized but managed on a state by- state basis. Quality control of water supply is monitored by a few agencies in the country such as State Water Supply Department (Pillay et al., 2001). The Department of Environment (DOE) is the public agency that is responsible to monitor the water quality of surface water (river and streams) to control major pollution (Jahi, 2002), while state water authorities are responsible to monitor the raw water quality in the reservoir at the intake point of the treatment plants for public water consumption (Chan, 2004).

Heavy metals are natural components in the earth's crust and at small rate; they enter human bodies via food, drinking water and air (Raihan, 2008). Heavy metal are common type of pollutants in water that harmful to human whether through direct ingestion of contaminated water or accumulation of the heavy metals in the tissue of organisms eaten by humans (Raihan, 2008). One of the heavy metal that commonly found in water is lead (Pb). Historically, lead exposure was linked to food, paint, petrol and drinking water. Lead in paint and petrol were removed in the early 1980s. Leaded solder for jointing copper pipes and jointing food cans were also banned. In consequence, the remaining problems are likely to be due to drinking water which is presence from pipes containing lead, as indicated also in International Water Association's (2010), the main source of lead exposure in drinking water is due to the continued use of lead pipes.

The World Health Organization (2011a) has progressively tightened its guidelines value for lead from maximum allowable concentration of 0.1 mg/l to 0.01 mg/l. The WHO Guidelines recognize that lead is exceptional, and that most lead in drinking water arises from plumbing (WHO, 2011b). According to IWA (2010), Lead in drinking water is a major public health concern. Lead (Pb), is a dangerous and major environmental pollutant. Lead has been used for thousands of years and its poisoning effects have been recognized for several centuries. According to Zietz et al. (2010) intake of the lead in drinking water is commonly due to metal corrosion in the peripheral water distribution system, especially the user's plumbing or lead service lines.

Lead in tap water is also increased by leaching from lead-bearing materials in premise plumbing (PP), such as lead-tin solders containing up to 50% lead (Subramanian et al., 1995), and brass materials containing up to 8% lead (Dudi and Murray et al., 2005). Inorganic elements in tap water are the main health concern as high levels of certain minerals or heavy metals in the drinking water may pose adverse side effects.

1.2 Problem Statement

Lead has been a challenge and a bane for water suppliers since historical times (WHO, 2011a). The presence of lead in drinking water is not a new problem. In Malaysia, Ministry of Health (2009) has progressively tightened its guideline value for lead allowable concentration is until 0.01 mg/l which is stated in National Standards for Drinking Water Quality (NSDWQ).

Lead historically used to produce pipes to carry water and later to solder iron and copper pipes for old housing. This had caused most lead in drinking-water arises from plumbing, and the remedy consists principally of removing plumbing and fittings containing lead (WHO, 2011b). According to Swistock and Sharpe (1994), lead exists in drinking water is through metal corrosion from the usage of lead pipe. Numerous utilities still serve homes with lead plumbing, which can contribute to 50-75% of the total lead mass measured in the tap water (Sandvig et al., 2008). In addition, IWA (2010) also has indicated the main source of lead in drinking water is due to the continued use of lead pipes.

Lead can affect almost every organ and system in the body causing pathophysiological changes in several organ systems including central nervous, renal, hematopoietic, and immune system (Goyer, 1986). Among these damages, a very important issue is that the main target for lead toxicity is the nervous system, both in adults and children. The temporal dimension of exposure to this element in drinking water is of interest because their toxicological effects, such as kidney disease, and impaired cognitive function, are considered to result from chronic exposure rather than short-term exposure (Mushak and Crocetti, 1996).

1.3 Study justification

In our daily routine, water is an important source to our life especially for drinking water. Although serious problems with lead pollution of drinking water were largely considered historical, some lead problems still emerged in recent years (Edwards and Dudi, 2004). Therefore, the studies need to be conduct in order to know the status of lead contamination in drinking water among Malaysia population. From this study, we can determine the level of water quality in context of lead contamination in drinking water that supply to resident's houses in certain area in Malaysia.

The selected study location in this study was at Federal Land Development Authority (FELDA) Palong, Gemas, Negeri Sembilan which were known as rural area. As we know, mostly people who lived in rural area have low education level compared to people in urban area. Therefore, they are not really concerned about the quality of water as they thought that the government responsibility to ensure the water is in good quality to be used. Furthermore, research will investigate awareness among residents in Malaysia about the safe drinking water.

Besides that, the Felda Palong area were known as old housing area that build since 1970's which the residence have possibility they still use the pipes containing lead for home water distribution and problem with not properly maintenance of piping systems. So by that, there is possibility having lead contamination in their drinking water.

Besides, in Malaysia, there are limited data available to determine the risk associated with lead exposure in drinking water among the Malaysian population, so the result that found from this study can be used for future references. Morever, this research was conduct at rural area which is Felda Palong in Negeri Sembilan and no related study had been conduct regarding lead concern at that area before.

The aim of this study is to assess the present state of drinking water contamination with lead referred to the referred population group. Lead concentration values in this study were compared with the National Standards for Drinking Water Quality provided by Malaysia Ministry of Health.

1.4: Conceptual framework

The Figure 1.1 showed that the conceptual framework for this study of interest. Lead is the heavy metal concern in this study which comes from two sources that are from environment and also from product. The main concern in the study was the lead that produced by the product which were comes from plumbing system. This plumbing system that used for the home distribution water supply was one of the factors that can caused lead contamination in drinking water, especially for residents who use the tap water for their drinking water source. The route of exposure was via ingestion as the resident's drink the drinking water contaminated with lead and by that exposure, the body can develop some adverse health effect such as effect to nervous system, renal, haematological and also reproductive system. Heath risk assessment was the main concern in this study in order to measure the risk of the population towards lead contamination in drinking water to their health.

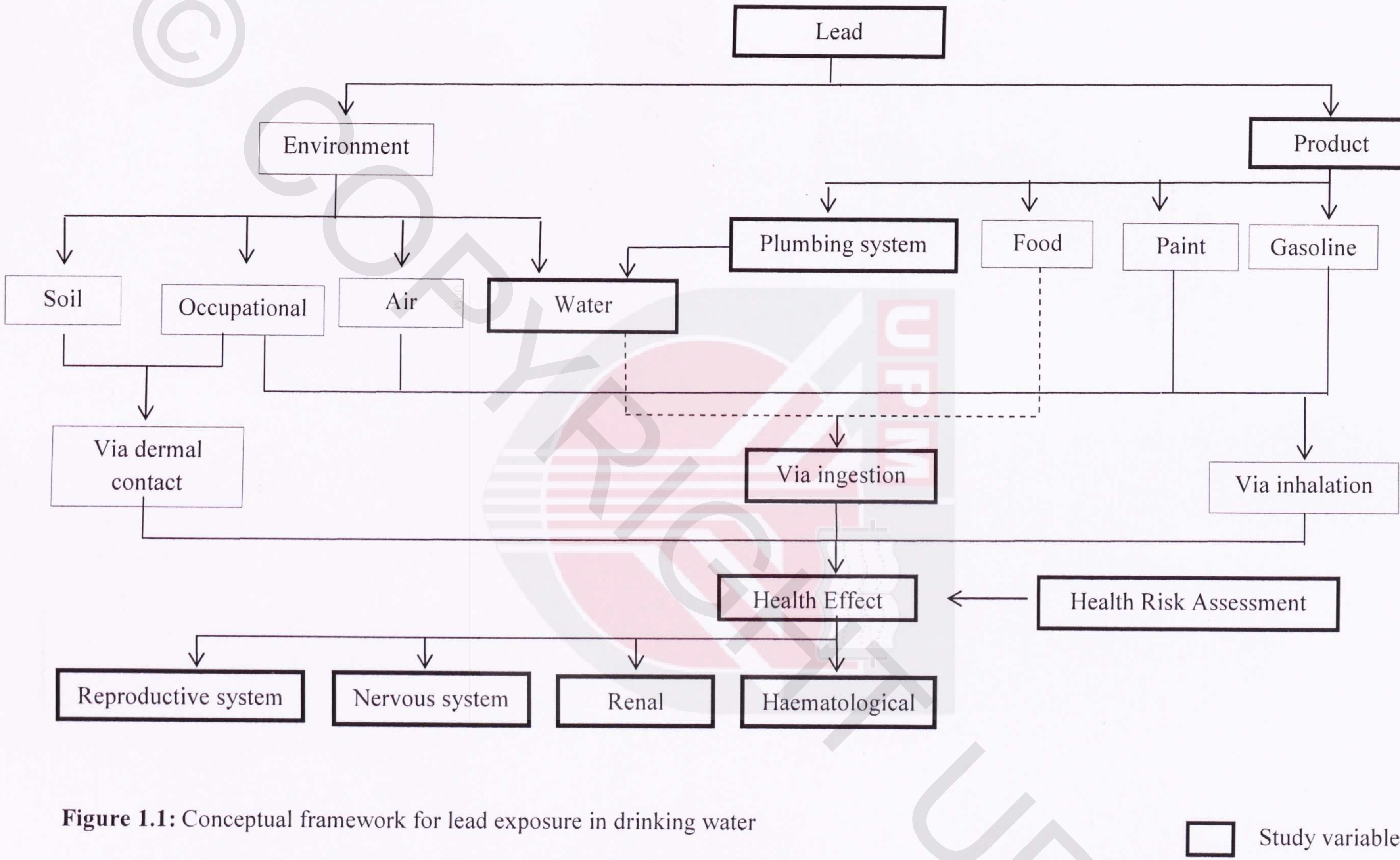

Figure 1.1: Conceptual framework for lead exposure in drinking water

1.5 Definition

1.5.1 Conceptual Definition

1.5.1.1 Drinking water

Drinking water or potable water is water pure enough to be consumed or used with low risk of immediate or long term harm.

1.5.1.2 Lead

Lead is a toxic metal that is harmful if inhaled or swallowed. It is a natural and ubiquitous element found in several sources, including many foods, the water, air and soils (CMAJ, 2008)

1.5.1.3 Health Risk Assessment

Health risk assessment is the process of quantifying the probability of a harmful effect to individuals or populations from certain human activities. The risk assessment process is typically described as consisting of four basic steps: hazard identification, exposure assessment, dose-response assessment, and risk characterization (United States Environmental Protection Agency, 2005).

1.5.2 Operational Definition

1.5.2.1 Drinking water

The drinking water samples were collected at each resident's kitchen tap water using 250ml high density polyethylene (HDPE) bottles. Two water samples are collect at the morning, which are first-flush sample that water sample from very first drops of tap water and fully-flush sample which is the water sample taken after 2 minutes of flushing.

1.5.2.2 Lead

Lead in drinking water is determined by analysing lead content from samples collected from residential tap water. The water samples are analyse by using PerkinElmer® AAnalysts™ 600 Graphite Furnace Atomic Absorption Spectrometer (AAS). Each sample result will compare with Malaysia National Standards for Drinking Water Quality (NSDWQ) which is cannot exceed 0.01 mg/l.

1.5.2.3 Health Risk Assessment

According USEPA (1992), to estimated daily exposure of individuals for lead exposure through ingestion is by calculating the chronic daily intake (CDI) as the exposure metric. Then, to estimate the non-carcinogenic risk of lead, the hazard index (HI) is calculated using the equation.

1.6 Objective

1.6.1 General Objective

To determine the risk of lead exposure in drinking water among residents in Felda Palong, Negeri Sembilan

1.6.2 Specific objective

1. To determine socio-demographic data of residents in Felda Palong, Negeri Sembilan
2. To determine the concentration of lead (Pb) in drinking water sample among residents in Felda Palong, Negeri Sembilan.

3. To determine the distribution of lead concentration in drinking water among residents in Felda Palong by using Graphical Information System (GIS).
4. To compare the lead concentration in drinking water sample of residents with the Malaysia National Standards for Drinking Water Quality (NSDWQ).
5. To determine the relationship between lead concentration and pH of drinking water sample.
6. To compare the lead concentration level of first flush and fully-flush in water sample.
7. To calculate chronic daily intake, CDI values and hazard index, HI value for lead exposure in water sample among residents.

1.6.3 Hypothesis

1. Lead concentration in drinking water sample is higher than the Malaysia National Standards for Drinking Water Quality (NSDWQ).
2. There is a significant relationship between lead concentration and pH of water sample.
3. There is a significant difference between lead concentration levels of first flush and fully-flush water sample.
4. The Hazard Index (HI) among residents is more than 1.

CHAPTER 2

LITERATURE REVIEW

2.1 Lead

Lead is a heavy, low melting, bluish-gray metal that occurs naturally in the Earth's crust. However, it is rarely found naturally as a metal (Agency for Toxic Substances and Disease Registry, 2007a). Lead has long environmental residents. Man has mined and used lead for many thousand years and this is resulted to accumulation of environmental lead (Smith, 1986).

2.1.1 Physicochemical properties of Lead

Lead is a naturally occurring element and in periodic table is a member of Group 14 (IVA). Natural lead is a mixture of four stable isotopes, 208Pb (51–53%), 206Pb (23.5– -27%), 207Pb (20.5–23%), and 204Pb (1.35–

1.5%). Lead exists in three oxidation states: Pb(0), the metal; Pb(II); and Pb(IV). In environment, lead primarily exists as Pb(II),while Pb(IV) is only formed under extremely oxidizing conditions and inorganic Pb(IV) compounds are not found under ordinary environmental conditions. Metallic lead, Pb(0) exists in nature, but its occurrence is rare (ATSDR,2007a). Lead has a melting point of 327°C, which lower than the melting points of other common metals with exception of tin (Smith, 1986).

2.1.2 Major Uses

The lead physical properties like comparative ease of extraction from ore, corrosion resistant and poor conductivity have resulted in multiplicity of uses of metal all over 3000 years (Ratcliffe, 1981). According to ATSDR (2007a), lead is easily moulded and shape and can be combined with other metals to form alloys.

Lead-acid batteries are the largest outlets for lead throughout the world which were widely used in automotive manufacturing. It also be used in paints, radiation shielding, ceramic, make-up and also in building industry which is pipes (Ratcliffe, 1981).

Lead also use in form of tetraethyl lead and Tetra methyl lead which were added in small quantities to petrol to increase its octane rating

(Urbanowicz, 1986). Hovewer, Tetra metyl lead was banned for use in gasoline for motor vehicles beginning in January 1st, 1996, whereas tetraethyl lead still is being used in gasoline for off-road vehicles and airplanes (ATSDR, 2007b).

2.2 Source of Lead in the environment

Lead occurs naturally in the environment. However, most of the high levels of lead were found throughout the environment come from human activities. The lead source in the environment can be divided into two, from natural resources and anthropogenic source.

2.2.1 Natural source

Lead is the most abundant of the heavy metals in earth's crust, occurring principally as the sulphide ore, galena (Ratcliffe, 1981). Approximately, 0.002 per cent of earth's crust is lead, localised into deposits sufficiently rich to justify mining (Smith, 1986).

2.2.2 Anthropogenic source

Lead in dust and soil can originate from several anthropogenic sources such as paint and plaster chippings, mobile and stationary source emissions (Ratcliffe, 1981). It also can release to the environment from mining activities, used of gasoline petrol, industrial manufacturing, lead alloys, burning of coal, oil, and waste (ATSDR, 2007a).

Other source of lead includes the use of lead-containing ceramics for cooking, eating or drinking. In some countries, people are exposed to lead after eating food products from cans that contain lead solder in the seams of the cans. Children are at high risk of lead contamination through the ingestion of paint chips from lead-based paint (WHO, 2011b).

2.3 Exposure to Lead

Exposure to lead is occurring via food ingestion, drinking of water containing lead, inhalation, and dermal contact.

According to WHO (2011b), exposure to lead through water is generally low in comparison with exposure through air or food. Lead from natural sources is present in tap water to some extent, but analysis of both surface and ground water suggests that lead concentration is fairly low. Leafy fresh vegetable grown in lead containing soil may contain small amounts of lead (ATSDR, 2007a). According to Moore (1986), plants are the primary food stuff containing lead, so it is one of the human exposures towards this heavy metal. However lead content on plants becomes less significant to man when these foods are washed and peeled.

Motor vehicle exhaust of leaded gasoline, the indoor paint containing lead as well as the cause by the occupational exposure such as smelters, lead manufacturing and recycling industries are the exposure of lead via inhalation (WHO, 2011b).

Lead in soil normally reflects imperfectly the composition of the parent mineral material with alteration take place and also through airborne deposition of dust containing lead from anthropogenic sources deposit on the soil. According to the Tong et al. (2000), atmospheric lead that is deposited in soil may then be ingested by children and may substantially raise their blood lead levels.

2.4 Lead in drinking water

According to Ryan et al. (2000), individual exposure to lead (Pb) via drinking water may vary over time and Azrina and Idris (2011) said that it is because of human activities differ from place to place, change from time to time, and contamination or pollution of water sources also tend to vary from place to place. Lead in tap water is much bioavailable than lead in food, because of often consumed during semi fasting (between meals) or after fasting (overnight) condition (Ocran, 1996).The problem of lead in drinking water is most concern at this time, particularly to the old districts, where pipes containing lead was still used to connect houses to municipal water supply system and for internal plumbing (IWA, 2010).

According to the study of major inorganic elements in tap water in peninsular Malaysia by Azrina and Idris (2011), they found that some tap water from Kelantan show elevated levels of Pb which could be due to corrosion of household plumbing system and erosion of natural deposits. These factors also recognize by WHO (2011b) that the most lead in drinking water arises from plumbing. According to Canadian Medical Association or its licensors (2008), home built before 1950s were often built with lead plumbing, and those built as recently as 1990 may contain lead solder.

Pipes containing lead for household water supplies can raise water containing lead, especially if the water is acidic (Pocock, 1983). Ocran (1996) state in his study that source of lead presence in drinking water is by leaching into tap water as a by-product of galvanic corrosion of lead, and alloy solder joints, faucet fixtures or pipes in household plumbing. Study by Zietz et al. (2001) in Germany also indicated that lead contamination in water household only due to metal corrosion.

2.5 Health effects

Lead consider as a non-carcinogen hazard. The adverse health effects from prolonged exposure to high amounts of lead from occupational and environmental exposure includes: interfere hemoglobin biosynthesis, poor intention span, headache, kidney damage, loss of memory and gonad dysfunction (IWA, 2010).

2.5.1 Neurological

The toxicologic effects of lead to nervous systems that can cause low performance and mild retardation to human are considered as chronic rather than short term effect (Ryan et al., 2000). Most attention has been directed towards the retardation of child development, especially reductions IQ in relation to lead exposure (IWA, 2010).

Numerous studies have correlated the association between blood lead levels such as cognitive impaired among children (WHO and Centre of Environmental Health Activity, 2003). The best-studied effect is cognitive impairment, measured by IQ tests (Shannon et al., 2005). Blood lead concentration is associated with lower IQ scores as IQ becomes testable reliably, which is at approximately 5 years of age. As blood lead concentrations increase by 10 µg/dL the IQ at 5 years of age and later decreases by 2 to 3 points (Shannon et al., 2005).

2.5.2 Renal

Lead renal toxicity is characterized by proximal tubular nephropathy, glomerular sclerosis and interstitial fibrosis (ATSDR, 2007a). Acute effects of exposure to high concentration of lead resulting in proximal tubular damage manifested by glycosuria and amino acid uria (Karthryn et al., 2000).

Functional deficits in humans that have been associated with excessive lead exposure include enzymuria, low- and high-molecular weight proteinuria, impaired transport of organic anions and glucose, and depressed glomerular filtration rate (ATSDR, 2007a). According to Ratcliffe (1981), children and adult with severe acute poisoning of lead may show evidence of renal damage.

2.5.3 Haematological

Lead has long been known to alter the haematological system, anaemia induced by lead is microcytic and hypochromic and results primarily from both inhibition of heme synthesis and shortening of the erythrocyte lifespan (ATSDR, 2007a). The effect of lead exposure to haematological system consists of two types of effects: Firstly, interfere with heme and haemoglobin synthesis, and secondly effects on erythrocyte morphology and survival which those effect known as anaemia (Ratcliffe, 1981).

Lead certainly inhibits several enzymes particularly porphobilingen syntheses and heme syntheses. Of these two, heme syntheses is of particular interest, since it is a mitochondrial bound enzyme, suggesting the possibility that lead inhibits this enzyme simply by altering mitochondrial function rather than by specifically altering the enzyme (Karthryn et al., 2000).

2.5.4 Reproductive

High exposure to lead might result in abortion and pre-term delivery in women, and in alterations in sperm and decreased fertility in men (ATSDR, 2011b).

Lead also can effect on male reproductivity (Karthryn et al., 2000). According to ATSDR (2007b), high-level exposure in men can damage the organs responsible for sperm production while for pregnant women, high levels of exposure to lead may cause miscarriage.

2.6 Exposure and Risk Assessment

Health risk assessments are used to determine if a particular chemical poses a significant risk to human health and, in what circumstances (California Environmental Protection Agency, 2001). Risk assessment methods can also be used to estimate risk of effects due to toxic pollutants in the environment. There are four steps in risk assessment which were hazard identification, dose-response assessment, exposure assessment, and risk characterization (Boguski, 2010).

2.6.1 Hazard identification

The first step of risk assessment is hazard identification. This is in attempt to determine health problems caused by specific toxic pollutants (Boguski, 2010). According to Jamal and Zailina (2010), hazard identification is the process of determining whether exposure to an agent can cause an increase in the incidence of health condition. It involves characterizing the nature and strength of the metal exposure (Paustenbach, 1989). In this study, hazard identification step involved in determining lead concentration in drinking water sample each respondent house.

2.6.2 Dose-response assessment

Dose-response assessment is the evaluation of the relationship between the amount of exposure to a toxic substance and the extent of injury or disease caused. In this type of assessment, the dose is the amount of exposure to the toxic pollutant and the response is the reaction to the toxic pollutant (Boguski, 2010).

A dose-response relationship describes the increase in the probability of an adverse effect with corresponding increase in the exposure dose to the hazard. Therefore, some form of toxicological parameter must be used to describe the relationship in order to enable us to assess the health risk. The first parameter is the Reference Dose (RfD) present in unit mg.kg-day is used to estimated daily oral exposure of a toxicant (Jamal and Zailina, 2010).

The dose-response relationship for non-cancer effects are calculated differently than for cancer effects. For non-cancer effects, a very low dose may not cause harm to human health. Threshold values are developed for non-cancer causing chemicals. Doses below the threshold value are considered "safe" and doses above the threshold value are considered harmful (Boguski, 2010). The reference dose for lead was used in this study to calculate the hazard index in order to determine the risk of lead exposure each respondent.

2.6.3 Exposure assessment

Exposure assessment is the process measuring or estimating the intensity, frequency and duration of human to an agent currently present in the environment to estimate the exposure that may arise from the release of chemical to the environment (Paustenbach, 1989). Exposure to toxic pollutants occurs through three primary exposure pathways: ingestion, inhalation, and absorption through the skin. Exposure is investigated by taking air, water and soil samples and analysing them in the field or at laboratories. The results indicate the concentrations of toxic pollutants present at a specific location (Boguski, 2010). In this study, exposure assessment through calculated the chronic daily intake value each respondent.

2.6.4 Risk characterization

Risk characterization is the final step of baseline health risk assessment process (USEPA, 2005). It is the process of estimating the incidence of a health effect under the various conditions of human exposure describe in exposure assessment (Jamal and Zailina, 2010). Besides, the information from the hazard assessment, exposure assessment, and dose-response relationship helps scientists to estimate the extra risk to human health or the environment that is caused by toxic pollutants (CEPA, 2001).

The first step of risk characterization is to compute the total intake of a toxicant into human body, which reflect the body burden of the toxicant (Jamal and Zailina, 2010). The total toxicant can be termed as the average daily dose (ADD) or chronic daily intake (CDI). To estimate non-carcinogenic risk, hazard index (HI) is calculate by dividing the ADD or CDI value with reference dose (RfD). Hazard index greater than 1 indicates potential for an adverse effect to occur. In this study, CDI value is used to calculate the hazard index value in order to determine risk characterization.

CHAPTER 3

METHODOLOGY

3.1 Study location

The location of this study was at Felda Palong, Negeri Sembilan. This area was selected as study location because it is known as rural areas in Negeri Sembilan. The water supply in Felda Palong is managed by Syarikat Air Negeri Sembilan (SAINS). Figure 3.1 showed the location of study area.

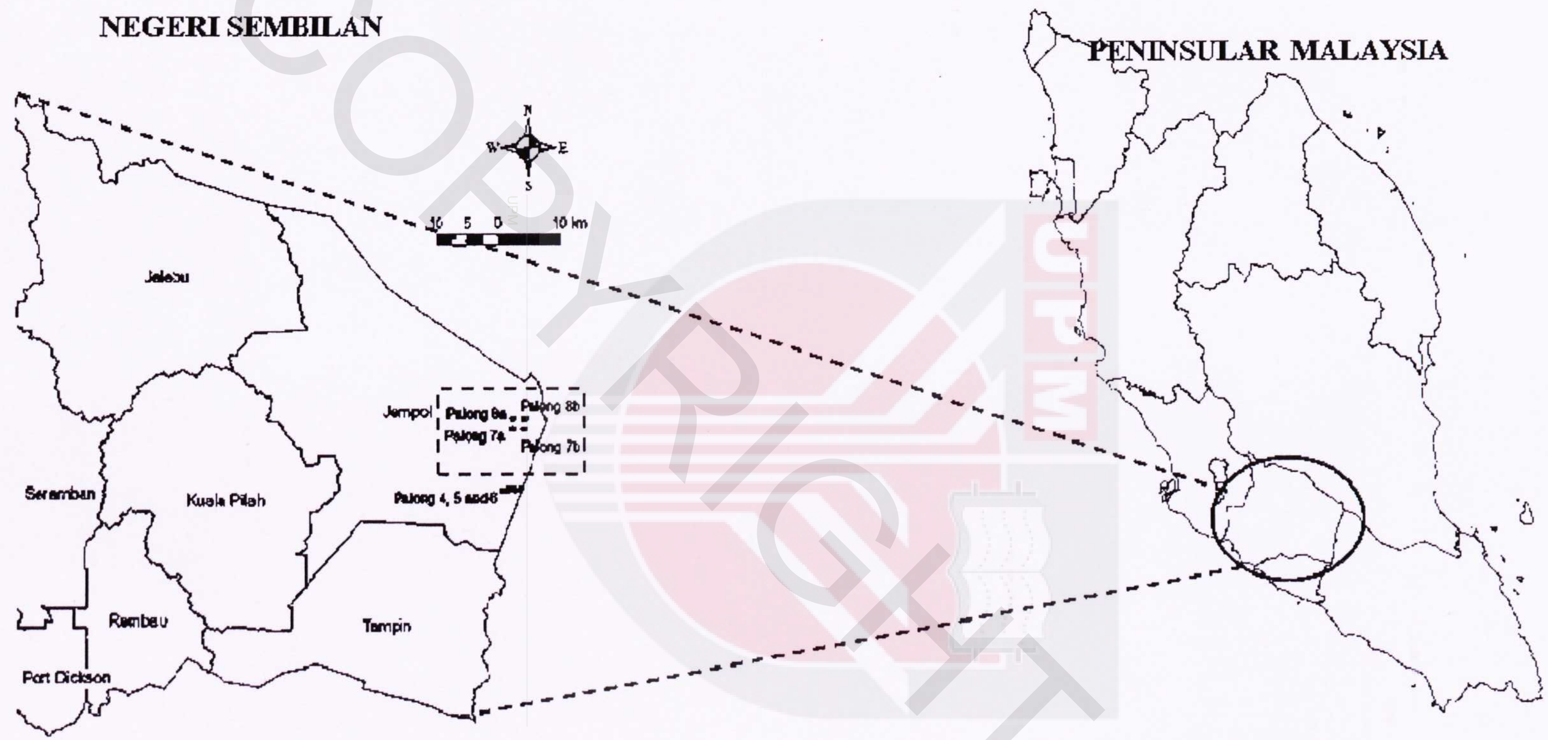

Figure 3.1: Study Location - Felda Palong, Negeri Sembilan

3.2 Study design

Study design is a cross sectional conducted to estimate the health risk associate with the exposure of lead in drinking water among Felda Palong population. Cross-sectional study can be thought of as providing a "snapshot" of the frequency and characteristics of a disease in a population at a particular point in time. Besides, this study is relatively easy and economical to be conduct in determining characteristic of the drinking water at the selected areas.

3.3 Study population

The study population were residents living in Felda Palong, Negeri Sembilan who used tap water as the main source of drinking water.

3.4 Sampling

3.4.1 Sample size

The sample size is calculated using formula by Kirkwood and Sterne (2009).

$$N = \frac{P\,(1-P)}{e^2}$$

Where, N = Sample size

P = Prevalence

e = Probability error

According to the Zietz et al. (2009), the prevalence of households with detected lead concentration in drinking water of 10μg/L or more was 7.5%. So, by insert 0.075 as prevalence and 0.05 as probability error, the sample size is calculated as below.

$$N = \frac{0.075(1-0.075)}{0.05^2}$$

$$=27.75$$

But to ensure that the data to be statistical significant and to take into consideration of non-conformity of respondents and damaged data, sample size will bring to 100 samples.

3.4.2 Sampling method

Sampling method that will be used in this study is purposive sampling for the selection of study location. Then, for the respondent selection, the stratified random sampling was used. The respondent was selected based on inclusive and exclusive criteria selected as described in section 3.4.3.

3.4.3 Sampling unit

The sampling unit was a residents living in Felda Palong who fulfilled the inclusive and exclusive criteria.

Inclusion criteria

- Malaysian who aged 18 and above (Undang-undang Malaysia, 2006)
- Long life residents in selected area
- Use treated water as their main source of drinking water

Exclusion criteria

- Residents who use personal water filtration
- Residents tap water source other that municipal water supply
- Residents that use bottled water or well water as their main source of drinking water

3.5 Study instrumentation and data collection

3.5.1 Questionnaire

A structured questionnaire which comprised two sections was used in this study. The first section contains questions regarding the respondents' background information such as age, household income and education level.

The second section gather information regarding duration of residence, body weight of respondent and daily water intake rate which will be used to calculate the Chronic Daily Intake (CDI) of lead exposure from their drinking water source. The questionnaire was adapted from the Baseline, Descriptive and Time Activity Questionnaires used in the National Human Exposure Assessment Survey (NHEXAS) Arizona study (Lebowitz et al., 1995).

3.5.2.1 Water sampling

In this study, 250 millilitre (mL) non-acidified high-density polyethylene (HDPE) bottles is use for water sample collection and storage.

Drinking water samples were collected at the respondents' kitchen tap. Water sample for each residents were collected included a 250ml first flush water sample which is the very first flush of water that come out from tap after one night stagnation and a fully-flushed water sample that taken after 2 minutes of flushing at kitchen tap. The first flush water sample use to determine if lead present from the house plumbing system and the fully-flush water sample use to determine if the lead is coming from the water distribution system. Figure 3.2 shows a flow diagram of sampling technique.

According to study conduct by Zietz et al. (2001), pH of water sample is measured directly on site using fully flush water sample.

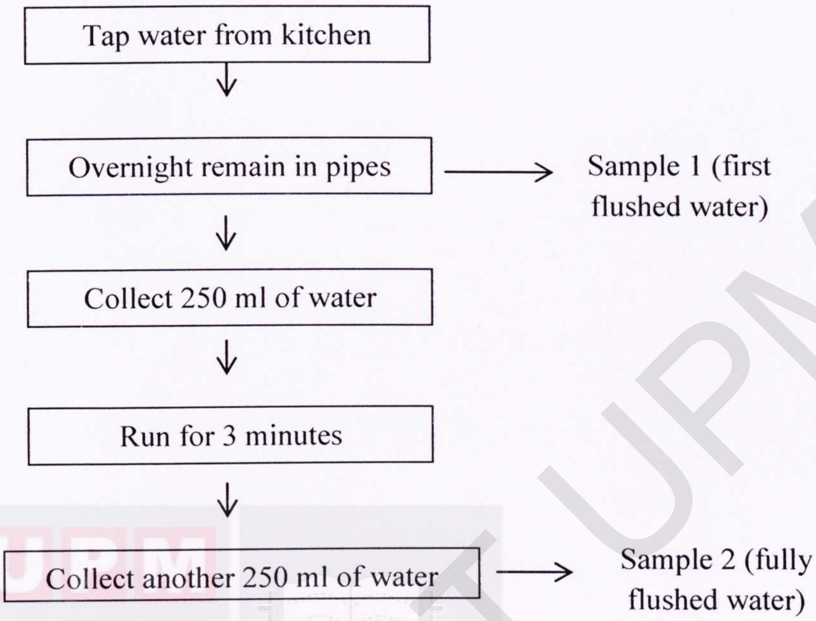

Figure 3.2: Flow diagram of sampling technique

3.5.2.2 Acidification of water samples

Water samples collected were then preserved at pH < 2 by adding 0.5ml of 69% pure concentrated nitric acid before being transported and analysed at the laboratory to ensure bacterial removal from the samples and to lengthen the storage time of the samples (Kavcar et al., 2009). Preserved samples could be stored up to 6 month before they are analysed in the laboratory (HACH, 2010).

3.5.2.3 Water sample analysis

For pH measurement, a pH meter (Figure 3.3) was used. This instrument could read the pH instantly by dipping the probe into the water.

A PerkinElmer® AAnalysts™ 600 Graphite Furnace Atomic Absorption Spectrometer (Figure 3.4) was used to determine the level of lead in the water samples. The combination of usage this instrument with the Intuitive WinLab32™ for AA (version 6.5) software will help in analyse samples, report and achieve data. The procedure for preparing stock standard (reference) solution for Pb is 0.5 g 10 ppm of Lead and mark-up to 1000 ml using deionized water. Table 3.1 showed the Graphite Furnace Atomic Absorption Spectrometer (GFAAS) recommended condition for lead analysis.

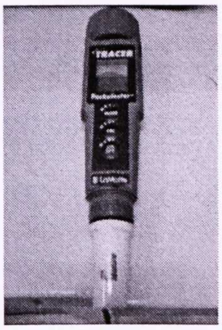

Figure 3.3: pH meter

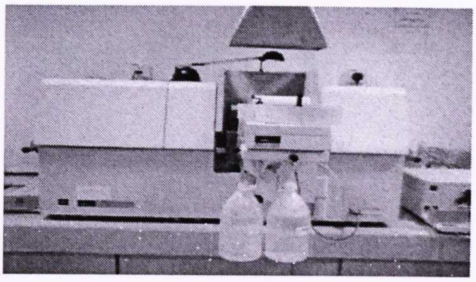

Figure 3.4: PerkinElmer® AAnalysts™ 600 Graphite Furnace Atomic Absorption Spectrometer

Table 3.1: Recommended conditions for lead (Pb)

Pb	**Recommended Condition for Lead**		
Wavelength(nm):	283.3	**Pretreatment Temp. °C :**	850
Low Slit (nm):	0.7	**Atomization Temp. °C :**	1500
Tube/Site	Pyro/Platform	**Rollover(A):**	
Matrix Modifier	0.05mg NH4H2PO4 + 0.003 mg Mg(NO3)2		
Characteristic mass	30.0 pg/0.0044 A-s		
Sensitivity Check	50.0 µg/L for 0.15 A-s		

Source: Graphite Furnace Atomic Absorption Spectrometer (GFAAS) model Perkin Elmer AAnalyst 600 Manual

3.5.3 Weight measurement

The body weights of respondents were measured using Seca Body Weight Scale (Figure 3.5). The readings were taken three times and then averaged.

Figure 3.5 : Seca Body Weight Scale

3.5.4 Geographical Information System (GIS)

GIS is a computer system that used to capture, store, analyse and display geographically referenced information which the data identified according to location. It also used to view, interpret, and visualize the data that reveal the patterns, and trends of lead concentration in drinking water at the study area in the form of maps.

Global Positioning System (GPS) receiver was used to collect the latitude and longitude coordinates of each respondent housing location. This will be plot in a GIS mapping tools.

The location of Felda Palong was gathered from Department of Statistic, Malaysia, and was scanned and digitized in order to produce digital data files for further analysis in GIS software.

Lead concentrations were key in according to the coordinate of each respondent house in GIS to generate the distribution and trends of map.

3.6 Quality control

3.6.1 Standard Operating Procedures (SOPs)

The analysis of water samples using PerkinElmer® AAnalysts™ 600 Graphite Furnace Atomic Absorption Spectrometer (GFAAS) followed the standard operating procedures that from the manufacturer. By following the standard operating procedure, it will reduce the analytical error during analysis.

3.6.2 Calibration

The PerkinElmer® AAnalysts™ 600 Graphite Furnace Atomic Absorption Spectrometer (GFAAS) initially calibrated first before start the analysis. A calibration curve obtained prior to analysis of water sample.

3.6.3 Pre-test

Pre-test of questionnaire will be conducted on 10% of samples before the data collection. The reason is to ensure that the questionnaire can be understood and can be answered by the respondents.

3.7 Risk Assessment

In order to estimate health risk associated with lead in drinking water, chronic daily intake (CDI) was first calculated using the following equation which is similar representation of daily exposure for ingestion route modified by USEPA (1999).

$$CDI = \frac{C \times DI}{BW}$$

Where, CDI = Chronic Daily Intake (µg/kg/day),

C = Lead concentration in water (µg/L),

DI = average daily intake rate of water (L/day),

BW = body weight (kg).

Then, to conclude the significant exposure and overall potential for non-carcinogenic health effects posed by lead in drinking water, the Hazard Index (HI) was calculated using the following equation (USEPA, 1992).

$$HI = \frac{CDI}{RfD}$$

Where, HI = Hazard Index,

CDI = Chronic Daily Intake (µg/kg/day),

RfD = Reference dose (µg/kg/day)

A HI value more than 1 shows a significant risk level, the higher the value, the greater is the likelihood of adverse non-carcinogenic health impact. RfD value use in this study referred to Provisional Weekly Tolerable Intake (PWTI) of 25µg of lead per kg of body weight (equivalent to 3.5µg/kg of body weight per day).

3.8 Ethical issues

Before started the data collection, permission to carry out this study will be requested from Ethical Committee, Faculty Medicine and Health Sciences of Universiti Putra Malaysia.

3.9 Data analysis

Data entered and analysed using the Statistical Program for Social Science software (SPSS for Windows version 17.0). For descriptive data, descriptive statistic is used to determine socio demographic data of respondents, information on water consumption and result of water analysis in percentage, means, standard deviations, ranges, percentiles, maximum and minimum values.

Then, Shapiro-Wilk Test is used to determine the normality of the data, where $p>0.05$ is indicates a normal distributed data. The parametric test is use if the data is normally distributed and non-parametric test will be used to analyse the not normally distributed data.

Bivariate analysis which is then used to test the hypothesis, which is testing for statistical significant different of lead concentration in first flush and fully-flush water sample and relationship between lead concentration and physical properties (pH) of water sample. To compare two independent variables, the Wilcoxon sign rank test was used for data not normally distributed. Then, to determine the relationship between two variables, Spearman Spearman-rho correlation was used because the data is not normally distributed.

3.10 Study limitation

There are limited local studies done about the lead exposure in drinking water. Therefore, it is hard to predict current local drink water status towards lead exposure. This study only focuses on ingestion route to access the risk of lead exposure among residents.

Furthermore, this study is a cross sectional study that measures lead in a specific period of time and population only. Therefore, there is limited information to support the argument on the lead exposure completely. In addition, this study is prone to recall bias which occurs when we determine the daily intake rate of drinking water among respondents by using a standard cup of 200 ml, each respondent has to recall back their water assumption in a day based on the standard.

CHAPTER 4

RESULTS

4.1 Socio-demographic data of respondent

In total, only 60 respondents participated in this study after taking into consideration the exclusive and exclusive criteria. The data collection was carried out from 13 December 2011 until 16 December 2011 at the respective areas.

Table 4.1 shows the socio-demographic information of respondents. For the respondent's age, mean ± standard deviation was 49 ± 14 and the median was 55 years old. The range of respondent age was from 18 to 66 years old.

For gender, female respondents had a higher number (36 (60%)) compared to the male respondents which were 24 (40%). All 60 (100%) respondent were Malays.

For data on educational level, 30 (50%) respondents completed UPSR, then follow by SPM level, SRP/PMR level and STP/Diploma level which were 14 (23.3%), 7 (11.7%) and 1 (1.7%), respectively. None of the respondents were degree holder.

For respondent income per month, none of them were classified in poverty category which has an income less than RM 750. Meanwhile, 54 (90%) respondents had an income of between RM 750 to RM 1999 per month, 4 (6.7%) respondents had income of between RM 2000 to RM 3999 and only 2 (3.3%) respondents had income of more than RM 4000 per month.

Table 4.1: Socio-demographic information of respondent

Variable	Mean + SD	Median		Range
Age	49.57 + 14.11	55		18 - 66
Variable	**Category**	**N**	**%**	**Cumulative Percentage (%)**
Gender	Male	24	40	40
	Female	36	60	100
Races	Malay	60	100	100
Education Level	Never	8	13.3	13.3
	UPSR	30	50.0	63.3
	SRP/PMR	7	11.7	75.0
	SPM	14	23.3	98.3
	STPM/Diploma	1	1.7	98.3
	Degree	0	0	100.0
Income				
	<RM750	0	0	0
	RM750-RM1999	54	90.0	90.0
	RM2000-RM3999	4	6.7	96.7
	≥RM4000	2	3.3	100.0

N=60, *Poverty Line Income (United Nation Development Programme, 2005)

4.2 Lead concentration and pH of water sample

Table 4.2 showed the result of lead concentration and pH of water sample. For the first flushed water sample, mean ± SD value of lead concentration was 3.22 ± 4.09 µg/L and the range was from 0.09 µg/L to 16.6 µg/L. For the fully flushed water samples, the mean ± SD of lead concentration were 2.02 ± 2.24 µg/L and the range was from 0.049 µg/L to 9.921 µg/L. For pH of water samples, results showed that the mean ± SD which was 6.86 ± 0.43 and the range were from 6.27 to 8.03.

Table 4.2: Lead concentration (µg/L) and pH value of water sample

Variable	Mean ± SD (µg/L)	Median (µg/L)	Range (µg/L)
First flush water sample (lead concentration)	3.22 ± 4.09	1.32	0.09 - 16.6
Fully flush water sample (lead concentration)	2.02 ± 2.24	1.14	0.049 - 9.92
pH	6.86 ± 0.43	6.70	6.27 - 8.03

N=60

There were 5 housing areas in Felda Palong which were chosen in this study. The results of lead concentration of first flushed water samples and fully flushed by housing area are summarize in Table 4.3. Figure 4.1 showed the mean and standard error for lead concentration for both water samples across the 5 study areas. Felda Palong 7 was found to have the highest lead concentration in first flushed water sample with mean ± SD at 4.05 ± 4.70. For fully flush water samples, the highest lead concentration was found at Felda Palong 4 (mean ± SD, 2.60 ± 2.42).

Table 4.3: Description of lead concentration in first flushed and fully flushed water samples across area in Felda Palong

	First Flushed Water Sample (Lead concentration, µg/L)			**Fully Flushed Water Sample (Lead concentration, µg/L)**		
	N	**Mean ± SD**	**Range**	**N**	**Mean ± SD**	**Range**
Palong 4	11	3.21 ± 5.34	0.383 - 16.62	11	**2.60 ± 2.42**	**0.054 - 7.40**
Palong 5	19	3.26 ± 3.95	0.335 - 14.27	19	2.34 ± 2.80	0.136 - 9.92
Palong 6	9	2.50 ± 2.59	0.09 - 6.65	9	2.26 ± 2.14	0.066 - 5.84
Palong 7	8	**4.05 ± 4.70**	**0.688 – 13.81**	8	1.40 ± 2.04	0.327 – 6.32
Palong 8	13	3.22 ± 4.09	0.115 – 13.85	13	1.26 ± 1.04	0.049 – 3.05

N=60

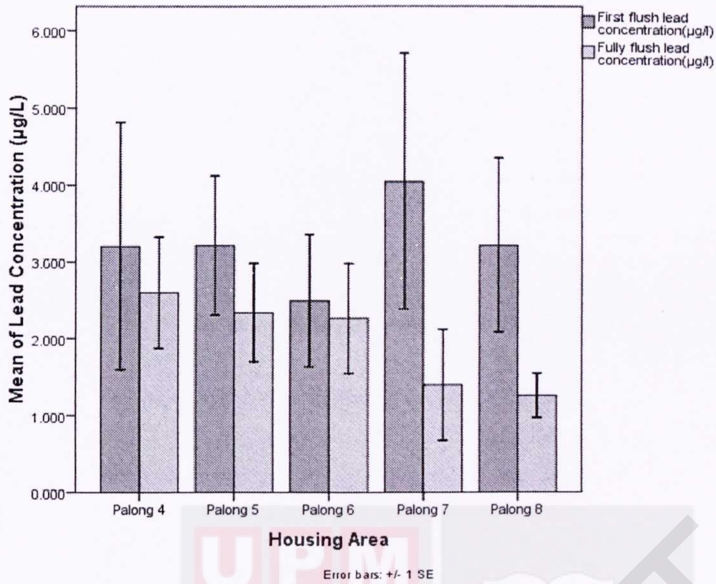

Figure 4.1: Mean and standard error for lead concentration in first flush and fully flush water sample by housing area

Figure 4.2 until Figure 4.7 showed the distribution of lead concentration in each sampling locations through Inverse Distance Weight (IDW) interpolation of Spatial Analyst GIS. High concentration was indicated by red colour whereas low concentration was indicated by the green colour.

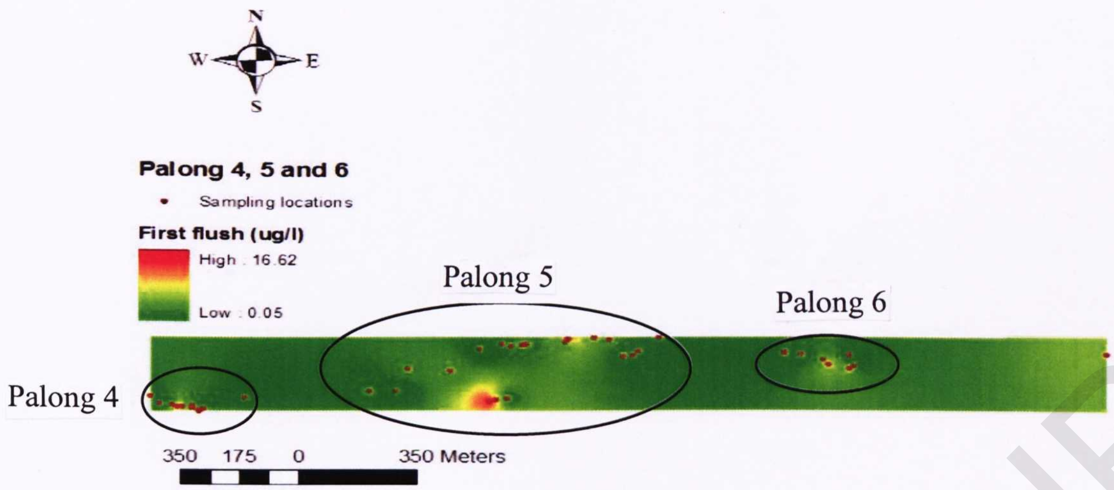

Figure 4.2 : GIS coordinates of lead level in first flush water samples at Felda Palong 4, 5 and 6

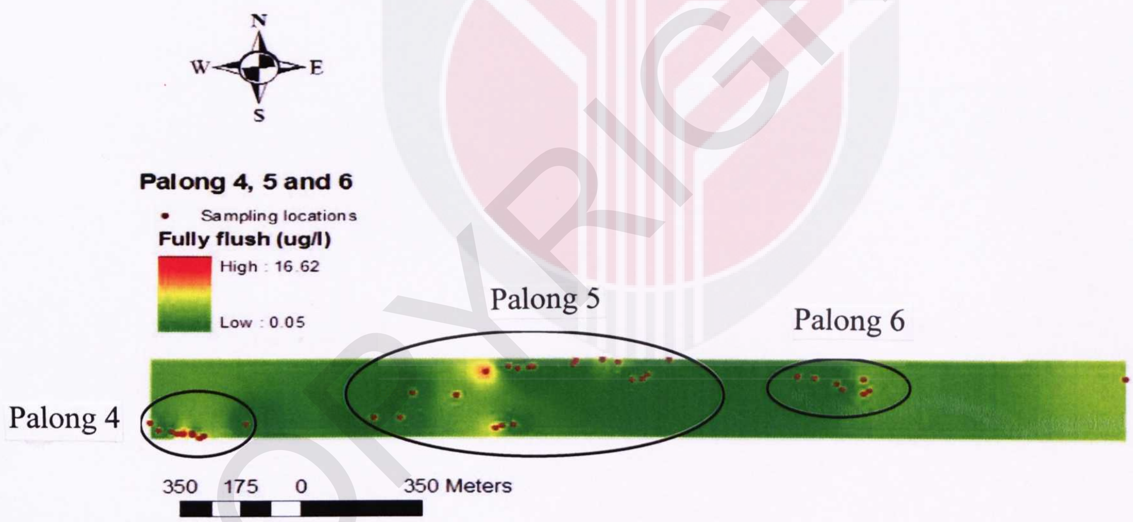

Figure 4.3 : GIS coordinates of lead level in fully flush water samples at Felda Palong 4, 5 and 6

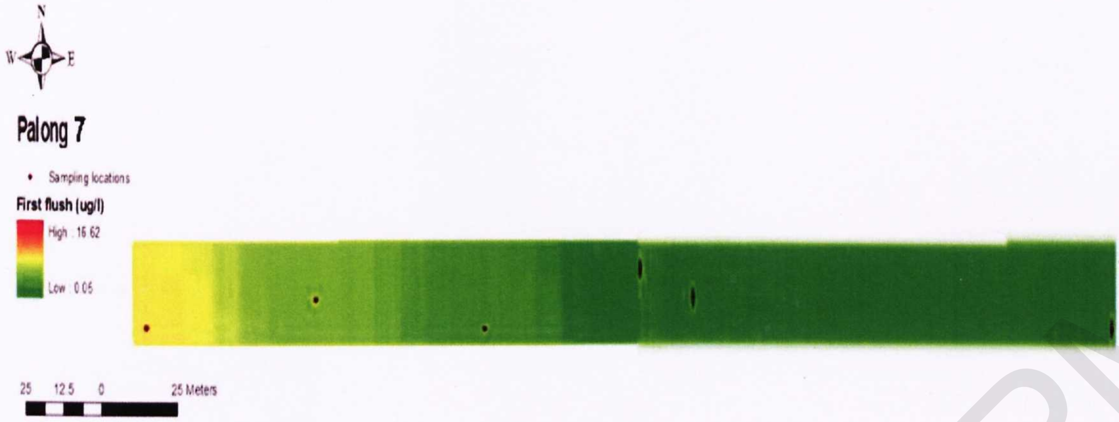

Figure 4.4 : GIS coordinates of lead level in first flush water samples at Felda Palong 7

Figure 4.5 : GIS coordinates of lead level in fully flush water samples at Felda Palong 7

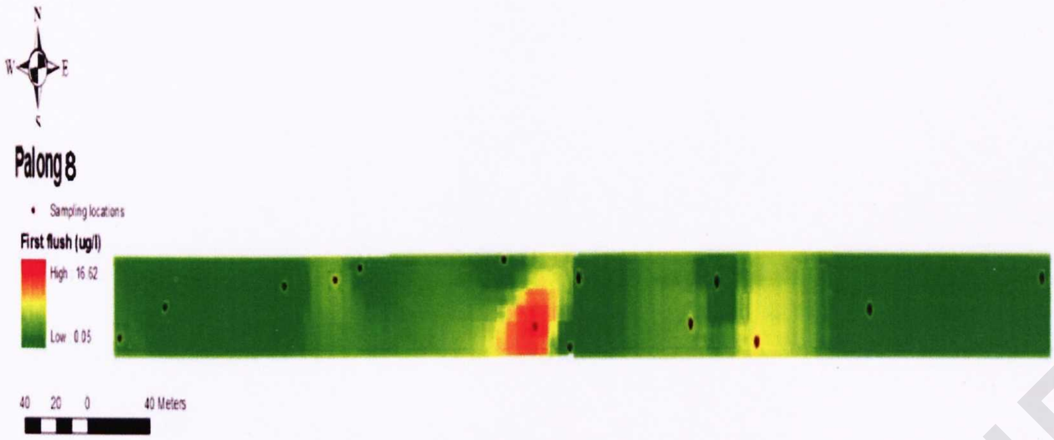

Figure 4.6 : GIS coordinates of lead level in first flush water samples at Felda Palong 8

Figure 4.7 : GIS coordinates of lead level in fully flush water samples at Felda Palong

4.3 Comparison of lead concentration and pH in water sample with available water standard

According to the Malaysia National Standards for Drinking Water Quality (NSDWQ) developed by Ministry of Health, the permissible limit value for lead concentration in drinking water is 10 μg/L.

Figure 4.8 showed that from 60 first flushed water samples, 6 samples had exceeded the drinking water quality standards. Samples exceeded were from Palong 4 (16.62 μg/L, 10.49 μg/L), Palong 5 (14.27 μg/L, 12.89 μg/L), Palong 7 (13.81 μg/L) and Palong 8 (13.85 μg/L). For the fully flushed water samples, none of the sample exceeded the permissible limit value (Figure 4.9).

For pH, the acceptable value for drinking water was ranged from 6.5 to 9.0 according to the drinking water quality standards developed by Ministry of Health. There were 8 fully flushed water samples which exceeded the recommended pH value for drinking water. The samples were collected from Palong 4 (6.45), Palong 5 (range was 6.27 to 6.48) and Palong 8 (6.38).

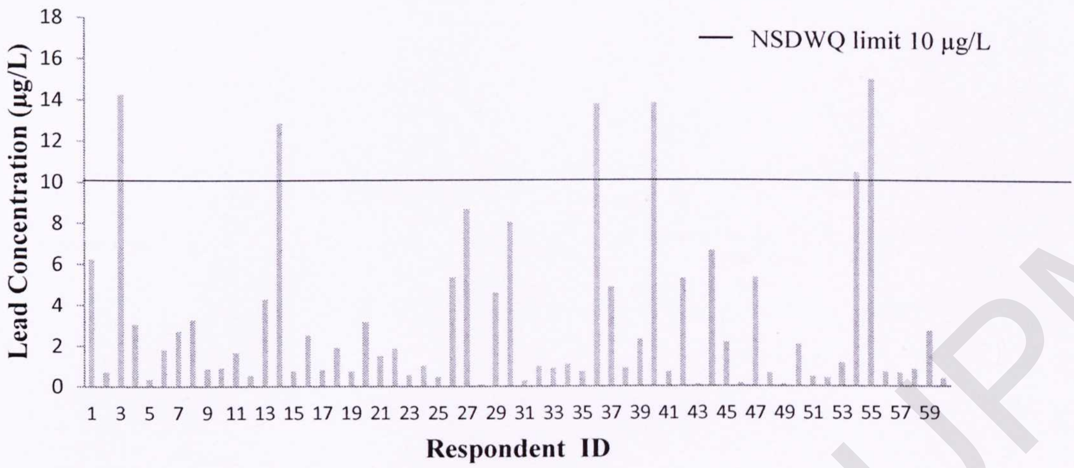

Figure 4.8: Comparison of lead concentration in first flushed water sample with Malaysia National Standards for Drinking Water Quality (NSDWQ).

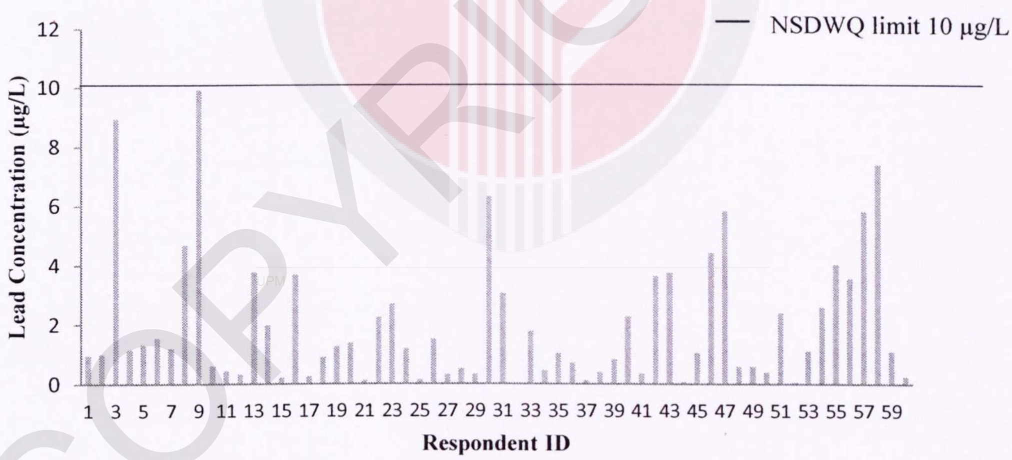

Figure 4.9: Comparison of lead concentration in fully flushed water sample with Malaysia National Standards for Drinking Water Quality (NSDWQ).

4.4 Correlation of lead concentration with pH of water sample

A correlation test is a test used to describe the degree of relationship between two variables. Shapiro-Wilk Test was used for the normality test. It showed that the p-value was less than 0.05, which indicated that the distribution was not normal.

Since the data was not normally distributed, the Spearman Rank Order Correlation test was used to determine the degree of relationship between the two variables.

Table 4.4 showed the result of the correlation test of lead concentration with pH of water sample. The test showed no significant correlation between lead concentrations in first flushed and pH of water sample and the same result goes for fully flushed water samples which showed no significant correlation between lead concentrations in fully flushed water samples and pH.

Table 4.4: Relationship of lead concentration and pH in water sample

	Variable	r	p
pH vs Lead Concentration	Lead in first flush water sample	-0.065	0.622
	Lead in fully flush water sample	-0.079	0.549

N=60, Significant value at $p<0.05$

4.5 Comparison of lead concentration in first flushed and fully flushed water sample

First flushed water samples were taken from the very first drop of water from the kitchen tap after overnight of stagnation while fully flushed water samples were taken from tap after 3 minutes of flushing.

To determine the differences of lead concentration in first and fully flushed water samples, Wilcoxon Signed-Rank Test was used. This non-parametric test was chosen because the lead concentration in first flushed and fully flush of water sample were not normally distributed.

According to Table 4.5, Thirty-nine (39) of the samples have higher lead concentration in the first flushed while 21 of the samples have higher lead concentration in the fully flushed. For the Wilcoxon Signed Ranks Test, the results showed that there was a significance difference between lead concentration levels of first flush and fully-flush water sample with Z-value of -2.15 and p-value of 0.032 ($p < 0.05$).

Table 4.5: Comparison of lead concentration in first and fully flushed water sample

Pair	Rank	N	Mean rank	Sum of ranks	Z	p-value
Lead concentration	-ve rank	39[a]	31.0	1210		
(first flush – fully flush)	+ve rank	21[b]	29.7	623		
	Ties	0[c]			-2.15[d]	0.032
	Total	60				

N=60, Significant value at $p<0.05$

a. Lead concentration (fully flushed < first flushed)
b. Lead concentration (fully flushed > first flushed)
c. Lead concentration (fully flushed = first flushed)
d. Based on positive rank

4.6 Exposure assessment

Table 4.6 showed the results daily water intake, body weight and chronic daily intake (CDI) of respondents. For daily water intake, the mean ± SD were 1.57 ± 0.92 L/day, while the range was from 0.4 L/day to 4.5 L/day.

The mean ± SD body weight of respondent were 63.85 ± 14.35 kg. The range of respondent's body weight was from 34 kg to 100 kg.

The CDI value was calculated using equation 2 that was stated earlier in Chapter 3. The mean ± SD of CDI were 0.146 ± 0.203 and the range was from 0.01 to 4.5μg/kg/day.

Table 4.6: Water Daily Intake (DI), Body weight (W) and CDI of respondent

	DI (L/day)	W(kg)	CDI (μg/kg/day)
Mean	1.57	63.85	0.146
Median	1.300	61.00	0.0692
SD	0.92	14.35	0.203
Min	0.4	34.00	0.006
Max	4.5	100.00	0.934

N=60

4.7 Risk assessment

To estimate non-carcinogenic risk, hazard index (HI) was calculated by dividing the CDI value with reference dose (RfD). A hazard index greater than 1 indicates potential for an adverse effect to occur. Table 4.7 showed the results of hazard index calculation of respondents. The range of hazard index was from 0.002 to 0.267, while the mean ± SD value were 0.0417 ± 0.0579, and the median value was 0.0198. As showed a Table 4.7, all the respondents had the hazard index of less than 1 which indicated that the risk was acceptable.

Table 4.7: Hazard Index (HI) of respondent

HI	Frequency	%	Mean ± SD	Med(IQR)	Range
<1	60	100	0.042 ± 0.058	0.02(0.04)	0.002-0.27
>1	-	-	-	-	-

N=60

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

5.1.1 Socio-demographic data of respondent

According to the result summarized in Table 4.1, the aged of respondent ranged from 18 to 66 years old, with mean ± SD of 50 ± 14. The highest age group of respondent were 40 years old and above which 45 (75%) of respondents. Majority of the residence in Felda Palong were felda settlers whereas the young generation have moved to the town to work or to further their study.

In this study, all respondent were Malay (N=60). This was in line according to Zulkifli et al., (2010) which stated that the largest ethnic among Felda settlers were Malays.

Table 4.1 showed majority of the respondent had an income between RM 750 to RM 1999 per month. This was the allowance range paid by FELDA Plantation to each felda settlers every month. The salary for felda settlers were different based on the commodity in that area. For example, Felda Palong 4, 5 and 6, received RM 1500 per month based on profit of palm oil production while Felda Palong 7 and 8, received RM 1300 per month based on profit of rubber production. Meanwhile, for respondents with income RM 2000 and above, they got the side income from their own businesses.

5.1.2 Lead concentration and pH of water sample

The mean ± SD for lead in first flush water sample in this study was 4.05 ± 4.70 µg/L (Palong 7), 3.26 ± 3.95 µg/L (Palong 5), 3.22 ± 4.09 µg/L (Palong 8), 3.21 ± 5.34 µg/L (Palong 4) and 2.50 ± 2.59 µg/L (Palong 6). The highest mean of lead concentration in first flush water sample was in Palong 7. These were slightly lower than most of the lead detected in previous studies. Zietz et al., (2007) indicated the mean lead concentration for first flush water sample in district of Lower Saxony, Germany was 4.1µg/L.

The mean ± SD concentration for lead in fully flushed water samples in this study were 2.60 ±2.42 µg/L (Palong 4), 2.34 ± 2.80 µg/L (Palong 5), 2.26 ± 2.14 µg/L (Palong 6), 1.40 ± 2.04µg/L (Palong 7), and 1.26 ± 1.04µg/L (Palong 8). The highest concentration of lead in fully flushed water was in Palong 4. However, these values were still lower compared to a study by Rajaratnam et al., (2002) in a suburban area of Sydney (3.7 µg/L).

The mean ± SD of pH in this study were 6.86 ± 0.43, considered as neutral. Other studies, for example Deshommes et al., (2010) indicated the mean water sample was high as 7.65 (slightly basic).

5.1.3 Comparison lead concentration and pH in water sample with available water standard

Only 10% of the water samples exceeded the National Standard for Drinking Water Quality (NSDWQ) Ministry of Health Malaysia (10 ug/L). They were in Palong 4 (16.62 μg/L, 10.49 μg/L), Palong 5 (14.27 μg/L, 12.89 μg/L), Palong 7 (13.81 μg/L) and Palong 8 (13.85 μg/L). This is probably due to the used of metal and PVC pipes for their household water distribution system.

According to the Canadian Ministry of Health, (2009), the usage of metal pipes such as lead, copper and galvanized pipes were the factors contributed to the presence of lead in water, meanwhile, PVC pipes also can be a potential source of lead due to the using of stabilizers containing lead compounds. High concentration of lead in first flushed water sample most probably due to the corrosion of pipes and when it get contact with the water.

Even though lead concentration in this study exceeded the permissible limit value, but the value can be considered as low compared to other previous studies. For example, Zietz et al. (2007) and Rajaratnam et al. (2002) found high concentration of lead in their water samples; 62.1 μg/L and

64 μg/L respectively. These studies were conducted in suburban area. The huge difference of lead concentration in this study may be related to the age of piping system and stagnation time of water in the pipe which is the older of piping systems and the more long stagnation time will contribute to the high concentration of lead in water samples.

As for fully flushed water sample, none of the samples were exceeded the permissible limit value. Fully flushed water samples represent water samples that come from public water distribution systems to resident's house. Since, fully flushed water samples did not exceed the permissible limit value, this indicated that there were low lead contamination from the public water distribution system. However, study conducted by Zietz et al. (2001) had showed that 2.1% from of 1474 fully flushed water samples had reading above the permissible limit of World Health Organization (10 ug/L) in Germany.

The standard pH value for water is from 6.5 to 9.0 (Malaysia Ministry of Health, 2009). However, the pH values of 13% water sample were not between the acceptable range (6.27 to 6.48). This situation occurred because of the low level of calcium carbonate that was added in water during water treatment process to raise the pH (Swistock and Sharpe, 1994). But, these pH values are almost neutral pH, and can considered as safe for drinking water usage.

5.1.4 Correlation of lead concentration with pH of water sample

The lead corrosion in pipes is strongly dependent on pH, increasing at low pH values and decreasing as pH increased (Kim et al., 2011) and lead concentrations can be considerably higher at lower pH values (<7) (IWA, 2010).

According to the result mentioned in Table 4.5, there was no significant correlation between lead concentration and pH of water samples. Therefore, the initial hypothesis in this study that there is a significant relationship between lead concentration and pH of water sample was rejected.

This was consistent with the study done by Le et al. (2003). However, findings in the study conduct by Kim et al. (2011) found low correlation between lead concentration and pH of water sample.

5.1.5 Comparison of lead concentration in first flushed and fully flushed water sample

Results in Section 4.5 have indicated that first flushed water samples have higher lead concentration compared to the fully flushed water samples. There was a significant difference between lead concentration in first flushed and fully flushed of water sample with z-value -2.15 and p-value 0.032.

This was consistent with the Kim et al. (2011) and Rajaratnam et al. (2002) studies. High concentration of lead in first flushed may be due to the standing time of water in the pipe, while the low concentration of lead in fully flushed water samples may be due to the time of water contact with public piping systems are less because the water is always running and the efficiency of water treatment activity. Deshommes et al. (2010) and Lasheen et al. (2008) have reported that the concentration of lead will increase with stagnation time. This is when the water standing in lead pipes for many hours and get contacted with the plumbing system.

5.1.6 Exposure assessment

The exposure assessment in this study was calculated as chronic daily intake (CDI). CDI was calculated based on the equation 2 for each participant. The daily water intake, body weight and total lead concentration were used to calculate this value. Results of CDI were then used to calculate the hazard index.

According to USEPA, the average drinking water intake daily for adult is 2 L/day. The average drinking water intake daily in this study was 1.57 L/day (see Table 4.7) slightly lower than the USEPA average. However, this was consistent with drinking water consumption amounts obtained in previous studies such as in Fertmann et al. (2004) and Ryan et al. (2000). Low drinking water intake in this study was influenced by the seasonal or weather patterns. According to Sharrett et al. (1982), the daily drinking water intake was high during hot season (summer). Water sampling in this study was done in the raining season in December, thus this has influenced the water intake.

The average chronic daily intake (CDI) of this study was 0.146 with the range of from 0.01 to 0.934 µg/kg/day.

5.1.7 Risk assessment

Hazard index (HI) is used to determine the risk of exposure each participant. HI greater than one indicate a potential of adverse effect to human health to occur (Kavcar et al., 2009).

Hazard index is calculated based on the equation 3 stated in Chapter 3. The reference dose in this study used the value of Provisional Weekly Tolerable Intake (PWTI) by FAO/WHO Expert Committee on Food Additive (JECFA) since there is no reference dose proposes by the USEPA (1989).

The average of HI value in this study was range from 0.002 to 0.26, less than 1. This suggested that lead exposure in drinking water of FELDA Palong residents considered as low and the risk was acceptable.

5.2 Conclusion

In conclusion, only 10% of water samples in this study have lead concentration above the upper limit of Malaysia National Standards for Drinking Water Quality (NSDWQ) for first flushed water and none of the fully flushed water samples violated the limit value. Finding in this study showed that the concentration of lead was not related to the pH of water sample, and the lead concentrations in first flushed has significantly higher than fully flushed of water samples. As for calculation health risk assessment among Felda Palong residents, the hazard index showed that the non-carcinogenic risks of lead exposure in drinking water among Felda Palong residents were acceptable.

5.3 Recommendation

The results of this study are relevance for preventive measures in several aspects. In order to reduce the exposure of lead in drinking water among community, the roles of all related agencies as well as the community itself are very important.

Agencies such as State Water Supply Department and District Health Office are responsible to manage and check the quality of water. They need to perform periodic monitoring of water quality at each the residence house, as well as at the water treatment plant.

Besides that , lead prevention programme can be organize by the Ministry of Health and District Health Office by identify and carry out full replacement of all lead plumbing systems for residence house who still used that type of pipe for their household water distribution system. This is the only permanent solution in order to eliminate lead contaminant in drinking water, but it is quite costly.

The collaboration between Ministry of Health, District Health Office and mass media also play an important role in order to increase the awareness among public towards safe drinking water. By doing that, the related health information may be received to the public in various medium such as through pamphlet, poster, television advertisement and health campaign or health talk.

Nowadays, more and more communities are concerned about health risks posed by contamination of contaminants in their drinking water. Preventive health behaviour is one such measure to reduce lead exposure in drinking water. In practice, flushing household water supplies for 2 min after prolonged standing can effectively reduce lead contamination levels well below NDWQS guideline values. Moreover, the home owner itself need to take care of the plumbing system such as be carefully considered during choosing the type of pipe materials used for their household water distribution networks, and alert about their household piping system status like the type of piping used and age of that pipe.

For future studies, larger numbers of participants are required in order to generalize the study finding for the specific population. Besides that, they need to consider the other physical properties of water such as temperature and conductivity which also influence the presence of lead in drinking water. The comparison in exposure of lead in drinking water between rural and urban area also can be done since no such study have been conduct in our country.

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APPENDICES

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

BORANG PERSETUJUAN RESPONDEN

RESEARCH TITLE : Kajian Risiko Kesihatan Terhadap Pendedahan Plumbum didalam Air Minum di Kawasan Felda Palong, Negeri Sembilan

RESEARCHER : NOR ZAHIDAH BINTI ZUKFALI

Saya...No.K/P...............................
Alamat...
bersetuju untuk menyertai kajian bertajuk seperti di atas.

Saya telah membaca dan memahami isi kandungan kajian berdasarkan apa yang telah dinyatakan di dalam 'PENERANGAN KEPADA PESERTA' yang telah dilampirkan bersama surat kebenaran ini dan penerangan tambahan daripada penyelidik.

Saya faham bahawa kajian ini dijalankan untuk mengenalpasti risiko kesihatan terhadap pendedahan plumbum di dalam air minum di kawasan Felda Palong, Negeri Sembilan.

Saya juga faham bahawa segala maklumat yang diberikan dan segala keputusan yang saya perolehi adalah sulit dan hanya akan digunakan untuk tujuan penyelidikan dan rujukan penyelidik.

Saya juga faham bahawa maklumat ini boleh digunakan untuk penerbitan tetapi setiap individu tidak akan dinyatakan identitinya.

Saya faham bahawa saya mempunyai hak untuk menarik diri dan juga mempunyai hak untuk menarik semula keizinan pada bila-bila masa sekiranya perlu apabila merasa tidak selesa pada mana-mana ujian atau aktiviti yang dijalankan oleh penyelidik semasa kajian dijalankan dan tiada sebarang tindakan boleh dikenakan ke atas saya atas tindakan tersebut.

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FACULTY OF MEDICINE AND HEALTH SCIENCES
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SELANGOR, MALAYSIA

Tandatangan ……..…………………………… (*Responden*)

Tandatangan……..………………………… (*Saksi*)

Tarikh :………………………………….…..

Nama…………………………………

No. K/P :…………………………………...

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

Tarikh ……..…………………………

Tandatangan ……..…………………………… (Researcher)

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UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG, SELANGOR, MALAYSIA

PENERANGAN KEPADA PESERTA

TAJUK KAJIAN:

Kajian Risiko Kesihatan terhadap Pendedahan Plumbum di dalam Air Minum di Kawasan Felda Palong, Negeri Sembilan

Terima kasih kerana membantu kami di dalam kajian ini.

1. Apakah kajian ini?

Kajian ini adalah berkaitan dengan risiko kesihatan terhadap air minum kalangan responden. Kandungan plumbum dalam air minum boleh menyebabkan kesan kesihatan seperti hilang daya ingatan, kerosakan buah pinggang serta penyebab kepada pencapaian IQ yang rendah terutamanya dikalangan kanak-kanak.

2. Apakah tujuan kajian ini?

Kajian ini dijalankan bertujuan untuk mengkaji risiko kesihatan terhadap pendedahan plumbum di dalam air minum di kalangan penduduk Felda. Kajian ini menentukan sama ada penduduk terdedah atau tidak.kepada risiko kesihatan disebabkan pendedahan plumbum dalam air minum.

3. Berapa ramai responden yang terpilih?

Responden akan dipilih dari kalangan penduduk Felda Palong, Negeri Sembilan. Seramai 100 orang responden akan dipilih untuk kajian ini.

4. Apakah jenis ujian yang akan dijalankan?

Semua responden akan diberikan borang soal selidik untuk diisi sendiri oleh responden. Selain daripada itu, sampel air minum dari pili air di bahagian dapur akan diambil bagi proses analisis sampel air. Berat badan respondent serta pengambilan air minum bagi sehari untuk setiap respondent akan dicatat oleh pengkaji.

5. Adakah bayaran dikenakan?

Pengkaji akan menanggung segala pembiayaan ujian yang akan dijalankan dan tiada sebarang bayaran dikenakan terhadap setiap responden.

6. Adakah maklumat dijamin sulit?

Semua maklumat yang diberikan oleh responden di dalam borang kaji selidik adalah dijamin sulit. Tiada huraian individu akan dibuat pada mana-mana bahagian di dalam kajian atau penerbitan.

7. Adakah hak anda?

Kajian ini melibatkan anda secara sukarela. Oleh itu, peserta mempunyai hak untuk menarik diri dari penyertaan dalam kajian ini pada bila-bila masa sekiranya peserta merasa tidak selesa untuk memberikan maklumat kepada pengkaji.

8. Apakah yang harus anda lakukan?

Anda dikehendaki menandatangani borang penyertaan responden yang menyatakan minat anda untuk menyertai kajian ini. Ianya boleh dilakukan setelah anda membaca dan memahami isi kandungan penerangan ini. Borang penyertaan responden haruslah dikembalikan kepada penyelidik sebelum ujian dijalankan. Sekiranya anda mempunyai sebarang kemusykilan, penyelidik akan membantu untuk memberi maklumat yang selanjutnya.

Terima kasih atas kerjasama dan bantuan anda.

NOR ZAHIDAH BINTI ZUKFALI

Penyelidik

B. Sc. Kesihatan Persekitaran dan Pekerjaan

Jabatan Kesihatan Persekitaran dan Pekerjaan

Fakulti Perubatan dan Sains Kesihatan

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nailozar_zindex@yahoo.com

Semua maklumat adalah untuk kegunaan kajian sahaja dan maklumat ini akan dianggap sulit.

Arahan : Sila jawab semua soalan pada bahagian yang disediakandan tandakan √ pada soalan yang berkenaan

Bahagian A: Maklumat respondent

Nama : ______________________________

Alamat : ______________________________

____

1. Umur : ☐☐ tahun
2. Jantina : ☐ Lelaki ☐ Perempuan

3. Bangsa : ☐ Melayu ☐ Cina

   ☐ India ☐ Lain-lain,sila nyatakan________

4. Berapakah berat badan anda?

   __________kg

5. Tahap pendidikan tertinggi anda?

☐ Tidak bersekolah ☐ Sekolah Rendah ☐ SRP/PMR

☐ SPM ☐ STPM/Diploma ☐ Ijazah

6. Berapakah pendapatan anda sebulan?

   ☐ <RM750 ☐ RM750-RM1500

   ☐ RM1501-RM2500 ☐ >RM2500

Bahagian B: Maklumat Penggunaan Air Paip

7. Apakah punca air paip di rumah anda?

☐ Jabatan Bekalan Air ☐ Telaga

☐ Lain-lain,sila nyatakan________________

8. Berapa gelaskah air yang anda minum dalam sehari?

   ________________ gelas(200ml)

9. Penggunaan air dari dapur adalah untuk:

   ☐ Air minum ☐ Memasak ☐ Kegunaan domestic

   ☐ Lain-lain,sila nyatakan ________________

10. Adakah anda berpuas hati dengan kualiti air paip yang digunakan?

    ☐ Ya ☐ Tidak ☐ Tidak pasti

Bahagian C: Tempat kediaman

11. Adakah terdapat kawasan perindustrian berdekatan dengan tempat kediaman anda?

    ☐ Ya ☐ Tidak

12. Apakah jenis paip yang digunakan di rumah anda?

    ☐ Logam ☐ PVC ☐ Tidak pasti

13. Bilakah rumah ini dibina?

- [ ] 2001-2011
- [ ] 1990-2000
- [ ] 1981-1991
- [ ] Sebelum 1980
- [ ] Tidak pasti

Bahagian D : Maklumat kesihatan

14. Adakah anda merokok?

- [ ] Ya,sila nyatakan berapa batang dalam sehari : _____batang
- [ ] Tidak

15. Adakah seringkali anda bersifat pelupa?

- [ ] Ya
- [ ] Tidak

Terima kasih atas kerjasama anda.

TAMAT