



UNIVERSITI PUTRA MALAYSIA

***RISK ASSESSMENT OF LEAD (Pb) EXPOSURE THROUGH TAP WATER
AMONG RESIDENTS OF FELDA JENDERAK SELATAN IN TEMERLOH,
PAHANG.***

**BY
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ABSTRACT

RISK ASSESSMENT OF LEAD (Pb) EXPOSURE THROUGH TAP WATER AMONG RESIDENTS OF FELDA JENDERAK SELATAN IN TEMERLOH, PAHANG.

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This cross sectional study was conducted at Felda Jenderak Selatan, Pahang. The main objective of this study was to determine the risk of exposure to lead in tap water among selected residents of Felda Jenderak Selatan. A total of 99 respondents that fulfilled the inclusive and exclusive criteria were selected. The type of sampling that being used was quota sampling method. The concentration of lead in water samples collected was analysed using graphite furnace atomic absorption spectrometer. Body weight of the respondents was taken by using Tanita digital weight scale. The results showed mean value for lead concentration in first flushed water samples was 4.51 $\mu\text{g/L}$ while for lead concentration in fully flushed water samples was 4.03 $\mu\text{g/L}$. Based on the results, there was no significance difference between lead concentration in first flushed and fully flushed samples. There was a significance difference between concentration of lead in water samples and National Drinking Water Quality Standard. In addition, there was no significance relationship between lead concentration and pH of the water samples. The value of hazard index was less than 1. As a conclusion, this study may suggest possibility of the respondents to get adversely health effects from exposure towards lead was negligible.

Keywords: Lead concentration, pH, hazard index, first flushed water samples, fully flushed water samples.

ABSTRAK

**PENILAIAN RISIKO PENDEDAHAN PLUMBUM (Pb) MELALUI PAIP AIR
DIKALANGAN PENDUDUK FELDA JENDERAK SELATAN DI
TEMERLOH, PAHANG.****Mohd Faizal, R., Shaharuddin M.S, & Ahmad Zaid Fattah, A.***Jabatan Kesihatan Persekitaran dan Pekerjaan, Fakulti Perubatan dan Sains
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Kajian keratan rentas ini telah dijalankan di Felda Jenderak Selatan, Pahang. Objektif utama kajian ini adalah untuk menentukan risiko pendedahan kepada plumbum di dalam air paip dikalangan penduduk Felda Jenderak Selatan. Seramai 99 orang responden yang memenuhi kriteria-kriteria yang ditetapkan telah dipilih. Kaedah yang digunakan untuk memilih responden adalah kaedah persampelan kuota. Kepekatan plumbum di dalam sampel air yang diambil dari rumah responden telah dianalisis dengan menggunakan Spektrometer Penyerapan Atom. Berat badan responden telah ditimbang menggunakan mesin timbang digital Tanita. Keputusan menunjukkan nilai min bagi kepekatan plumbum di dalam sampel air jirusan pertama adalah 4.51 $\mu\text{g/L}$ manakala bagi kepekatan plumbum di dalam sampel air jirusan penuh adalah 4.03 $\mu\text{g/L}$. Berdasarkan kepada keputusan, tiada perbezaan signifikan antara kepekatan plumbum di dalam sampel air jirusan pertama dan sampel air jirusan penuh. Terdapat perbezaan signifikan antara kepekatan plumbum dalam sampel air dan piawaian. Selain itu, tiada hubungan signifikan antara kepekatan plumbum dengan nilai pH sampel air. Nilai indeks bahaya adalah kurang dari 1. Sebagai kesimpulan, kajian ini menyatakan bahawa kebarangkalian responden untuk mendapat kesan buruk terhadap kesihatan disebabkan pendedahan kepada plumbum boleh diabaikan.

Kata kunci: kepekatan plumbum, indeks bahaya, pH, sampel air jirusan pertama, sampel air jirusan penuh.

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LIST OF TERMS

%	Percentages
°C	degree Celsius
±	plus minus
µg	microgram
µg/L	microgram per litre
µg/m ³	microgram per cubic metre
cm	centimetre
g/cm ³	gram per cubic centimetre
mA	miliampere
mg/kg	milligram per kilogram
ml	millilitre
mL/min	millilitre per minute
nm	nanometre
sec	second
AAP	American Academy of Pediatrics

ADHS	Arizona Department of Health Services
AECLP	Alliance to End Childhood Lead Poisoning
ATSDR	Agency for Toxic Substances and Disease Registry
DMTE	Department of Materials Testing and Evaluation
DNA	Deoxyribonucleic acid
ED	Exposure duration
FELDA	Federal Land Development Authority
HDPE	High density polyethylene
HI	hazard index
HSDB	Hazardous Substances Data Bank
HSE	Health and Safety Executive
IARC	International Agency for Research on Cancer
ILA	International Lead Association
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LADD	lifetime average daily dose
LT	Life time
MOH	Ministry of Health

NDWQS	National Drinking Water Quality Standards
NJDHSS	New Jersey Department of Health and Senior Services
NRC	National Resources Canada
NTP	National Toxicological Program
pH	potential hydrogen
PMR	Penilaian Menengah Rendah
PWTI	provisional tolerable weekly intake
RfD	reference dose
RM	ringgit malaysia
SPM	Sijil Pelajaran Malaysia
UNEP	United Nations Environment Programme
USDHUD	U.S. Department of Housing and Urban Development
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Introduction:

Good drinking water quality is essential for the well being of all people. In the last 20 years, many people have suffered from diseases that led to serious studies to find out the relationship between drinking water and chronic diseases. The chemistry of drinking water commonly has been cited as an important factor in many diseases (Salem et al., 2000). Nowadays, there are many contaminants in our drinking water. Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have found their way into water supplies as a result of inadequate treatment and disposal of waste (human and livestock), industrial discharges, and over-use of limited water resources (Singh et al., 2003). Some of the contaminants are made up from metal based such as aluminium and lead. Lead (Pb) exposure through drinking

water accounts on average for 20% of total lead exposure in the United States (US) (USEPA, 2005).

Lead is a metal that looks bluish gray in colour. It is found in the earth's crust in small amounts. It doesn't really have an odour or a taste (ATSDR, 1990). Lead, a metal found in natural deposits, is commonly used in household plumbing materials and water service lines. Lead is rarely found in source water, but enters tap water through corrosion of plumbing materials (USEPA, 2009).

Lead in drinking water can also cause a variety of adverse health effects. Recent cases of childhood lead poisoning, in Washington DC, Greenville North Carolina and Durham North Carolina were tied to lead particles in tap water (Triantafyllidou et al., 2009). In babies and children, exposure to lead in drinking water above the action level of lead (0.015 milligram per litre) can result in delays in physical and mental development, along with slight deficits in attention span and learning abilities. Adults who drink this water over many years could develop kidney problems or high blood pressure (USEPA, 2009).

1.2 Problem Statement

Lead is mostly used to make batteries. It is also used to make ammunition (bullets) and pipes, and roofing materials. It was used in the past to make paint and gasoline (ATSDR, 1993). Due to its widespread use, lead is commonly found in the air, food, soil and water. According to the U.S. Environmental Protection Agency (USEPA), 80-90% of lead exposure comes from air, food and soil, while 10-20% comes from drinking water. Lead (Pb) particles that detach from the plumbing and contaminate drinking water can pose a significant health threat, which is often underestimated (Triantafyllidou et al., 2009).

In Europe several countries are known to have significant numbers of buildings with elevated lead tap water concentrations, for example, the United Kingdom (Watt et al., 1996), Austria (Haider et al., 2002) and Germany (Becker et al., 2001). The effects of lead are the same whether it enters the body through breathing or swallowing. The main target for lead toxicity is the nervous system, both in adults and children (ATSDR, 1998). If the level of lead in the body gets too high, it can cause headaches, tiredness, and irritability. Continued uncontrolled exposure could cause more serious symptoms includes kidney damage, nerve and brain damage, and infertility (HSE, 2009).

1.3 Study Justification

All water sources are dependent on rainfall. The total average annual rainfall was about 320cm for Peninsular Malaysia (MOH, 2001). State governments are responsible for water management including the gazetment of water catchments area. In the country, there are 56 water supply dams and only 11 dam catchments have been gazetted for water supply purposes (Raja, 2004). The main purpose of this research was to determine whether the water that is supplied to our home contains lead which is dangerous to our health.

Unfortunately in many countries around the world, including Ghana, some drinking water supplies have become contaminated, which has impacted the health and economic status of the populations (Akoto et al., 2007). Besides that, lead exposure accounts for about 1% of the global burden of disease and most exposure affects children in developing countries (WHO, 2004). From this research, we can know if our water supplies have become contaminated with trace metal such as lead. In addition, we can provide mitigation measures to avoid any diseases caused by lead that can hardly impact our health.

Throughout this study, the information that has been gathered can be used to improve water quality in our country. If the data that obtained was detrimental to community health, a larger scale of study could be done by the authority such as Water Supply Department of Malaysia so that the mitigating measures could be

initiated to ensure the quality of water that is supplied to the population was in a good level and not dangerous to our health.

Actually, it is quite difficult to find published studies in Malaysia that is related with this study. So, it's quite difficult to make comparisons and find the appropriate way to conduct this study. This is the first time the study regarding lead in water drinking has been conducted in a Federal Land Development Authority (FELDA) settlement. So, the data collected will be an initiator to other researcher who is interested to conduct further studies at a FELDA settlement.

1.4 Conceptual Framework

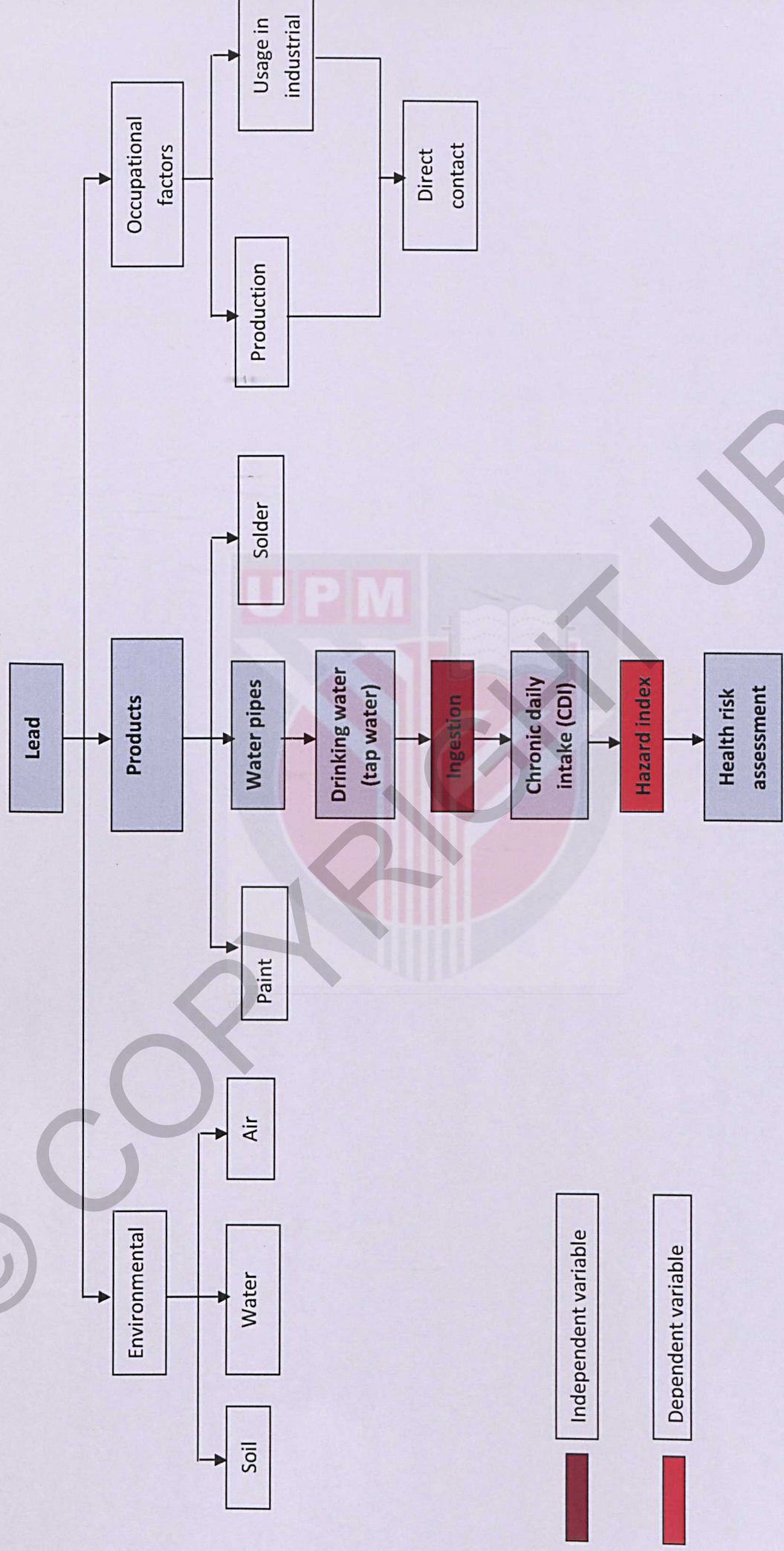


Figure 1.1: Conceptual framework

1.5 Definition

1.5.1 Conceptual definition

a) Risk assessment

Risk assessment is the process used to quantifying the risk of a person or individual get harmful from the human activities or exposures to certain element. It involved several steps which are hazard identification, exposure assessment, dose-response relationship and risk characterization (HSE, 2011).

b) Lead

Lead is a soft, blue-gray metal. It was dense and ductile metal. Lead exists in both organic and inorganic forms. Lead is very stable and resistant to corrosion, although acidic water may leach out of pipes, fittings, and solder. Lead is an effective shield against radiation. (ATSDR, 2010).

c) Tap water

Water drawn off through taps from pipes in a house, as distinguished from distilled water, mineral water, etc (HarperCollins Publishers, 2003).

1.5.2 Operational definition

a) Risk assessment

According to USEPA (1992), chronic daily intake (CDI) is suggested to estimate the exposure of individual to lead through ingestion as the exposure metric.

b) Lead

The concentration of lead in water has been determined by using Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) model Perkin Elmer Analyst 600 in the unit of $\mu\text{g/L}$.

c) Tap water

The tap water samples were collected from the kitchen tap using 250 ml high density polyethylene (HDPE) bottles. The two water samples were taken namely first flushed sample and fully flushed sample. First flushed sample was taken at the first draw of water that came out from a kitchen tap in the while fully flushed sample was taken from the kitchen tap after an estimated ten pipe volumes of water had been run off.

1.6 Objectives

1.6.1 General Objective:

To assess the risk of exposure to lead in tap water among residents of Felda Jenderak Selatan in Temerloh, Pahang.

1.6.2 Specific Objectives:

- i. To collect socio demographic data of respondents in Felda Jenderak Selatan.
- ii. To determine the concentration of lead in water supply.
- iii. To compare the concentration of lead in water supply with the National Drinking Water Quality Standard (NDWQS).
- iv. To determine the hazard index and chronic daily intake of each respondent.
- v. To compare the lead concentration between first flushed water and fully flushed water.
- vi. To determine the relationship of lead concentration with pH of the water samples.

1.7 Hypothesis

- i. There is a significance difference between concentration of lead in water samples and standard of concentrations of lead in water.
- ii. The value of hazard index among residents is more than 1.
- iii. There is a significance difference between lead concentration in first flushed water and fully flushed water samples.
- iv. There is a significance relationship between lead concentrations and pH of water samples.



CHAPTER 2

LITERATURE REVIEW

2.1 Lead

Heavy metals (elements with an atomic density greater than 6 g/cm^3) are one of the most persistent pollutants in water (Akor, 2010). Lead is the commonest of the heavy elements, accounting for 13 mg/kg of Earth's crust. Several stable isotopes of lead exist in nature, including, in order of abundance, ^{208}Pb , ^{206}Pb , ^{207}Pb and ^{204}Pb (WHO, 2011). The use of lead had reached such an impressive level by about 2,000 years before present (estimated at 550 grams per capita per year) that lead is oftentimes referred to as a "Roman metal" (Nriagu, 2009). Later, because of its malleability and resistance to corrosion, lead was used extensively by the Romans for water pipes, aqueducts, tank linings and cooking pots and then by ancient scientists in early cosmetics, paints and pigments, and in lead-rich glazes (ILA, 2011).

Lead is a heavy metal that cannot be created or destroyed. It has no role in the human body and is toxic. It has been released into the environment increasingly with industrialization and most dramatically, with intense industrial development. Most of the lead in the environment today is anthropogenic in origin (from activities of people) (AAP, 2003). Lead has been used for many products such as toys, water pipes, pottery, solder and other objects. This is due to its low melting point. Due to its virtues as a stable compound and lustre, it has been utilized extensively as a paint additive (Clay et al., 2006). Lead is rarely found in source water, but enters tap water through corrosion of plumbing materials. Very old and poorly maintained homes may be more likely to have lead pipes, joints, and solder (USEPA, 1999).

2.1.1 Physicochemical Properties of Lead

Elemental lead is an odourless, silver-bluish-white metal that is insoluble in water (Budavari et al., 1996). Lead sub acetate is a white heavy powder that is soluble in ethanol (HSDB, 2009). The physical properties of lead can be seen in Table 2.1 below;

Table 2.1: Physical information of lead (ATSDR, 2007).

Atomic number	82
Melting point	600.65 Kelvin
Boiling point	2013 Kelvin
Density	11350 kg m ⁻³

2.1.2 Major Uses

In worldwide metal use, lead ranks behind only iron, copper, aluminium, and zinc (Howe, 1981). Lead is used in the production of lead acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, ammunition, glazes and plastic stabilizers (WHO, 1989). Lead carbonate, lead fluoride, lead flu borate, and lead naphthenate are used as catalysts, with additional uses in the electronic and optical industries (lead fluoride), in coatings for thermo graphic copying (lead carbonate), as a curing agent for epoxy resins (lead flu borate), and as a varnish drier (lead naphthenate) (NTP, 2011). From a drinking-water perspective, the almost universal use of lead compounds is in plumbing fittings and as solder in water distribution systems of older systems (Quinn et al., 1990).

2.2 Source of Lead in the Environment

Lead occurs naturally in the environment. However, most of the high levels found throughout the environment come from human activities or anthropogenic sources. The other source of lead is natural sources.

2.2.1 Natural sources

Lead contents of waters are generally low, but significant amounts of lead-rich dusts and vapours are carried in the air, from windblown material and volcanoes.

According to Richardson et al. (2001), the average global lead concentration in soil is reported to be 22 mg/kg and the total emissions from natural sources was estimated at 220,000 to 4,900,000 tons per year. Lead is found at low concentrations in the earth's crust predominantly as lead sulfide (IARC, 2011).

2.2.2 Anthropogenic sources

The single largest use of lead worldwide is for lead-acid batteries, which represents 75% of total western world lead use (NRC, 2001). The largest source of lead in the atmosphere has been from leaded gasoline combustion, but with the phase down of lead in gasoline, air lead levels have decreased considerably (ATSDR, 1997). Other airborne sources include combustion of solid waste, coal, and oils, emissions from iron and steel production and lead smelters, and tobacco smoke (ATSDR, 1992).

Lead can enter the environment through vehicle and industry exhausts and sewage sledge application in agriculture (Vogiatizis, 2001).

2.3 Exposure to Lead

There are several factors that human can be exposed to lead in their daily life such as environmental factors, occupational factors, and products factors. The National Institute for Occupational Safety and Health has estimated that more than

three million Americans potentially are occupationally exposed to some form of lead (Staudinger et al., 1998). For U.S. industries identified by the Occupational Safety and Health Administration as having significant airborne lead in the workplace, the mean concentration ranged from 165 $\mu\text{g}/\text{m}^3$ at secondary smelters to 200 $\mu\text{g}/\text{m}^3$ at storage-battery plants and brass, bronze, and copper foundries (Froines et al., 1990).

Furthermore, people are exposed to lead by eating food contaminated with lead or lead containing soils or dusts, by drinking contaminated water, by inhaling lead particles and by using consumer products that contain lead (Juberg et al., 2000).

The routes of environmental exposure to lead resulting in its absorption into the body are inhalation (with 30% to 50% of the inhaled dose absorbed into the bloodstream), ingestion (with 8% to 15% of the ingested dose absorbed into the bloodstream) and, to a limited extent, dermal contact (NTP, 2011). Absorption of lead is affected by age, the chemical form of the lead, and minerals in the diet (e.g., iron, calcium, and zinc) (ATSDR, 1999).

For young children, the most common source of environmental lead exposure is direct ingestion of paint chips and lead-laden dust and soil released from aging painted surfaces. These sources can contribute an additional daily intake of 5 μg for a toddler engaging in normal hand-to-mouth activity (Lanphear et al., 1998). Sources of drinking water also may be exposed to run off and other types of pollution from local farming operation (Atalay et al., 2008).

Besides that, lead poisoning also has been recognized due to its uses in piping systems and paints (Atalay et al., 2008). Industrial processes, particularly lead smelters, are now the primary source of lead emissions and accounted for more than 78% of emissions in 2001 (USEPA, 2003).

Lead also has been used as anti knocking agent in gasoline in the early 1980s which is released to the atmosphere as lead oxide which can cause brain damage which in turn lead to mental retardation and kidney failure (Sawyer et al., 1978).

2.4 Lead in Drinking Water

From a drinking-water perspective, the almost universal use of lead compounds in plumbing fittings and as solder in water distribution systems is important. Lead pipes may be used in older distribution systems and plumbing (Quinn et al., 1990). In drinking water supplies the intake of the toxic heavy metal lead is commonly due to metal corrosion in the peripheral water distribution system, especially the user's plumbing or lead service lines (Rebecca, 2010).

Although the main sources of exposure to lead are ingesting paint chips and inhaling dust, EPA estimates that 10 to 20 percent of human exposure to lead may come from lead in drinking water. Infants who consume mostly mixed formula can receive 40 to 60 percent of their exposure to lead from drinking water.

In Europe several countries are known to have significant numbers of buildings with elevated lead tap water concentrations, for example, the United Kingdom (Watt et al., 1996), Austria (Haider et al., 2002) and Germany (Zietz et al., 2007). Lead exposure from drinking water has been a topic of public health prevention programs in several parts of Germany (Fertmann et al., 2004).

Acidic water cause corrosion in pipelines and toxic metal formed in drinking water while alkaline water cause scaling and clogging of water pipes (Sawyer et al., 2008). The USEPA (2004) has set a range between 6.5 until 8.5 on the pH scale for the drinking water.

2.5 Health Effect

The International Agency for Research on Cancer (IARC) lists lead and inorganic lead compounds in Group 2B, or as possible human carcinogens, based on sufficient evidence of carcinogenicity in animal studies (IARC, 1987). Lead exposure has been associated with increased risk of lung, stomach, and urinary-bladder cancer in diverse human populations (Steenland et al., 2000). In most studies, lead caused micronucleus formation, chromosomal aberrations, and DNA damage (NTP, 2011). When lead is absorbed into the body, it can cause damage to the brain and other vital organs, like the kidneys, nerves, and blood (USDHUD, 2011).

2.5.1 Neurological effect

Lead is easily absorbed into growing bodies, interfering with the developing brain and other organs and systems (AECLP, 2011). In adults, high levels of lead can cause headaches and problems with mood, thinking, and memory. It may also damage peripheral nerves, which can cause tremors or weakness in fingers, wrists, or ankles (Van & Dosemeci, 2006).

Lead as a potent neurotoxin to the developing brain it produced behaviour disorders and neurochemical dysfunction (Khaled, 2009). A lead (Pb) is a neurotoxin agent, and even at low doses produces adverse effects on the developing central nervous system (CNS) (Antonio et al., 1999). Behavioural disorders and CNS biochemical dysfunction have been observed in lead exposed subjects (Cory, 1995).

2.5.2 Renal effect

The high blood lead levels in children body can cause renal effect to them. According to a study by UNEP (2011), the blood samples collected from the children also indicated a significantly high level of certain enzymes that collectively with other parameters or individually results in cellular damage in the body or the presence of a disease process affecting the liver. In addition from this study, high levels of creatinine in some children examined indicated the need of closer follow-up in order to determine the onset of renal dysfunction.

Chronic exposure to high concentrations of lead results in interstitial fibrosis, glomerular sclerosis, tubular dysfunction and, ultimately, in chronic renal failure (IARC, 2011).

2.5.3 Haematological effect

Gastrointestinal absorption of lead is greater in children than in adults, and once it is absorbed, lead is distributed to blood plasma, the nervous system, and soft tissues. It subsequently is redistributed and accumulates in bone; 75% to 90% of the lead body burden is found in bones and teeth (Hammad et al., 1996). Increased blood levels of lead have resulted in increased mortality rates from a variety of causes (Lustberg et al., 2002).

2.5.4 Endocrine effect

Lead (Pb) interferes with pituitary regulation of thyroid hormone production and secretion (Ashraf et al., 2009). Lead has been reported to enhance lipid peroxidation through inhibition of superoxide dismutase and other related enzymes (Gutierrez et al., 1998). In the haeme biosynthetic pathway, it inhibits δ -aminolevulinic acid dehydratase (also known as porphobilinogen synthase), probably through its high affinity for the zinc-binding site in the enzyme (IARC, 2011).

2.5.5 Reproductive effect

Studies on male lead workers have reported severe depression of sperm count and decreased function of the prostate and/or seminal vesicles at blood lead levels of 40 to 50 $\mu\text{g}/\text{dL}$ (USDHHS, 1993). Pregnant women exposed to lead levels of 10 - 15 $\mu\text{g}/\text{dL}$ can reduce the birth weight of infants and decrease their mental ability (ATSDR, 2001).

2.6 Exposure and Risk Assessment

Risk assessments are a systematic review of a chemical or an operation. It is conceded that the limitations of the risk assessment process must be understood; particularly a recognition that risk assessment is troubled by gaps in knowledge (Baron, 1992). The objective of risk assessment is to support decision making by assessing risks of adverse effects on human health and the environment from chemicals, physical factors, and other environmental stresses.

2.6.1 Hazard Identification

Hazard identification is the process of determining whether exposure to a chemical agent can cause an increase in the incidence of a particular adverse health effect (e.g., cancer, birth defects) and whether the adverse health effect is likely to occur in humans.

Lead in its solid metallic state would not normally present a hazard. However, lead is a toxic metal and may present a hazard via lead fumes when melted and/or from lead dust. Low concentrations of other various elements will be present, some as alloying constituents, others, as impurities. Oxidation of the surface of the lead will occur forming a surface layer of lead compounds. Furthermore, IARC has classified lead as probable human carcinogen based on sufficient evidence of carcinogenicity in animals and inadequate human data.

2.6.2 Dose-Response Assessment

Statistical evaluation of the dose-response function in lead epidemiology is rarely attempted (Stephen & Jesse, 2005). Dose-response assessment evaluates potential risks to humans at particular exposure levels. For oral dose, based on current science, an appropriate default option is to scale daily applied doses experienced for a lifetime in proportion to body weight raised to the 3/4 power (U.S. EPA, 1992b).

According to USEPA (1993), it is inappropriate to develop an RfD for inorganic lead because it appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. In general, the oral Reference Dose (RfD) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human

population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis and is expressed in units of mg/kg-day.

However, provisional tolerable weekly intake (PWTI) value developed by Joint FAO/WHO Expert Committee on Food Additives (JECFA) will be used as the reference dose for this study. The value of PWTI is 25 μg of lead per kg of body weight.

2.6.3 Exposure Assessment

Exposure assessment is the determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure (USEPA, 1992a).

An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed) (ATSDR, 2009). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

In this study, the route of exposure that will be considered was through ingestion only which is drinking water. When only oral ingestion was considered as the only route of exposure, exposure duration (ED) and life time (LT) may be omitted since they can be assumed to be equal.

2.6.4 Risk Characterization

The risk characterization process first summarizes findings on hazard, dose response, and exposure characterizations and then develops an integrative analysis of the whole risk case (USEPA, 2005).

Risk characterizations often must derive a best estimate of risk from multiple lines of evidence. These may include results of toxicity tests of different species, results of single chemical and mixtures toxicity tests, and exposure estimates derived from different fate models and from environmental measurements.

For this study, hazard index has been used as the tool to determine the risk of residents getting exposed with lead through drinking water. Hazard index has been calculated by dividing CDI with RfD. If the value of hazard index was more than 1, it shown potential for an adverse health effect towards the respondents.

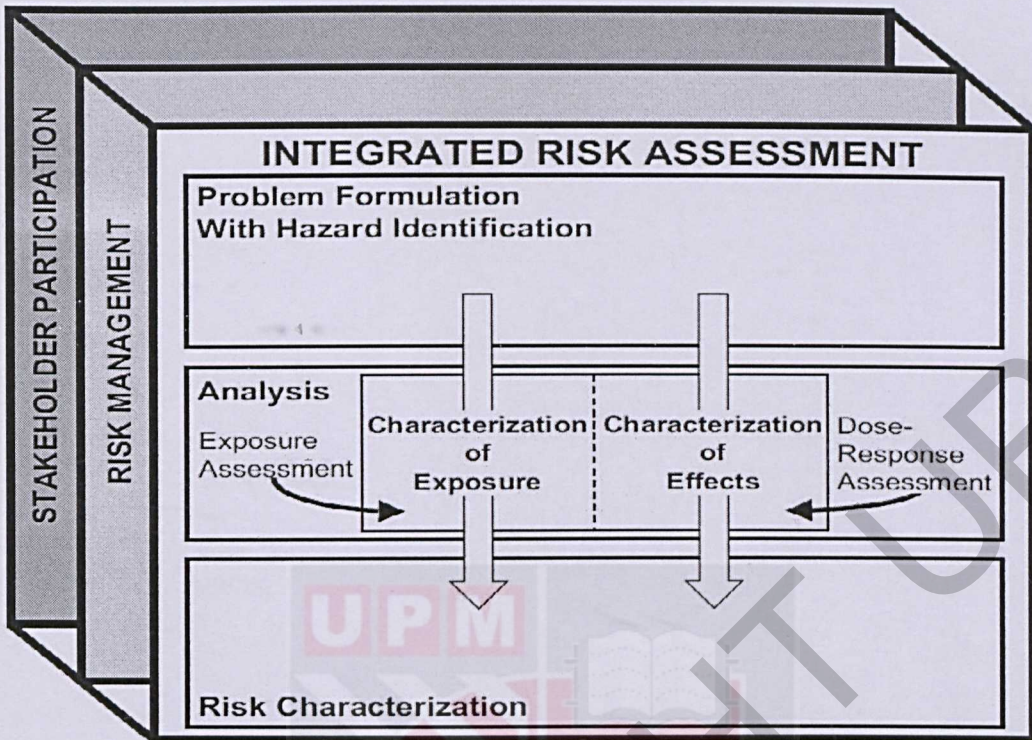


Figure 2.1: A framework for integrated human health and ecological risk assessment that has been modified from USEPA (Suter, 1998).

CHAPTER 3

METHODOLOGY

3.1 Location of Study

The location of this study was in Felda Jenderak Selatan. This area is located in the district of Temerloh, Pahang. It is part of Temerloh Municipal Council. Felda Jenderak Selatan was selected as the study location because target respondents were FELDA residents and it has a high population density.

The municipal water supply in Felda Jenderak Selatan is managed by Water Supply Department of Temerloh and the water source is from the Pahang River. Results from the research and analysis shown the average total value of Water

Quality Index at the mouth of Pahang river is 76.93% and can be classified as Class II with a status slightly polluted (Khairul Nizam, 2010).

Therefore, the study on drinking water quality is very important to ensure the community is not be affected by contaminated water supply. Furthermore, the study of risk exposure to lead in tap water among FELDA residents population has not yet been conducted.

3.2 Study Design

A cross sectional study was conducted to determine the risk of exposure to lead in tap water among the population of Felda Jenderak Selatan. In this research study, a subset of population which is 100 respondents was selected, and from these individuals, data were collected to help answer research questions of interest. It is called cross-sectional because the information about lead exposure through tap water that has been gathered represents what was going on at only current time.

3.3 Study Population

The population were the residents of Felda Jenderak Selatan who used tap water as the main source of drinking water.

3.4 Sampling

3.4.1 Sample size

The sample size of this study was calculated based on formula by Kirkwood and Stern. (2009). Where;

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

N= Sample size

P= Prevalence of household with detected lead concentrations in the tap water of 10µg/L or more.

e= Probability error

According to Zietz et al. (2009), the prevalence of household with detected lead concentrations in the tap water of 10µg/L or more was 0.075. Therefore, by computing the prevalence (0.075) as well as setting the probability error at 0.05, the sample size was calculated as below;

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

$$= 27.75$$

However, to ensure the data are representative and to take into consideration of missing and damaged data, samples are increased four times approximately 100 samples. Therefore, 100 respondents have been selected after the consideration of inclusive and exclusive criteria. This sample size was equivalent with the study by Kavcar et al. (2008).

3.4.2 Sampling Method

The sampling method in this study was quota sampling as individual who exhibited certain visible characteristics only were selected from this area until the required sample size was reached. The respondents were selected based on a few inclusive and exclusive criteria. The inclusive criteria were permanent residents, adult Malaysian which was more than 18 years old who used the tap water as source of drinking water. The exclusive criteria those using filtered water and the source of tap water were not from Water Supply Department.

3.4.3 Sampling Unit

The sampling unit was a resident at Felda Jenderak Selatan that fulfilled the inclusive and exclusive criteria.

3.5 Study instrumentation and data collection

3.5.1 Questionnaire

The respondents chosen were then asked to answer a questionnaire and the content included socio demographic of respondents, health status, water supply and piping system of the house. The questionnaire was administered during a visit to the house.

The questionnaire used in this study was modified from the Baseline, Descriptive and Time – Activity questionnaires that was used by Lebowitz et al. (1995) and Kavcar (2005). The questionnaire was translated into Bahasa Malaysia since all residents at Felda Jenderak Selatan were Malay.

Data collected from the questionnaire were very useful to this study. The two important parameters in order to determine the chronic daily intake of the respondents were body weight and daily water intake rate. The socio demographic data such as gender, age, education and income level were used to compare the exposure and risk of different subgroups such as married respondents and single respondents.

3.5.2 Atomic Absorption Spectrophotometer (AAS)



Figure 3.1: The PerkinElmer® AAAnalyst™ 600 Graphite Furnace Atomic Absorption Spectrophotometer (AAS).

The analytical determination of trace levels of lead in drinking water was performed by using PerkinElmer® AAAnalyst™ 600 Graphite Furnace Atomic Absorption Spectrophotometer (AAS). The analytical procedure was performed in a computer controlled (Winlab software) PerkinElmer AAAnalyst 600 Atomic Absorption Spectrophotometer with a Zeeman furnace module that includes a HGA-600 graphite furnace and an AS-60 furnace autosampler (PerkinElmer, 2004).

The patented transversely-heated graphite atomizer (THGA) tube used in the Analyst systems provides a uniform temperature distribution along its entire length. This eliminates cooler temperatures at the tube ends and removes most interferences. With the THGA tube design, accuracy and sample throughput are improved by reducing the need for the time-consuming standard additions technique.

With longitudinal Zeeman-effect background correction, the amount of light throughput is doubled by eliminating the need for a polarizer in the optical system. All other commercial Zeeman designs incorporate inefficient polarizers that reduce light throughput and diminish performance. With this unique design, the Analyst systems provide the lowest detection levels available. To further improve detection levels and accuracy, the Analyst systems also include optimized sampling frequency and interpolated background correction.

WinLab32 software improves laboratory productivity by reducing the time required for method development, sample analysis and report generation. Furnace method development is completely automated, helping to optimize the pyrolysis and atomization temperatures as well as sample and modifier volumes.

3.5.3 Water Sample Collection

3.5.3.1 Water sampling

For the purpose of this study, 250ml high density polyethylene (HDPE) bottles had been used for sampling and storage of tap water. Before sampling, all bottles were acid washed (Atalay et al., 2008). The bottles were soaked overnight in 10% nitric acid bath before washing twice with distilled water. After being dried in the fume hood at room temperature, the HDPE bottles were tightly capped (Kavcar et al., 2008). Then, put the HDPE bottles into plastic bags and sealed to avoid any contamination from the external environment.

Two replicates of water samples from each house were collected while respondents who fulfilled the inclusive and exclusive criteria were selected. The first sample was first flush water samples. This sample was the very first flush of water that comes out from the tap after an overnight stagnation. This sample determines whether the water in the house contains lead after having contact with the plumbing system overnight. The second sample was fully flushed water sample. The fully flushed water samples were collected after 3 minute of flushing (Kavcar et al., 2008). This sample would determine if the plumbing system was the source of lead leakage into water.

Flow diagram of sampling technique is shown in Figure 3.2. All HDPE bottles were collected after the sampling.

The pH of the samples collected was measured directly on site after the sampling process. Then, all samples were preserved by adding 0.5 ml of nitric acid with 69% concentration. Preservation was needed because the study was conducted at a rural area that was far away from laboratory and can only be analysed after 2 weeks. Preservation was important to prevent biological or chemical reactions or both from occurring in the samples taken. Preserved samples could be stored up to six months (HACH, 2003) before they are analysed in the laboratory. All samples were stored in the refrigerator at 4°C until analysed.

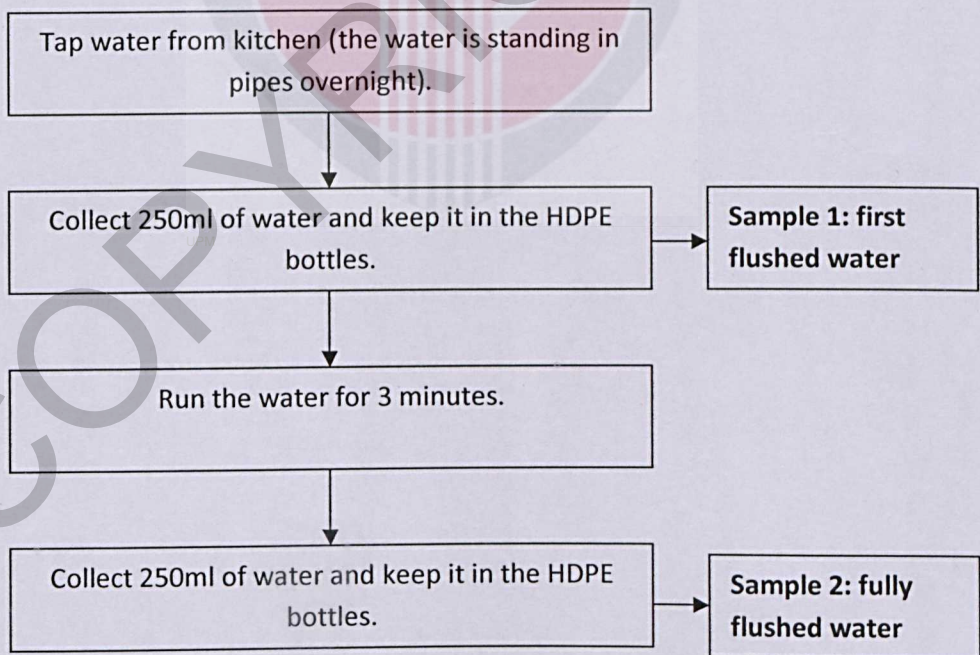


Figure 3.2 Flow diagram of sampling technique

3.5.2.2 Water Sample Analysis

For the measurement of pH, a pH meter LAMOTTE TRACER ORP PockeTester was used (Figure 3.3). This instrument could read pH instantly by dipping the probe into the water and it could measure pH from 0.00 to 14.00 with an accuracy of ± 0.01 .



Figure 3.3: The pH meter LAMOTTE TRACER ORP PockeTester.

The measurement of lead content in the water samples had been performed using a PerkinElmer® AAnalyst™ 600 Graphite Furnace Atomic Absorption Spectrophotometer (Figure 3.4) equipped with the intuitive WinLab32™ for AA (Version 6.5) software, which featured all the tools to analyse samples, report, and archive data. The instrument featured longitudinal Zeeman Effect background correction for graphite furnace analysis.

Lead hollow cathode lamp was used as the radiation source. The operating conditions of lead hollow-cathode were those recommended by the manufacturer, Perkin Elmer as shown in Table 3.1 and the graphite furnace temperature program was shown in Table 3.2.

Table 3.1: Instrumental condition for the Furnace Analysis on the AAnalyst 800

Element	Plumbum (Pb)
Wavelength (nm)	283.3
Slit (nm)	0.7
Mode	AA-BG
Processing	Peak area
Lamp	EDL
Lamp current (mA)	440
Calibration equation	Linear with calculated intercept

Source: (Sarojam, 2011)

Table 3.2: Graphite Furnace Temperature Program

Element	Step	Temperature (°c)	Ramp time (sec)	Hold time (sec)	Internal gas flow (mL/min)	Gas type
Lead	1	110	1	30	250	Argon
	2	130	15	30	250	Argon
	3	850	10	20	250	Argon
	4	1600	0	5	0	Argon
	5	2450	1	3	250	Argon

Source: (Sarojam, 2011)

3.6 Quality Control

3.6.1 Standard Operating Procedure (SOP)

The analysis of water samples by using Graphite Furnace Atomic Absorption Spectrophotometer (AAS), model of Perkin Elmer AAnalyst 600 followed the standard operating procedure that has been provided by the manufacturer. The Environmental Protection Agency (EPA) mandated level “for action” was fifteen (15) parts-per-billion (ppb) of lead in drinking water, therefore, our main goal was to be able to reliably detect and timely report if the trace lead content of the submitted samples was above or below that critical point (DMTE, 2009).

In addition, the pH meter that was used was operated according to SOP given by the respective manufacturer. The reason of following SOP was to minimize analytical errors. Besides that, this was one of the precautionary steps that must be applied to ensure data was valid and representative.

3.6.2 Calibration

All the instruments used were calibrated before being used. Calibration procedures for the PerkinElmer AAnalyst 600 Furnace-Only Atomic Absorption Spectrometer instrument consist of an initial calibration whenever an initial instrument calibration has not been performed on the day of analysis and periodic recalibration and calibration verification throughout the run. Furthermore, the pH meter LAMOTTE TRACER ORP PockeTester will enter Automatic Calibration Mode when turn on. Therefore, we can directly calibrate it each time we used it.

3.6.3 Pre test

Pre testing of questionnaire was conducted on 10% of the sample size before data collection to ensure that every question asked in the questionnaire was understood and could be answered by respondents. It was conducted on the Felda Jenderak Utara population on a voluntarily basis. The pre test of equipment used which was AAnalyst 600 Furnace-Only Atomic Absorption Spectrometer involved the standard which was must be $\pm 5\%$ from actual reading.

3.7 Risk Assessment

Risk assessment is a methodological approach in which the toxicities of a chemical are identified, characterized, analyzed for dose-response relationships, and the data generated are applied to a mathematical model to produce a numeric estimate representing a guideline or decision concerning allowable exposure (James, 1985).

For this study, the consideration of mode of transmission was focusing on the risk of the community to get exposure toward lead through drinking water. To estimate the daily exposure of an individual, USEPA (2005) suggested the Lifetime Average Daily Dose (LADD) as the exposure metric. The equation that had been used was a similar representation of daily exposure for ingestion route modified from USEPA (1992) and Chrostowski (1994);

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

Where; CDI = Chronic daily intake (mg/kg/day)

C = Lead concentration in water (mg/L)

DI = Average daily intake rate of drinking water (L/day)

BW = Body weight of the respondent (kg)

The joint FAO/WHO expert panel has established a provisional tolerable weekly intake (PWTI) value of 25µg of lead per kilogram of body weight (JECFA, 1987). This PWTI was referring as RfD value for this studies that has been established to all age groups (WHO, 2004).

The hazard index (HI) is the ratio of an exposure level over a specified period (CDI) to the chemical specific RfD which is not expected to produce toxic effects over the period of concern (ADHS, 1998). The HI was calculated as follows:

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

Where;

HI = Hazard index

CDI = Chronic daily intake (mg/kg/day)

RfD = Reference dose (mg/kg/day)

If the HI exceeded 1 the possibility that exposed individuals may experience adverse health effects cannot be ruled out. If the HI was higher, the concern of the individual gets adverse health effect also higher.

3.8 Ethical Issues

For the purpose of this study, the ethics committee reviewed the proposal before this study was conducted. The permission to carry out this study was requested from the Ethical Committee, Faculty of Medicine and Health Sciences of Universiti Putra Malaysia. The purpose of the study was explained to the respondents when visiting their home. A participation consent form was issued to them before the water samples were collected from their homes. They need to sign the form, and the identity of the respondent and all details about them remained confidential and will not be used for publication.

3.9 Data Analysis

All the data collected was analysed using Statistical Package of The Social Sciences (SPSS) for Windows version 18 software. Every part in the questionnaire was analysed using this software. Descriptive statistics was used to analyse descriptive data such as socio demographic, water consumption, results of water analysis, and others.

The normality test was done according to p value more than 0.05 where this indicated that the data was normally distributed. This was analysed by using the Kolmogorov-Smirnov test. If the data was not normally distributed, non-parametric tests were used.

Wilcoxon sign rank test was used to determine the difference of lead concentration between first flushed water samples and fully flushed water samples.

Spearman rho correlation was used to determine the relationship between two scale data which were not normally distributed. For this study, the Spearman correlation was used to determine the relationship between lead concentration and pH of the water. A p value less than 0.05, it was considered as significant values in this study.

3.10 Study Limitation

There was several study limitations that has been identified in this study. Firstly, only one of the modes of transmission was studying in this research. As we know, lead can enter human body through ingestion, dermal absorption, and inhalation. However, this study just considers the ingestion of lead through drinking water and was not considered other modes of transmission. Besides that, we were only did 24 hours water sampling only which were early in the morning and in the evening. The appropriate way was to conduct the water sampling according to a range of time. Furthermore, recall bias may occur during questionnaire sessions. Then, we did not take biological samples such as blood from the respondents to determine the blood lead level in their body. Causal effect relationship between blood lead and lead concentration in water cannot be developed. In addition, the data collected cannot be representative to general population because this study just

focuses on FELDA residents in the particular study area which is all of them are Malay.



CHAPTER 4

RESULTS

4.1 The socio demographic data of respondents

For this study, a total of 100 respondents were selected in Felda Jenderak Selatan which is located in Temerloh, Pahang. However, one of the respondents has to be excluded because having problem with its data. Therefore, the respondents became 99 settlers only. The socio demographic data of respondents were collected through questionnaires. The data can be seen in Table 4.1 and Table 4.2. The data regarding socio demographic of the residents in Felda Jenderak Selatan was age, gender, marital status, educational level, income, and body weight.

For age, the oldest respondent was 78 years old and a youngest respondent was 20 years old. These ages were fulfilled the requirement of inclusive criteria for the respondents in this study. The mean age was 49.88 years old.

The body weights of respondents were used to calculate chronic daily intake for health risk assessment. The mean value for body weight was 62.85 kilogram. The maximum value for body weight was 104 kilogram and a minimum value was 31.20 kilogram.

The gender that dominated this study was female which 71.7% compare to male 28.3% only.

For the races, all of them were Malay (100%). There are no other races that live in the FELDA residential area during the study period.

For marital status, 81.8 % of respondents were married while 7.1% of them were single and 10.1% of them were widowed. There were only 1% of them who were divorced.

In term of educational level, 12.1% of them have never been to school. Meanwhile 45.5% of them got education from primary school. It is only 19.2% of them has seated for PMR and 20.2% for SPM. Only 3% of them have qualification from diploma or matrices. None of them were degree holder.

Majority of them had an income range of RM750 to RM1999 per month which represented 55.6% of respondents. Meanwhile, 34.3% of them had a monthly income RM2000 to RM3999. In addition, 7.1% of the respondents had a monthly income below of than RM750. There were only 3% of respondents which had a monthly income of more than RM4000 per month.

Table 4.1: The descriptive data of age and body weight.

Variable	Mean	Standard deviation	Maximum	Minimum
Age (years)	49.88	15.23	20	78
Weight (kg)	62.85	13.87	104.00	31.20
N=99				

Table 4.2: The socio demographic data of respondent.

Variable	Category	Frequency	Percentage %
Gender	Female	71	71.7
	Male	28	28.3
Races	Malay	99	100
	Chinese	0	0
	Indian	0	0
	Others	0	0
Marital status	Single	7	7.1
	Married	81	81.8
	Divorced	1	1
	Widowed	10	10.1
Educational level	Never been to school	12	12.1
	Primary	45	45.5
	PMR	19	19.2
	SPM	20	20.2
	Diploma/Matrices	3	3
	Degree/Above degree	0	0
Income	<RM750	7	7.1
	RM750-RM1999	55	55.6
	RM2000-RM3999	34	34.3
	>RM4000	3	3

N=99

4.2 The concentration of lead in water supply

The concentration of lead in water supply was categorised into two classes which were first flushed water samples and fully flushed water samples. The concentration of lead in water supply was determined using a PerkinElmer® AAnalyst™ 600 Graphite Furnace Atomic Absorption Spectrophotometer (AAS). The concentration of lead in water samples was measured in unit of microgram per litre ($\mu\text{g/L}$). The result is shown in Table 4.3.

For concentration of lead in first flushed water samples, the mean value was $4.51 \mu\text{g/L}$. The standard deviation value was $5.19 \mu\text{g/L}$. The lowest value of lead concentration for first flushed water samples was $0.07 \mu\text{g/L}$ while a highest value was $28.00 \mu\text{g/L}$. Therefore, the distribution of lead concentration for first flushed water samples within the range $0.07 \mu\text{g/L}$ to $28.00 \mu\text{g/L}$.

Next, for concentration of lead in fully flushed water samples, the mean value was $4.03 \mu\text{g/L}$. The value was low compare to mean value of first flushed water samples. The standard deviation value was $5.58 \mu\text{g/L}$. The highest value of lead concentration in fully flushed water samples was $33.00 \mu\text{g/L}$ while the lowest value was $0.26 \mu\text{g/L}$. It can be clearly seen in Figure 4.0.

Table 4.3: Concentration of lead in water sample.

Variables	Mean	Standard deviation	Minimum	Maximum
Lead concentration in first flushed water samples ($\mu\text{g/L}$)	4.51	5.19	0.07	28.00
Lead concentration in fully flushed water samples ($\mu\text{g/L}$)	4.03	5.58	0.26	33.00

N=99

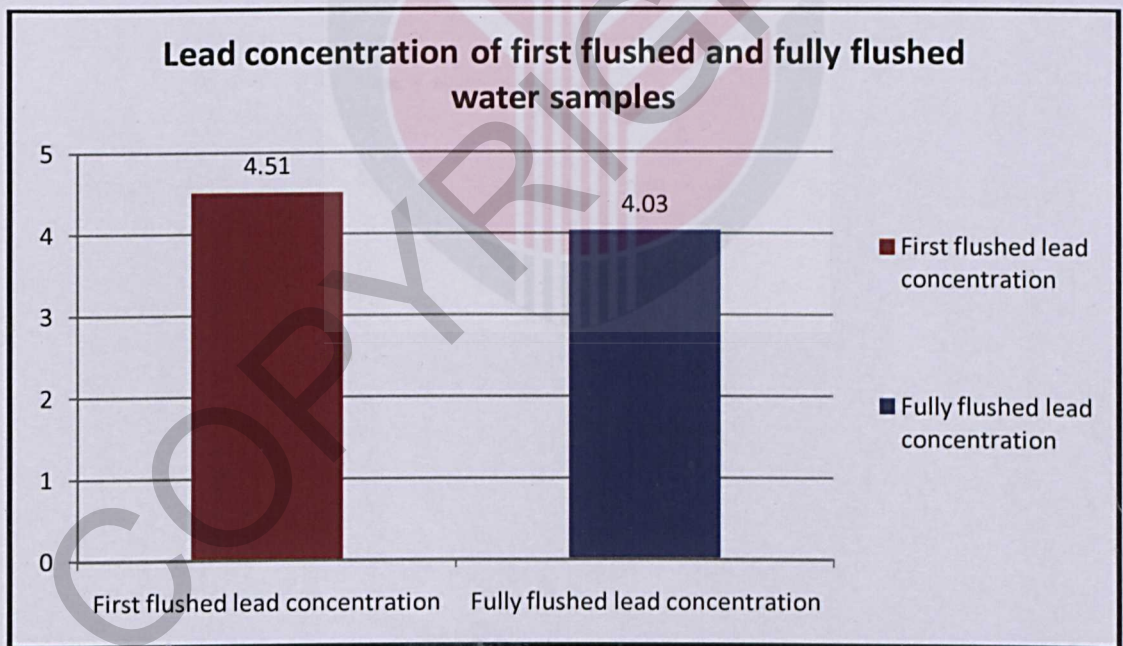


Figure 4.0: Bar chart of lead concentration

4.3 Comparison of the concentration of lead in water supply with the National Drinking Water Quality Standard.

According to the National Drinking Water Quality Standard established by Ministry of Health Malaysia, the permissible concentration of lead in drinking water must be less than 10 $\mu\text{g/L}$.

After the normality test had been done, the result showed the data was not normally distributed even after we \log_{10} the data. Therefore, the statistical test used was Wilcoxon Signed Rank test. The value of z-value was -6.913 for first flushed samples while for the fully flushed samples were -7.014. Throughout this statistical test, the p-value for both water samples (first flushed and fully flushed) were identical to each other ($p = 0.0000$). The result can be referred in Table 4.4.

Table 4.4: Comparison of lead concentration with standards.

Pair	Ranks	N	Mean rank	Sum of ranks	z	p
First flushed lead concentration and standard	Negative ranks	12 ^a	34.54	414.50	-7.192 ^b	0.00
	Positive ranks	87 ^b	52.13	4535.50		
	Ties	0 ^c				
	Total	99				
Fully flushed lead concentration and standard	Negative ranks	8 ^d	60.13		-6.960 ^h	0.00
	Positive ranks	91 ^e	49.11	481.00		
	Ties	0 ^f		4469.00		
	Total	99				

N=99

- a. First flushed lead concentration > standard of lead concentration
- b. First flushed lead concentration < standard of lead concentration
- c. First flushed lead concentration = standard of lead concentration
- d. Fully flushed lead concentration > standard of lead concentration
- e. Fully flushed lead concentration < standard of lead concentration
- f. Fully flushed lead concentration = standard of lead concentration
- g. Based on negative ranks
- h. Based on positive ranks

4.4 Chronic daily intake (CDI) and hazard index (HI)

Chronic daily intake (CDI) was measured in mg/kg/day. The descriptive statistics was be used to determine the mean value, standard deviation value, minimum value, and maximum value. The mean value for CDI was 0.0003 mg/kg/day. The standard deviation value for CDI was 0.0005. The minimum value for CDI was 0.0000 while the maximum value was 0.0039.

Besides that, the value of hazard index (HI) was also determined through descriptive statistics. The mean value for HI was 0.0799 while the standard deviation value was 0.1389. In addition, the lowest value of HI was 0.0032 and the maximum value was 1.1003. The result as shown in Table 4.5.

Table 4.5: Descriptive statistics of CDI and HI

Variables	Mean	Standard deviation	Minimum	Maximum
Chronic daily intake	0.0003	0.0005	0.0000	0.0039
Hazard index	0.0799	0.1389	0.0032	1.1003

N = 99

4.5 Comparison of lead concentration between first flushed water samples and fully flushed water samples.

The comparison of the lead concentration between first flushed water samples and fully flushed water samples was determined by using Wilcoxon Signed rank test. This was because the normality test that has been run shows the data was not normally distributed. p -value that has been fixed was $p > 0.05$. The result as shown in Table 4.6.

Table 4.6: Comparison of lead concentration

Pair	Ranks	N	Mean rank	Sum of ranks	Z	p
First flushed lead concentration	Positive	43 ^b	47.65	2049.00		
Fully flushed lead concentration	Negative	56 ^a	51.80	2901.00		
	Ties	0 ^c			-1.487 ^d	0.137
	Total	99				

N = 99

- Lead concentration of fully flushed < lead concentration of first flushed
- Lead concentration of fully flushed > lead concentration of first flushed
- Lead concentration of fully flushed = lead concentration of first flushed
- Based on positive rank

4.6 Relationship of lead concentration with pH of the water samples

According to several studies, lead concentration in water of the plumbing systems was high if the water was acidic. Therefore, this specific objective was to determine the relationship between lead concentration and pH value of the water samples. Based on the normality test, all the data was not normally distributed. Therefore, the test used was Spearman-rho correlation.

In the interest of relationship of lead concentration with pH of the first flushed water samples, the r -value was 0.134 and a p -value was 0.186. Meanwhile, for the relationship of lead concentration with pH of the fully flushed water samples, the r -value was 0.194 and the p -value was 0.054. The result as shown in Table 4.7.

Table 4.7: Correlation between lead concentration and pH of water samples

Variables	r	p
pH of the first flushed water samples	0.134	0.186
pH of the fully flushed water samples	0.194	0.054

N = 99

*significant at $p \leq 0.05$

CHAPTER 5

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 Discussion:

5.1.1 The socio demographic data of respondents

Based on the result that had been summarized in Table 4.1 and Table 4.2, a total of 99 respondents was selected and all of them were Malay. This was because entire area of Felda Jenderak Selatan was occupied by Malays who came from different states in Malaysia. In addition, the main purpose of the Federal Land Development Authority (FELDA) was to help Malays living in the rural area to increase their economic status. FELDA's schemes were generally open only to ethnic Malays who form a majority of the Malaysian population. That is why FELDA settlements were dominated by the Malays.

The age of respondents ranged from 20 to 78 years old. However, the mean age was 49.88 years old. This result shows that the majority of respondents were the elderly. This was because a second generation or youth generation in this area was moved to urban area and living outside their hometown. There were only their parents that still living in the Felda Jenderak Selatan. This information was gathered through interview sessions with residents in the area.

The body weight of the respondents was used to calculate the chronic daily intake. According to the results, the body weight of respondents ranged from 31.20 to 104.0 kilogram. The body weight varied from one person to another due to size of the body and diet.

The gender that dominated this study was female which 71.7% compare to male 28.3% only. This was because majority of the women that living in this area were full time housewives. During conducted this study, their husband was not at home at that time due to working.

According to Table 4.2, 55 out of 99 respondents were having monthly salary in the range of RM750 to RM1999. This was because each settler in the Felda Jenderak Selatan received income from FELDA every month based on the amount of

palm oil generated from their estate. Usually, the amount of income they received was in range of RM750 to RM1999.



5.1.2 The concentration of lead in water supply

As shown in Table 4.3, the mean value for lead concentration in first flushed water samples was 4.51 ± 5.19 $\mu\text{g/L}$ while for lead concentration in fully flushed water samples was 4.03 ± 5.58 $\mu\text{g/L}$. This finding was accordance with a study conducted by Watt et al. (2000). The main reason of this occurrence was due to concentration of lead which is high in water supply and stagnant water inside house pipelines. In addition, a previous study by Rajaratnam et al. (2001) also showed the same results where concentration of lead in first flushed samples was higher than fully flushed samples. This study also stated that the high level of lead in tap water maybe due to unused tap water for a long period of time. The finding that first flush water samples contain the highest concentrations of metals was generally in agreement with the study by Gulson et al. (1997).

5.1.3 Comparison of the concentration of lead in water supply with the National Drinking Water Quality Standard (NDWQS).

According to National Drinking Water Quality Standard (NDWQS) established by Ministry of Health, the permissible concentration of lead in drinking water must less than 10 µg/L. Based on the results in Table 4.4, 12.12% (12 samples) of first flushed water samples exceeding 10 µg/L while 8.08% (8 samples) of the fully flushed water samples also exceeding the standard available.

This occurrence may be due to corrosion of water pipe containing lead in its material. Based on the questionnaires, the type of water pipe being used in this area was made of metal. This was similar with the findings from a study by Prabjit et al. (2011) that mentioned lead can enter treated water systems through leaching from plumbing, including tin-lead solder and brass fittings, within the municipal water distribution system.

Besides that, the age of water pipe that had been used more than 20 years old may also contribute significantly to the concentration of lead in the plumbing system of this area. According to a study by Lasheen et al. (2008), the concentration of lead and iron increase as pipe age increases.

According to statistical results in Table 4.4, p-value was less than 0.05. To summarize, there was a significance difference between concentration of lead in water samples and National Drinking Water Quality Standard (NDWQS).

5.1.4 Chronic daily intake (CDI) and hazard index (HI)

Chronic daily intake (CDI) and hazard index (HI) was the two main components used to determine health risk assessment for this study. Based on results in Table 4.5, the mean value for CDI was 0.0003 mg/kg/day while the range was 0.0000 to 0.0039 mg/kg/day.

From the CDI calculation, the value of HI can be determined. From the results, the mean value for HI was 0.0799 which was less than 1. Based on this finding, we can conclude that the possibility of the respondents to get adversely health effects from exposure towards lead was negligible.

5.1.5 Comparison of the lead concentration between first flushed water samples and fully flushed water samples.

To determine the correlation between lead concentrations of first flushed water samples and fully flushed water samples, Wilcoxon Signed Rank test was used. This statistical test was used because the data of lead concentration of water samples were not normally distributed.

According to the results from Table 4.6, p-value was 0.137 while the z-value was -1.487. Since the significance value was more than 0.05, there was no significance difference between concentrations of lead in first flushed water samples and fully flushed water samples.

However, according to the result from Table 4.3, the concentration of lead in first flushed water samples was higher compared to fully flushed water samples. This may be due to concentration of lead which was high in the house plumbing systems. According to USEPA, if the lead content of the first draw sample is higher than that of the fully flushed sample, then the water is leaching from the in-house plumbing system. The concentration of lead which is low in fully flushed samples was similar to the finding from a study conducted by Levin. (1986).

5.1.6 Relationship of lead concentration with pH of the water samples

According to the results in Table 4.7, the r-value for relationship between pH of the first flushed water samples and concentration of lead in first flushed water samples was 0.134. Meanwhile r-value for relationship of lead concentration with pH of the fully flushed water samples was 0.194.

Based on Guildford rule of thumb, the relationship strength's of lead concentration with pH of the water samples was negligible if r-value less than 0.2. Therefore, the hypothesis regarding significance relationship between lead concentrations with pH of the water samples was failed to reject.

Refer to NDWQS, the maximum acceptable value of pH for drinking water ranged from 6.5 to 9.0. However, some of the samples having pH value less than 6.5. That means the water was acidic and corrosive. According to a study conducted by Malack (2001), the content of lead in water pipe systems increases with low pH value of water supplied. Furthermore, water which has a pH of less than 7 and low in calcium carbonate was more corrosive than water with a pH higher than 7 and high in calcium carbonate as mentioned by Bryan and William (1994).

5.2 Conclusion

For this study, the first hypothesis was to determine significance difference between concentration of lead in water samples and standard of concentration of lead in drinking water. The standard used was National Drinking Water Quality Standard (NDWQS) established by Ministry of Health Malaysia. To summarize, there was significance difference between concentration of lead in water samples and standard of concentrations of lead in water. Therefore, the first hypothesis stated was failed to reject.

For calculation of hazard index, the value was less than 1. Therefore, the second hypothesis that stated that hazard index is more than 1 was rejected. This means the concern of the exposed individual to get adverse health effects was low.

For the comparison of lead concentration in first flushed water samples and fully flushed water samples, based on the results there was no significance difference between lead concentration in first flushed samples and fully flushed samples. Hence, the hypothesis was rejected.

The fourth hypothesis was to determine significance relationship between lead concentrations with pH of the water samples. According to the result, there are weak relationship between pH of the water samples and lead concentration. Therefore, the hypothesis was failed to reject.



5.3 Recommendations

By referring to this study, several effective mitigating measures can be developed to avoid the exposure of the public towards lead in drinking water. Authorities such as the Water Supply Department must cooperate with the public to reduce the risk of people getting exposed to lead through drinking water. As an example, the authority can replace old water pipe with new ones to guarantee that the corrosion of plumbing systems containing lead does not occurring. Full replacement of lead service lines can significantly reduce lead concentrations at consumers' taps.

Besides that, we as the tap water users also can take protective action to reduce the possibility of getting expose to lead. "Flush" the tap before using the water for consumption. Flushing the tap means running the cold water faucet until the water gets noticeably colder, usually about 15-30 seconds. Do not cook with, or drink water from the hot tap. Hot water can dissolve more lead; more quickly than cold water.

Furthermore, installation of personal water filter outside the house and at the tap kitchen can reduce the concentration of lead in drinking water. Acid neutralizing filters can be installed to reduce water corrosives by adding calcium and by

increasing the pH of the water. These filters act to prevent lead from entering the water rather than removing it at the tap.

Besides that, according to Health Canada (2009), the adjustment of pH at the water treatment plant is the most common method for reducing corrosion in drinking water distribution systems and leaching of contaminants in the distributed water. Raising the pH remains one of the most effective methods for reducing lead and copper corrosion and minimizing lead, copper and iron levels in drinking water.

In addition, phosphate inhibitor can be used to control soluble lead release in water distribution systems. The agency such as Water Supply Department can apply this method which was very effective to reduce lead content in the drinking water.

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Appendix

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Appendix 1

Ethic letter



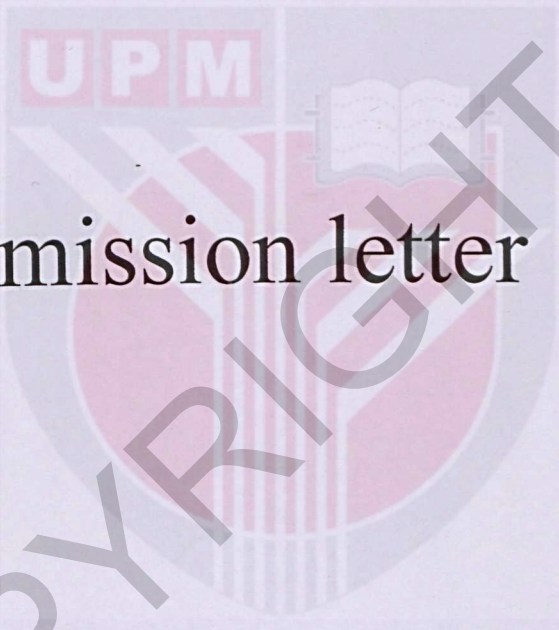
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Appendix 2

Permission letter



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LAMPIRAN 1

Berikut adalah butir-butir pelajar dan Projek Ilmiah Tahun Akhir yang akan dijalankan:

1. Nama Pelajar : **Mohd Faizal Bin Rozali**
2. No. Matrik/ Kad Pengenalan : 147309/ 890819-13-5155
3. No. Tel./ Emel : 017-6662579/ season89_laziaf@yahoo.com
4. Nama Penyelia Projek : Dr. Shaharuddin Mohd Sham
5. No. Tel. Penyelia / Emel : 012-3387305/ shaha@medic.upm.edu.my
6. Tajuk Kajian : **Penilaian Risiko Penduduk Felda Jenderak Selatan Di Temerloh, Pahang Yang Terdedah Kepada Plumbum (Pb) Melalui Air Paip**
7. Tempoh Penyelidikan : 12/01/2012 hingga 02/02/2012
8. Bilangan Responden Yang Diperlukan : 100 orang
9. Bahan Kajian : Borang soal selidik dan sampel air paip dari rumah responden

Appendix 3

Questionnaire



SOALAN KAJIAN RESPONDEN

Semua maklumat adalah untuk kegunaan kajian sahaja dan maklumat ini dianggap sulit. Maklumat anda hanya digunakan bagi membahagikan responden mengikut kategori yang sama.

Arahan: Sila jawab semua soalan pada bahagian yang disediakan dan tandakan (✓) pada soalan yang berkenaan.

A. MAKLUMAT RESPONDEN:

Nama : _____

Alamat: _____

Tel : _____

1. Umur:

A1

Tahun

2. Jantina:

A2

lelaki perempuan

3. Bangsa:

A3

1 Melayu 2 Cina

3 India 4 Lain-lain, sila nyatakan: _____

4. Status perkahwinan:

A4

1 Bujang 2 Berkahwin

3 Bercerai

5. Berapakah berat badan anda? A5
_____ kilogram

6. Berapakah ketinggian anda? A6
_____ meter

7. Tahap pendidikan tertinggi: A7

1 Tidak bersekolah

4 SPM

2 Sekolah rendah

5 STPM/Diploma

3 SRP/PMR

6 Ijazah

8. Berapakah pendapatan anda? A8

1 \leq RM 750

2 $>$ RM750 – RM1999

3 RM 2000 – RM 3999

4 \geq RM 4000

9. Berapakah bilangan ahli keluarga yang tinggal disini? A9
_____ orang

10. Berapa lamakah anda meluangkan masa di rumah? A10
_____ jam

11. Berapa lamakah anda menghabiskan masa di tempat kerja? A11
_____ jam

B. MAKLUMAT PENGGUNAAN AIR PAIP

12. Apakah punca air paip di rumah? B12

1 JBA

2 Telaga

3 Lain-lain, sila nyatakan: _____

13. Berapa gelas air yang anda minum untuk sehari?

B13

_____ gelas (200 ml)

14. Penggunaan air dari dapur:

B14

1 minum

2 memasak

3 kegunaan domestik

4 Lain-lain, sila nyatakan: _____

15. Adakah anda bepuas hati dengan kualiti air paip yang digunakan?

B15

0 Ya 1 Tidak

16. Adakah anda menggunakan sistem penapisan air persendirian di rumah?

B16

0 Ya 1 Tidak

C. MAKLUMAT LOKASI RUMAH:

17. Adakah terdapat kawasan perindustrian berdekatan dengan rumah anda?

C17

0 Ya 1 Tidak

18. Apakah jenis perpaipan air di rumah anda?

C18

Logam PVC Tidak pasti

19. Bilakah rumah ini dibina?

C19

Sebelum 1980 1991-2000

1981-1990 2001-2010

D. MAKLUMAT KESIHATAN:

20. Adakah anda merokok?

D20

0 Ya 1 Tidak

Jika Ya, nyatakan berapa batang dalam sehari: _____ batang.

21. Adakah anda mengambil minuman beralkohol?

D21

0 Ya 1 Tidak

Jika Ya, nyatakan berapa botol dalam sehari: _____ botol.

22. Adakah anda mengalami kegetaran badan yang serius?

D22

0 Ya 1 Tidak 2 Tidak pasti

23. Adakah anda sering kali bersifat pelupa?

D23

0 Ya 1 Tidak 2 Tidak pasti

TERIMA KASIH ATAS KERJASAMA ANDA

-TAMAT-

Appendix 4

Consent form of respondent



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CONSENT FORM (RESPONDENT)

RESEARCH TITLE :

RESEARCHER :

I Identity Card No.
address.....

.....hereby voluntarily agree to take part in the clinical research *(clinical study, questionnaire study/ drug trial) specified above.

I have been informed about the nature of the clinical research in terms of methodology, possible adverse effects and complications (refer to Information Sheet). I understand that I have the right to withdraw from this clinical research at any time without assigning any reason whatsoever. I also understand that this study is confidential and all information provided with regards to my identity will remain private and confidential.

I wish to *know/don't wish to know the results of the tests performed on my sample.

* delete where necessary

Signature
(Respondent)

Signature
(Witness)

Date

Name

I/C No.

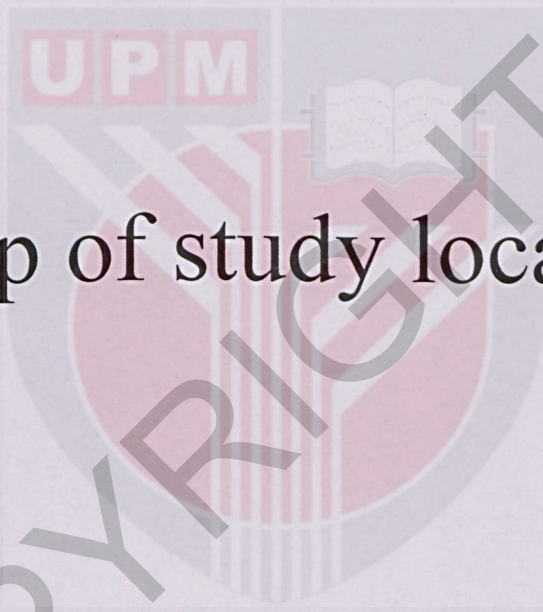
I confirm that I have explained to the respondent the nature and purpose of the above –mentioned clinical research.

Date

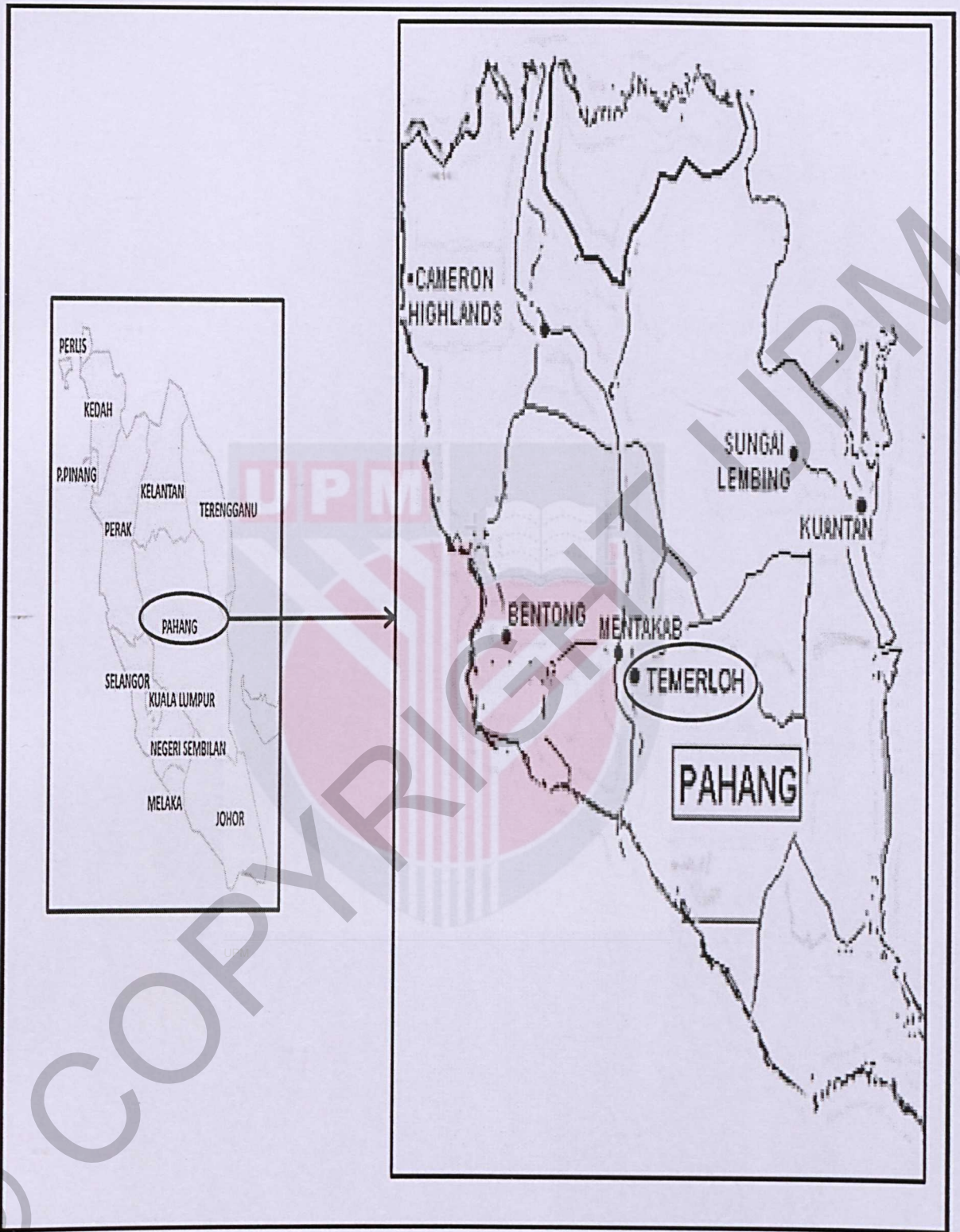
Signature
(Researcher)

Appendix 5

Map of study location



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The maps of Peninsular Malaysia and Pahang state

Appendix 6



Results

First flushed lead concentration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.07	1	1.0	1.0	1.0
	.30	1	1.0	1.0	2.0
	.30	1	1.0	1.0	3.0
	.41	1	1.0	1.0	4.0
	.50	1	1.0	1.0	5.1
	.52	1	1.0	1.0	6.1
	.55	1	1.0	1.0	7.1
	.59	1	1.0	1.0	8.1
	.61	1	1.0	1.0	9.1
	.82	1	1.0	1.0	10.1
	.83	1	1.0	1.0	11.1
	.85	1	1.0	1.0	12.1
	.85	1	1.0	1.0	13.1
	.90	1	1.0	1.0	14.1
	.91	1	1.0	1.0	15.2
	.96	1	1.0	1.0	16.2
	1.03	1	1.0	1.0	17.2
	1.10	1	1.0	1.0	18.2
	1.15	1	1.0	1.0	19.2
	1.15	1	1.0	1.0	20.2
	1.21	1	1.0	1.0	21.2
	1.22	1	1.0	1.0	22.2
	1.22	1	1.0	1.0	23.2
	1.25	1	1.0	1.0	24.2
	1.34	1	1.0	1.0	25.3
	1.39	1	1.0	1.0	26.3
	1.48	1	1.0	1.0	27.3
	1.50	1	1.0	1.0	28.3
	1.59	1	1.0	1.0	29.3
	1.65	1	1.0	1.0	30.3
	1.65	1	1.0	1.0	31.3
	1.69	1	1.0	1.0	32.3
	1.70	1	1.0	1.0	33.3
	1.71	1	1.0	1.0	34.3

1.77	1	1.0	1.0	35.4
1.86	1	1.0	1.0	36.4
1.90	1	1.0	1.0	37.4
1.98	1	1.0	1.0	38.4
2.00	1	1.0	1.0	39.4
2.08	1	1.0	1.0	40.4
2.18	1	1.0	1.0	41.4
2.19	1	1.0	1.0	42.4
2.22	1	1.0	1.0	43.4
2.27	1	1.0	1.0	44.4
2.34	1	1.0	1.0	45.5
2.44	1	1.0	1.0	46.5
2.45	1	1.0	1.0	47.5
2.47	1	1.0	1.0	48.5
2.55	1	1.0	1.0	49.5
2.63	1	1.0	1.0	50.5
2.65	1	1.0	1.0	51.5
2.65	1	1.0	1.0	52.5
2.74	1	1.0	1.0	53.5
2.84	1	1.0	1.0	54.5
2.99	1	1.0	1.0	55.6
3.17	1	1.0	1.0	56.6
3.19	1	1.0	1.0	57.6
3.22	1	1.0	1.0	58.6
3.22	1	1.0	1.0	59.6
3.22	1	1.0	1.0	60.6
3.23	1	1.0	1.0	61.6
3.36	1	1.0	1.0	62.6
3.56	1	1.0	1.0	63.6
3.57	1	1.0	1.0	64.6
3.98	1	1.0	1.0	65.7
4.10	1	1.0	1.0	66.7
4.23	1	1.0	1.0	67.7
4.29	1	1.0	1.0	68.7
4.35	1	1.0	1.0	69.7
4.51	1	1.0	1.0	70.7
4.54	1	1.0	1.0	71.7
4.55	1	1.0	1.0	72.7

5.07	1	1.0	1.0	73.7
5.26	1	1.0	1.0	74.7
5.48	1	1.0	1.0	75.8
6.08	1	1.0	1.0	76.8
6.34	1	1.0	1.0	77.8
6.48	1	1.0	1.0	78.8
6.75	1	1.0	1.0	79.8
7.10	1	1.0	1.0	80.8
7.37	1	1.0	1.0	81.8
7.74	1	1.0	1.0	82.8
7.94	1	1.0	1.0	83.8
8.15	1	1.0	1.0	84.8
8.43	1	1.0	1.0	85.9
9.77	1	1.0	1.0	86.9
9.83	1	1.0	1.0	87.9
10.06	1	1.0	1.0	88.9
10.23	1	1.0	1.0	89.9
11.14	1	1.0	1.0	90.9
11.36	1	1.0	1.0	91.9
12.21	1	1.0	1.0	92.9
12.26	1	1.0	1.0	93.9
14.80	1	1.0	1.0	94.9
16.23	1	1.0	1.0	96.0
16.40	1	1.0	1.0	97.0
23.60	1	1.0	1.0	98.0
24.35	1	1.0	1.0	99.0
28.00	1	1.0	1.0	100.0
Total	99	100.0	100.0	

Fully flushed lead concentration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.26	1	1.0	1.0	1.0
	.32	1	1.0	1.0	2.0
	.50	1	1.0	1.0	3.0
	.53	1	1.0	1.0	4.0
	.62	1	1.0	1.0	5.1
	.66	1	1.0	1.0	6.1
	.69	1	1.0	1.0	7.1
	.71	1	1.0	1.0	8.1
	.72	1	1.0	1.0	9.1
	.73	1	1.0	1.0	10.1
	.77	1	1.0	1.0	11.1
	.94	1	1.0	1.0	12.1
	.97	1	1.0	1.0	13.1
	.98	1	1.0	1.0	14.1
	.99	1	1.0	1.0	15.2
	1.02	1	1.0	1.0	16.2
	1.03	1	1.0	1.0	17.2
	1.05	1	1.0	1.0	18.2
	1.07	1	1.0	1.0	19.2
	1.09	1	1.0	1.0	20.2
	1.15	1	1.0	1.0	21.2
	1.28	1	1.0	1.0	22.2
	1.31	1	1.0	1.0	23.2
	1.32	1	1.0	1.0	24.2
	1.36	1	1.0	1.0	25.3
	1.40	1	1.0	1.0	26.3
	1.46	1	1.0	1.0	27.3
	1.47	1	1.0	1.0	28.3
	1.47	1	1.0	1.0	29.3
	1.48	2	2.0	2.0	31.3
	1.49	1	1.0	1.0	32.3
	1.49	1	1.0	1.0	33.3
	1.52	1	1.0	1.0	34.3
	1.53	1	1.0	1.0	35.4

1.53	1	1.0	1.0	36.4
1.57	1	1.0	1.0	37.4
1.63	1	1.0	1.0	38.4
1.63	1	1.0	1.0	39.4
1.64	1	1.0	1.0	40.4
1.64	1	1.0	1.0	41.4
1.81	1	1.0	1.0	42.4
1.82	1	1.0	1.0	43.4
1.89	1	1.0	1.0	44.4
1.94	1	1.0	1.0	45.5
1.98	1	1.0	1.0	46.5
2.07	1	1.0	1.0	47.5
2.11	1	1.0	1.0	48.5
2.14	1	1.0	1.0	49.5
2.22	1	1.0	1.0	50.5
2.23	1	1.0	1.0	51.5
2.26	1	1.0	1.0	52.5
2.27	1	1.0	1.0	53.5
2.32	1	1.0	1.0	54.5
2.35	1	1.0	1.0	55.6
2.42	1	1.0	1.0	56.6
2.42	1	1.0	1.0	57.6
2.55	1	1.0	1.0	58.6
2.56	1	1.0	1.0	59.6
2.76	1	1.0	1.0	60.6
2.78	1	1.0	1.0	61.6
2.78	1	1.0	1.0	62.6
2.79	1	1.0	1.0	63.6
2.80	1	1.0	1.0	64.6
2.88	1	1.0	1.0	65.7
2.92	1	1.0	1.0	66.7
2.94	1	1.0	1.0	67.7
3.23	1	1.0	1.0	68.7
3.36	1	1.0	1.0	69.7
3.47	1	1.0	1.0	70.7
3.49	1	1.0	1.0	71.7
3.63	1	1.0	1.0	72.7
3.70	1	1.0	1.0	73.7

3.85	1	1.0	1.0	74.7
3.94	1	1.0	1.0	75.8
4.02	1	1.0	1.0	76.8
4.07	1	1.0	1.0	77.8
4.15	1	1.0	1.0	78.8
4.39	1	1.0	1.0	79.8
5.09	1	1.0	1.0	80.8
5.17	1	1.0	1.0	81.8
5.27	1	1.0	1.0	82.8
5.82	1	1.0	1.0	83.8
6.14	1	1.0	1.0	84.8
6.40	1	1.0	1.0	85.9
6.45	1	1.0	1.0	86.9
7.06	1	1.0	1.0	87.9
7.33	1	1.0	1.0	88.9
7.94	1	1.0	1.0	89.9
8.33	1	1.0	1.0	90.9
8.79	1	1.0	1.0	91.9
13.26	1	1.0	1.0	92.9
14.40	1	1.0	1.0	93.9
17.14	1	1.0	1.0	94.9
17.75	1	1.0	1.0	96.0
20.71	1	1.0	1.0	97.0
23.79	1	1.0	1.0	98.0
25.61	1	1.0	1.0	99.0
33.00	1	1.0	1.0	100.0
Total	99	100.0	100.0	

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