UNIVERSITI PUTRA MALAYSIA

# *HEALTH RISK ASSESSMENT OF LEAD EXPOSURE IN DRINKING WATER IN TWO VILLAGES IN KUALA TERENGGANU, TERENGGANU*

BY
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# ABSTRAK

## KAJIAN RISIKO KESIHATAN TERHADAP PENDEDAHAN PLUMBUM DALAM AIR MINUM DI DUA BUAH KAMPUNG DI KUALA TERENGGANU, TERENGGANU

### MAISARAH BINTI ZAKARIAH

**Objektif:** Kajian ini dijalankan untuk mengenal pasti risiko kesihatan terhadap pendedahan plumbum dalam air minum di kalangan penduduk yang tinggal di dua buah kampung di daerah Kuala Terengganu. **Kaedah:** Kajian keratan rentas ini melibatkan 70 orang responden. Dua sampel air telah diambil di setiap rumah responden iaitu merujuk kepada air yang mula-mula keluar dari paip dan air yang keluar dari paip selepas 3 minit. Sampel air yang diambil diawet menggunakan asid nitrik dan dianalisis menggunakan alat Relau Grafit Spektrofotometer Serapan Atom bagi mengenal pasti kehadiran plumbum dalam setiap sampel. Berat badan responden diambil dan responden ditanya soalan berkaitan latar belakang, jumlah air minum dalam sehari, status air yang dibekalkan ke rumah dan jenis perpaipan yang digunakan di rumah. Daripada maklumat yang didapati, risiko kesihatan setiap responden dikira. Semua data dianalisis menggunakan SPSS. **Hasil:** Dua sampel air yang mula-mula keluar dari paip melebihi kepekatan plumbum 10 µg/L yang ditetapkan Piawaian Kualiti Air Minum Kebangsaan manakala tiada sampel yang diambil selepas tiga minit melebihi kepekatan plumbum 10 µg/L. Nilai min dan sisihan piawai bagi kepekatan plumbum dalam sampel air yang mula-mula keluar dari paip ialah $2.24 \pm 3.28$ µg/L manakala sampel air yang keluar dari paip selepas 3 minit adalah $0.55 \pm 0.86$ µg/L. pH sampel air berada dalam linkungan 5.35 ke 8.14. Ujian hubungkait Spearman menunjukkan tiada kaitan antara kepekatan plumbum dan nilai pH dalam sampel air. Ujian Wilcoxon menunjukkan ada perbezaan nilai kepekatan plumbum antara air yang mula-mula keluar dari paip dan air yang keluar dari paip selepas 3 minit ($Z = 4.696$, $p < 0.05$). Bagi kiraan risiko kesihatan terhadap pendedahan plumbum, kajian menunununjukkan hazad indeks adalah kurang daripada 1 iaitu risiko terhadap pendedahan plumbum adalah minima dan boleh diterima. **Rumusan:** Kepekatan plumbum tidak berkaitan dengan pH sampel air dan kepekatan plumbum dalam sampel air yang mula-mula keluar daripada paip adalah tinggi daripada kepekatan plumbum dalam sampel air yang diambil selepas tiga minit.

**Kata Kunci: Kepekatan plumbum, air minum, analisis risiko kesihatan, penduduk di Kuala Terengganu**

## ABSTRACT

### HEALTH RISK ASSESSMENT OF LED EXPOSURE IN DRINKING WATER IN TWO VILLAGES IN KUALA TERENGGANU, TERENGGANU

### MAISARAH BINTI ZAKARIAH

**Introduction:** This cross-sectional study was done in two villages in Kuala Terengganu, Terengganu. **Objectives:** The main objective of this study was to determine the risk of lead exposure in drinking water among residents in two villages in Kuala Terengganu. **Methods:** This study involved 70 respondents. Two water samples were taken from respondent's houses, which were first flushed water that came out from the pipe and fully flushed water which was taken after 3 minutes of flushing. The water samples were preserved using nitric acid and analysed using Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) to determine lead concentration in each water sample. Body weight of respondent was measured using Seca Body Weight Scale and questions were asked to the respondents regarding their socio-demographic background, total water daily intake and the type of their house piping system. The information gained was used to calculate the health risk. Data were analysed using SPSS Version 19.0. **Results:** Only two samples of first flushed water exceeded the standard value of 10 μg/L recommended by National Standard of Drinking Water Quality (NSDWQ) while none of fully flushed water exceeded the NSDWQ. Mean and standard deviation for lead concentration in first flushed water sample was $2.24 \pm 3.28$ μg/L and fully flushed was $0.55 \pm 0.86$ μg/L. pH of water samples were ranged from 5.35 to 8.14. Spearman Rank Order Correlation test showed there was no significant relationship between lead concentrations in both water samples and pH. Wilcoxon Signed-Rank test showed there was a significance difference between lead concentration levels in first flush and fully-flush water samples ($Z = -4.696$, $p < 0.05$). For calculation of health risk to lead exposure in drinking water, the hazard index (HI) was less than 1 which means the risk was acceptable. **Conclusion:** The concentration of lead was not related to pH of water samples and the lead concentrations in first flushed had a significantly higher than fully flushed water samples.



*Keywords*: **Lead, drinking water, first flush water samples, fully flushed water samples, health risk assessment, Kuala Terengganu**

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| | |
|---|---|
| ADD | Average daily dose |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| CDI | Chronic daily intake |
| GFAAS | Graphite Furnace Atomic Absorption Spectroscopy |
| HDPE | High-density polyethylene |
| HNO3 | Nitric Acid |
| JBA | Jabatan Bekalan Air |
| mg/L | milligram per litre |
| NSDWQ | National Standard of Drinking Water Quality |
| NRC | National Research Council |
| Pb | Lead |
| PTWI | Provisional Tolerable Weekly Intake |
| RfD | Reference Dose |
| SATU | Syarikat Bekalan Air Terengganu |
| SOP | Standard operating procedure |
| USEPA | United State Environmental Protection Agency |
| WHO | World Health Organization |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Lead and its compounds are potentially toxic and have no known physiological functions. It is widely distributed in nature and as a result of man's activities. The gross effects which it can have on health have been recognized for many years (Lansdown, 1986). It is a heavy, low melting and bluish-gray metal that occurs naturally in the Earth's crust (ATSDR, 1999). According to Fertman et al. (2004), lead in environment is not carcinogenic, but even low dose lead exposure has been shown to have detrimental and long-lasting effects on the renal, hemopoietic and nervous system.

Lead is one of the most ubiquitous toxic materials encountered in everyday life. Lead released into the environment makes its way into the air, soils, and water. Most of the high levels of lead found throughout the environment come from human activities. It also can enter the environment through releases from mining lead and other metals, and from factories that make or use lead, lead alloys, or lead compounds (ATSDR, 1999). Historically, lead exposure was linked to food, paint, petrol and drinking water (International Water Association (IWA), 2010).

In the body, lead can affect hematologic (blood), renal, neuromuscular, gastrointestinal, central nervous, and reproductive systems. However, the main target for lead toxicity is the nervous system, both in adults and children (ATSDR, 1999). This is especially true for fetuses and small children in who lead might cause developmental disruption in terms of neurological impairment (Fertman et al., 2004).

A number of chemical contaminants have been identified in drinking water. These contaminants reach drinking water supplies from various sources, including municipal and industrial discharges, urban and rural run-off, natural geological formations, drinking water distribution materials and the drinking water treatment process (Calderon, 2000). People may be exposed to lead by eating food or drinking water that contains lead. Lead has been widely used for municipal service pipes, household plumbing, joint and solders, being considered to be a cheap and convenient material to convey water to the consumer's tap (Francois et al., 2005).

Lead is present in tap water to some extent as a result of its dissolution from natural sources but primarily from household plumbing systems in which the pipes, solder, fittings, or service connections to homes contain lead. PVC pipes also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water (WHO, 1996). The main source of lead in drinking water is due to the continued use of lead pipes, although lead leaching from brass fittings and galvanic corrosion of leaded solder can be problematic in some circumstances (IWA, 2010).

## 1.2 Problem Statement

Lead has been a challenge and a bane for water suppliers since historical times. In addition to exposure to lead in the air, ingestion of lead in drinking water has become one of the major sources of human exposures to lead (Matte et al., 2000). According to Chiron et al., the presence of lead in drinking water is a public health problem due to their absorption and possible accumulation in organisms. Exposure to lead-contaminated tap water is a persistent problem in most developed eastern countries, which primarily concerns children and the economically less-favored population (Francois et al., 2005).

The presence of lead in drinking water is not a new problem. Lead was historically used to produce pipes to carry water and later to solder iron and copper pipes. It is ubiquitous heavy metal that has been used for centuries as a constituent in various products such as face powder, ceramic glazing, gasoline, plumbing, radiation shielding, children's toys and paint (Payne, 2008). The problem of lead in drinking water is most-publicized for the larger water supply systems of cities and towns, particularly the older districts, where lead piping was often used to connect houses to a municipal water supply system and for internal plumbing, up to the early 1980s (Hayes, 2010).

The World Health Organization (WHO) has progressively tightened its guideline value for lead from a maximum allowable concentration of 0.1 mg/l to the current 0.01 mg/l. The WHO Guidelines recognize that lead is exceptional, and that most lead in drinking water arises from plumbing and the remedy consists principally of removing plumbing and fittings containing lead. In Malaysia, Ministry of Health has progressively tightened its guideline value for lead from a maximum allowable concentration of 0.01 mg/l which is stated in National Drinking Water Quality Standards for Malaysia (NDWQS).

The effects of lead are well documented and identify a wide range of possible clinical conditions (Hayes et al., 2009), often making medical diagnosis difficult. According to Colin, prolonged exposures to high amount of lead from occupational and environmental exposure leads to adverse health effects including interference with haemoglobin biosynthesis, interference with calcium and vitamin D metabolism, gastrointestinal irritation, dullness, restlessness, irritability, poor attention span, headaches, muscle tremor, abdominal cramps, kidney damage, hallucination, loss of memory, encephalopathy, hearing impairment, gonad dysfunction and violent behavior.

**1.3 Study Justification**

The main purpose of this study was to determine the risk of exposure to lead in drinking water among the Malays residents in two villages in Kuala Terengganu, Terengganu. Basically, most of the residents at the selected area are consuming drinking water from the water system that is supplied by Syarikat Bekalan Air Terengganu (SATU). According to Agency for Toxic Substances and Disease Registry (ATSDR, 1999), more than 99% of all publicly supplied drinking water contains less than 0.005 parts of lead per million parts of water (ppm).

Acidic water makes it easier for the lead found in pipes, leaded solder, and brass faucets to be dissolved and to enter the water we drink. Public water treatment systems are now required to use control measures to make water less acidic. Plumbing that contains lead may be found in public drinking water systems, and in houses, apartment buildings, and public buildings that are more than 20 years old.

Recently, there is limited information and data regarding the risk of exposure to lead exposure in drinking water among Malaysians. To be specific, there are no previous studies regarding lead exposure in drinking water in Kuala Terengganu. Thus, the findings from this study will provide baseline data for the further research and the information gathered can be very useful for the relevant water authorities such as Ministry of Health, Kuala Terengganu Municipal Council and Syarikat Bekalan Air Terengganu (SATU) in order to improve their water quality status.

## 1.4: Conceptual Framework

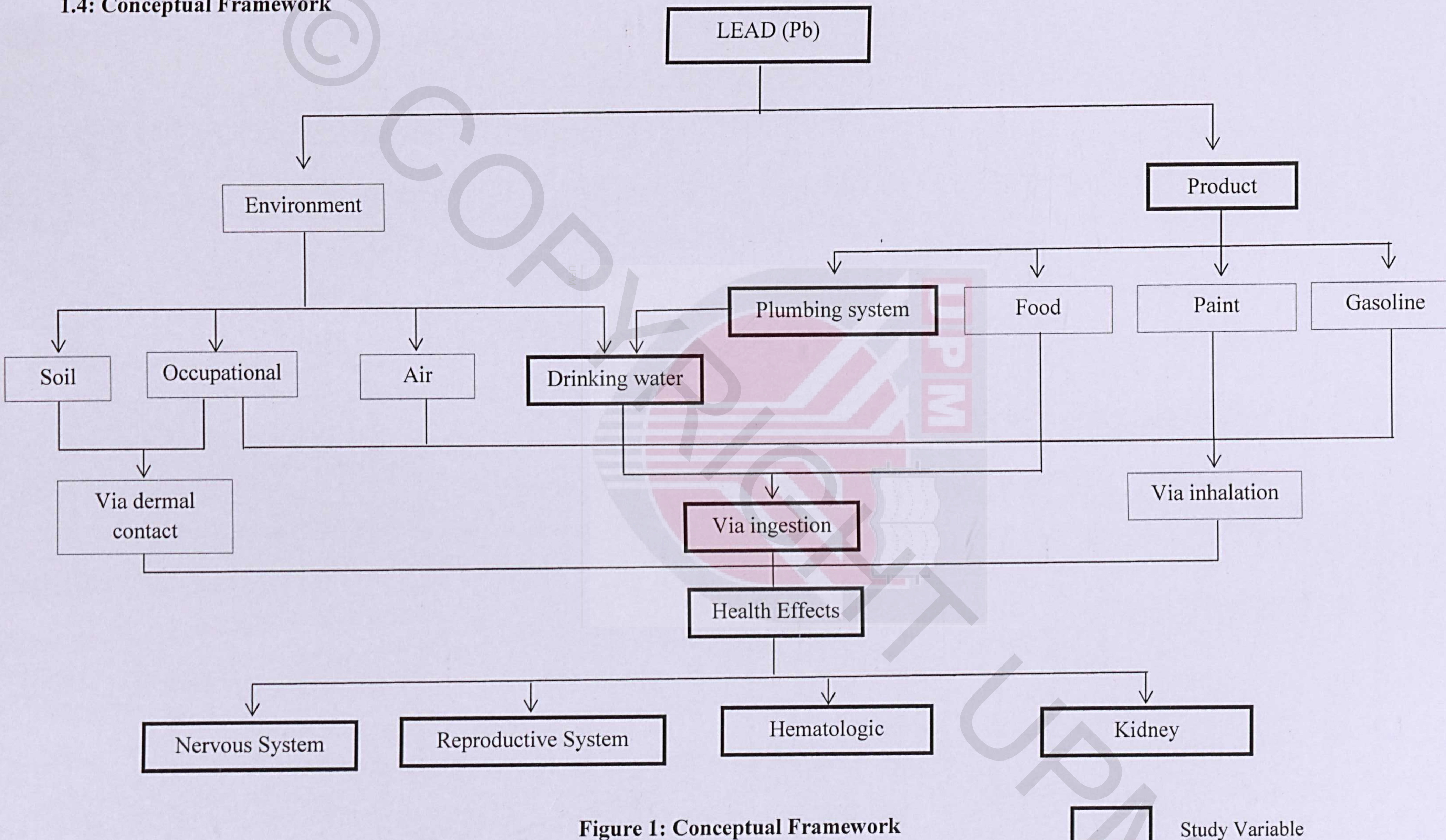


**Figure 1: Conceptual Framework**

## 1.5 Definition

### 1.5.1 Conceptual Definition

#### 1.5.1.1 Health risk assessment

Risk assessment refers to the process of quantifying the probability of a harmful effect to individuals or populations from certain human activities or exposures to certain constituents. It can be divided into four distinct steps which are hazard identification, exposure assessment, dose-response relationship and risk characterization (USEPA, 2005).

#### 1.5.1.2 Lead

Lead is a naturally occurring bluish-grey toxic heavy metal found in small amounts in the Earth's crust and also can be found in all parts of environment as well. Basically, lead is used in household plumbing materials or in water service lines used to bring water from the main source to the home. Lead is rarely found in water source, but it can enter into the tap water through corrosion of plumbing materials.

#### 1.5.1.3 Drinking water

Drinking water is refers to water reserved or water that is suitable and safe for human consumption or drinking with low risk of immediate or long term harm.

### 1.5.2 Operational Definition

#### 1.5.2.1 Health risk assessment

In regards to estimate the daily exposure of individuals to lead through ingestion, USEPA (1992) suggests the chronic daily intake (CDI) as the exposure metric. To estimate the non-carcinogenic risk of lead, the hazard index (HI) is calculate by using the equation suggested by USEPA (1999), in which CDI divided by reference dose (RfD).

### 1.5.2.2 Lead

The concentration of lead in tap water is determined by using Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) model Perkin Elmer AAnalyst 600 in the unit of µg/L.

### 1.5.2.3 Drinking water

The drinking water samples are collected from respondents' tap water by using 250ml high density polyethylene (HDPE) bottles. Two replicates of water samples were collected which was first-flush and fully-flush. The first-flush water is the very first drops of cold water that come out from the tap water after an overnight of stagnation where as the fully-flush water is refers to water sample that is taken from tap water after two minutes of flushing.

## 1.6 Objectives

### 1.6.1 General Objective

To determine the risk of exposure to lead in drinking water among residents in two villages in Kuala Terengganu, Terengganu.

### 1.6.2 Specific Objectives

1. To determine the socio-demographic data of respondents in two villages in Kuala Terengganu.
2. To determine the concentration of lead in drinking water among Malay residents in Kuala Terengganu.
3. To compare lead concentrations of water samples with the National Standard of Drinking Water Quality for Malaysia (NSDWQ).
4. To determine the relationship of lead concentration and pH of water samples.

5. To compare lead concentration in first-flushed and fully-flushed water samples.

6. To determine the risk of exposure to lead in drinking water among Malay residents in Kuala Terengganu by calculating the chronic daily intake (CDI) value and hazard index, (HI) values.

### 1.5.3 Hypothesis

1. The lead concentration in water sample was higher than the lead concentration in National Standard of Drinking Water Quality for Malaysia (NSDWQ).

2. There was a significant difference between lead concentration in first-flushed and fully-flushed water samples.

3. There was a significant relationship between lead concentration and pH of water samples.

4. The hazard index among residents was less than 1.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Lead

Lead is one of the oldest known toxic materials. It 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 but it can be found combined with two or more other elements to form lead compounds (ATSDR, 2007). There is a certain natural background concentration of lead in the physical and biological environment due to its mobilization and dissemination from these deposits (Ratcliffe, 1981).

Lead is unique among common metals in being very soft and malleable, but at the same time having virtually no elasticity and little mechanical strength. Since it is a heavy dense metal this lack of mechanical strength and softness means that lead has a tendency to flow or creep under its own weight (Lansdown and Yule, 1986).

Historically, lead exposure was linked to food, paint, petrol and drinking water. Lead in paint and petrol were removed in the early 1980s. At this time, leaded solder for jointing copper pipes and jointing food cans was also banned. In consequence, any remaining problems are likely to be due to drinking water, primarily in the presence of lead pipes, although concerns continue to be voiced in North America about the potential for exposure from soil and dust. The main source of lead in drinking water is due to the continued use of lead pipes, although lead leaching from brass fittings and galvanic corrosion of leaded solder can be problematic in some circumstances (IWA, 2010).

### 2.1.1 Physicochemical Properties

In the periodic table of elements, the chemical symbol for lead is Pb, from the Latin name for lead, which was plumbum (Lansdown & Yule, 1986). 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 the environment, lead primarily exists as Pb (II). Pb (IV) is only formed under extremely oxidizing conditions and inorganic Pb (IV) compounds are not found under ordinary environmental conditions (ATSDR, 2007).

### 2.1.2 Major Uses

One of the main reasons for the importance of lead in the world today is that it finds it way, in one form or another, into so many facets of modern life (Lansdown, 1986). Lead may be used in the form of metal, either pure or alloyed with other metals, or as chemical compounds. The commercial importance of lead is based on its ease of casting, high density, low melting point, low strength, ease of fabrication, acid resistance, electrochemical reaction with sulfuric acid, and chemical stability in air, water, and soil (King et al., 2000).

The automobile industry probably accounts for the largest proportion of lead used, principally in the manufacture of storage batteries and petrol or gasoline additives but also in the solders used for joints and in other ways. Lead is also used for the sheathing of telegraphs, telephone and power cables and, although other materials are being increasingly used, cables sheathing remains a major outlet for lead particularly in some European countries (Lansdown, 1986).

Besides, lead alloys used in bearings, brass and bronze and some solders; sheets and pipe for nuclear and x-ray shielding, cable covering, noise control materials; chemical resistant linings; ammunition; and pigments and lead compounds used in glass making, ceramic glazes, plastic stabilizers, caulk, and paints (ATSDR, 2007).

## 2.2 Source of Lead in Environment

Basically, the distribution of lead in the environment is different between one place and another. Some lead enters the ecosystem from natural sources and anthropogenic source. However, according to King et al., (2000), most of the lead enters the environment through human activities.

### 2.2.1 Natural Sources

As lead is an element that is naturally present in many minerals, it will be present in rocks and soils in low concentrations. The average global lead concentration in soil is reported to be 22 mg/kg (Richardson et al., 2001)

Lead occurs naturally in the environment. However, most of the high levels found throughout the environment come from human activities. Environmental levels of lead have increased more than 1,000-fold over the past three centuries as a result of human activity. The greatest increase occurred between the years 1950 and 2000, and reflected increasing worldwide use of leaded gasoline. Lead can enter the environment through releases from mining lead and other metals, and from factories that make or use lead, lead alloys, or lead compounds (ATSDR, 2007)

### 2.2.2 Anthropogenic Sources

Much of the high-lead containing paint is found in older pre-war housing and represent a persistent hazard today, although the lead content of indoor paint is now severely restricted and the problem well-recognized (Ratcliffe, 1981). Pacyna and Pacyna (2001) stated that from 1983 to the mid-1990s, the total global atmospheric emission of lead decreased from 330,000 tonnes to 120,000 tonnes.

According to WHO (2004), other sources of lead include 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. Very small children are especially at risk to exposure, for example through the ingestion of paint chips from lead-based paint. Sources of lead in dust and soil include lead that falls to the ground from the air, and weathering and chipping of lead-based paint from buildings, bridges, and other structures (ATSDR, 2007).

Most of disseminated lead is emitted initially into the atmosphere, from two principal sources: motor vehicles and a variety of stationary source process such as metallurgical smelting, coal and oil combustion, iron and steel production, waste oil combination and the burning of demolition waste, cables, battery cases (Ratcliffe, 1981).

## 2.3 Exposure to Lead

Basically, humans are exposed to lead by three main routes which are inhalation, ingestion and dermal contact. Lead is commonly found in soil especially near roadways, older houses, old orchards, mining areas, industrial sites, near power plants, incinerators, landfills, and hazardous waste sites. People living near hazardous waste sites may be exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing dust or dirt that contain lead (ATSDR, 2007).

Ingestion of contaminated soil, dust and old lead-based paint due to hand and mouth activities may also be important regarding lead intake in infants and young children. When tap water systems with leaded pipes are used, lead intake via drinking water can be an important source, especially in children. Inhalation exposure may be significant when lead levels in the air are high (WHO, 2007).

According to Clark et al. (2006), 66% of new paint samples from China, India and Malaysia were found to contain 5000 ppm and 78% contained 600 ppm or more, the limit for new paints. In contrast, the comparable levels in a nearby developed country, Singapore were 0% and 9%.Skin contact with dust and dirt containing lead occurs every day. Recent data have shown that inexpensive cosmetic jewelry pieces sold to the general public may contain high levels of lead which may be transferred to the skin through routine handling (ATSDR, 1999).

The exposure of lead via inhalation is when people exposed to lead contamination from the 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 (WHO, 1996).

Prepared food contains small but significant amounts of lead. Lead content is increased when the water used for cooking or the cooking utensils contain lead, or the food, especially if acidic, has been stored in lead-ceramic pottery ware or lead-soldered cans (WHO, 1996). Lanphear et al. (1998) said that dust and soil often constitute a major exposure pathway due to behavior patterns such as hand to mouth activities among infants and young children. The hand to mouth behavior of children increases their lead intake.

## 2.4 Lead in Drinking Water

Basically, lead that is found in lakes, rivers or groundwater used to supply the public with drinking water is very little. The main source of lead in drinking water is due to the continued use of lead pipes, although lead leaching from brass fittings and galvanic corrosion of leaded solder can be problematic in some circumstances (IWA, 2010). According to Chiron et al. (2003), the presence of lead in drinking water is a public health problem due to their absorption and therefore possible accumulation in organisms.

Lead is present in tap water to some extent as a result of its dissolution from natural sources but primarily from household plumbing systems in which the pipes, solder, fittings, or service connections to homes contain lead. PVC pipes also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water (WHO, 1996).

The amount of lead dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness, and standing time of the water, soft, acidic water being the most plumbosolvent (NRC, 1989). According to Levin (1986), although lead can be leached from lead piping indefinitely, it appears that the leaching of lead from soldered joints and brass taps decreases with time.

## 2.5 Health Effects

The effects of lead are well documented and identify a wide range of possible clinical conditions often making medical diagnosis difficult (Hayes et al., 2009). According to ATSDR (2005), the presence of lead in the body can lead to toxic effects, regardless of exposure pathway as lead toxicity involves fundamental biochemical processes. These also include lead's ability to inhibit or mimic the actions of calcium and to interact with.

### 2.5.1 Neurological

The most sensitive target organ of lead toxicity is nervous system. In children, acute exposure to very high levels of lead may produce encephalopathy and other accompanying signs of ataxia, coma, convulsions, death, hyperirritability and stupor

(ATSDR, 2005). Besides, the toxicological effects of lead such as damage nervous systems that can cause low performance and mild retardation are considered to result from chronic rather than short term effect (ATSDR, 2007).

Long-term exposure of adults to lead at work has resulted in decreased performance in some tests that measure functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists, or ankles. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage (ATSDR, 1999).

### 2.5.2 Renal

The earliest pathological evidence of lead exposure in the kidney is the appearance of intranuclear inclusion bodies and alterations in mitochondrial morphology (Ratcliffe, 1981). Lead nephrotoxicity is characterized by proximal tubular nephropathy, glomerular sclerosis and interstitial fibrosis. Acute high dose lead-induced impairment of proximal tubular function manifests in aminoaciduria, glycosuria and hyperphosphaturia and these effects appear to be reversible (ATSDR, 1999).

In study done by Chisolm et al. (1976), the acute lead-induces renal effects appear reversible with recovery usually occurring within two months of treatment in children.

### 2.5.3 Haematological

Numerous case studies have correlated exposure to lead with the concentration of lead in blood, and blood lead concentrations to clinical effects (Hayes, 2010). Lead can induce two types of anaemia, often accompanied by basophilic stippling of the erythrocytes. Acute high-level lead exposure has been associated with hemolytic anaemia.

Haematological effects of lead consist of two types which are interference with haem and haemoglobin synthesis and the other one is effects on erythrocyte morphology and survival. The clinical result of these effects is anaemia (Ratcliffe, 1981).

### 2.5.4 Reproductive effect

A number of studies have examined the potential association between lead exposure and reproductive parameters in humans. The available evidence suggest that occupational and environmental exposure resulting in moderately high PbBs might result in abortion and pre-term delivery in women, and in alterations in sperm and decreased fertility in men (ATSDR, 1999).

## 2.6 Exposure and Risk Assessment

According to Paustenbach (1989), 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.

According to ATSDR (1999), 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.

Basically, exposure and risk assessment involve mainly four main steps which are hazard identification, dose-response assessment, exposure assessment and risk characterization (National Research Council (NRC), 1989). The first two steps are concerned primarily with the properties of particular chemicals and the characterization of expected toxicological effects under a variety of circumstances. Meanwhile, the other second two steps are specific two the particular exposure scenario.

### 2.6.1 Hazard Identification

In this step, various health problems a chemical could cause will be determined by examining the available data about its effect in humans and laboratory animals. The effects maybe either for short term for instance headaches, nausea or throat irritation or long term such as cancer. Paustenbach (1989) stated that hazard identification is involves characterizing the nature and strength of the evidence if causation.

### 2.6.2 Dose- response Relationship

According to USEPA (2005), dose is amount of a substance available for interaction with metabolic process or biologically significant receptors after crossing the outer boundary of an organism. It refers to the determination of the relationship between the magnitude of dose and a specific biological response.

According to Hisyam and Zailina (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.

### 2.6.3 Exposure Assessment

Exposure assessment is the qualitative and quantitative determination of the magnitude, frequency, and duration of exposure and internal dose (USEPA, 1999). Exposure mainly occurs through three main routes; ingestion, inhalation and absorption.

Basically, this study only focus on ingestion route in order to assess exposure associated with lead in drinking water.

### 2.6.4 Risk Assessment

In risk assessment, the data obtained in the dose-response assessment is combined with that obtained in the exposure assessment to yield a numerical estimate of risk (USEPA, 1999). To estimate non-carcinogenic risk, the hazard index (HI) is calculated by dividing CDI with RfD. HI greater than 1 indicates a potential for an adverse effect to occur or the need for further study.

# CHAPTER 3

# METHODOLOGY

## 3.1 Study Location

The study was conducted in Kuala Terengganu, Terengganu as showed in Figure 3.1 which is an area of Kuala Terengganu Municipal Council. Two villages which were covered in this study were Kampung Tok Jembal and Kampung Pak Tijah. The municipal water supply in Kuala Terengganu is managed by Syarikat Bekalan Air Terengganu Sdn. Bhd. (SATU).

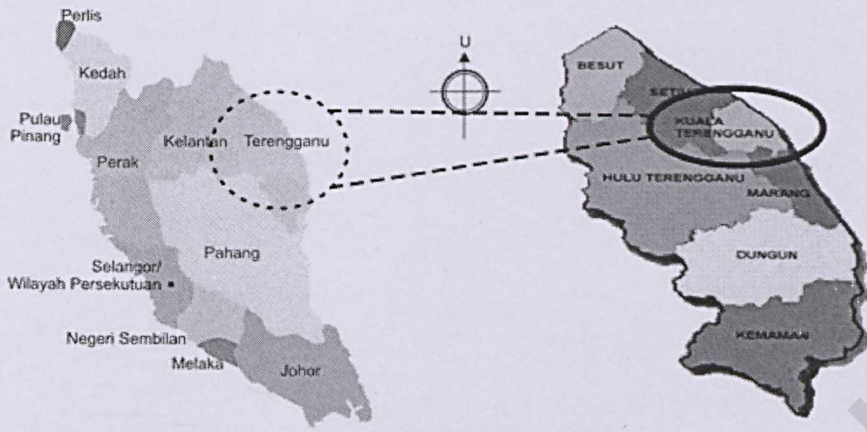


**Figure 3.1: Study Area – Kuala Terengganu, Terengganu**

## 3.2 Study Design

A cross-sectional study design was used in this study to determine the risk of exposure to lead in drinking water among Malays residents in two villages in Kuala Terengganu, Terengganu. This study was relatively easy and economical to conduct in determining characteristic of the drinking water at the selected areas.

## 3.3 Study Population

The study population was the population in two villages in Kuala Terengganu who used tap water as the main source of drinking water.

## 3.4 Sampling

### 3.4.1 Sample Size

The sample size of the study was calculated using the formula by Kirkwood and Sterne (2009):

$$n = \frac{p\,(1-p)}{e^2}$$

Where, n = Sample Size
p = Prevalence
e = Probability Error

According to Zietz et al. (2009), the prevalence of households 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.

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

$$= 27.75$$

To ensure the data to be statistical significant and represent the population of the study and to take into consideration of non-response, samples were increased, bringing to the figures of approximately 100. Apart from that, by increasing the sample size, the missing and damaged data or samples can be controlled. The sample size also was in line with a similar study conducted by Kavcar et al. (2009), who selected 100 respondents to participate in the study. Therefore, 100 respondents who fulfilled the inclusive and exclusive criteria were selected as respondents of the study.

### 3.4.2 Sampling Method

A purposive random sampling method was used in this study. The respondents were selected based on inclusive and exclusive criteria.

i. Inclusive criteria:

- Adult Malaysian aged 18 years and above (Undang-undang Malaysia, 1971)
- Permanent resident
- Respondent who use tap water as main source for drinking and cooking

ii. Exclusive criteria:

- Respondent who used tap water source not from municipal water supply (other source)
- Respondent who used bottled water or well water as the main source for drinking and cooking

### 3.4.3 Sampling Unit

The sampling unit was a resident living in study area who fulfill the inclusive and exclusive criteria.

## 3.5 Study Instrumentation and Data Collection

### 3.5.1 Questionnaire

A resident who fulfill the inclusive and exclusive criteria was invited to be the respondent and administered the questionnaire. The questionnaire were comprises few parts such as socio-demographics of the respondent, health status, water supply and plumbing system in the house.

Basically, the questionnaire used in this study was modified from the Baseline, Descriptive and Time- Activity Questionnaires used in NHEXAS- Arizona study (Lebowitz et al., 1995) and used by Kavcar et al., (2009). The questionnaire has been translated to Bahasa Malaysia since it is the language that will be understood by the respondents.

Two important data collected in the questionnaire were body weight and daily water intake rate. Both data were important parameters to use in estimating the chronic daily intake and hazard index in order to predict the risk levels which are usually practices in risk assessment studies.

### 3.5.2 Water Sample Collection

#### 3.5.3.1 Water Sampling

For the water sampling process, 250 ml high-density polyethylene (HDPE) bottles were used in this study. Previously, HDPE bottles had been used in many studies to detect the heavy metals in the water (Kavcar et al., 2009). Basically, before taking the water sample, the bottles were soaked overnight in 10% acid nitric bath and then wash twice with distilled water. Next, the bottles were let dry in the oven and tightly capped before sealed in plastic bags to avoid contamination from the environment.

During sampling, two replicate of water samples from each of the respondent's house were collected which is the first flush and fully flush. First flush sample is the very first flush of cold water that comes out from the tap after an overnight of stagnation. This sample was collected to determine if lead is has accumulated in the tap water since it is in contact with the plumbing system. For the fully flush, the water samples were collected from the tap after three minutes of flushing. This sample will help to determine if the plumbing system is the source of leakage of lead into the water. Flow diagram of sampling technique is shown in Figure 3.2.

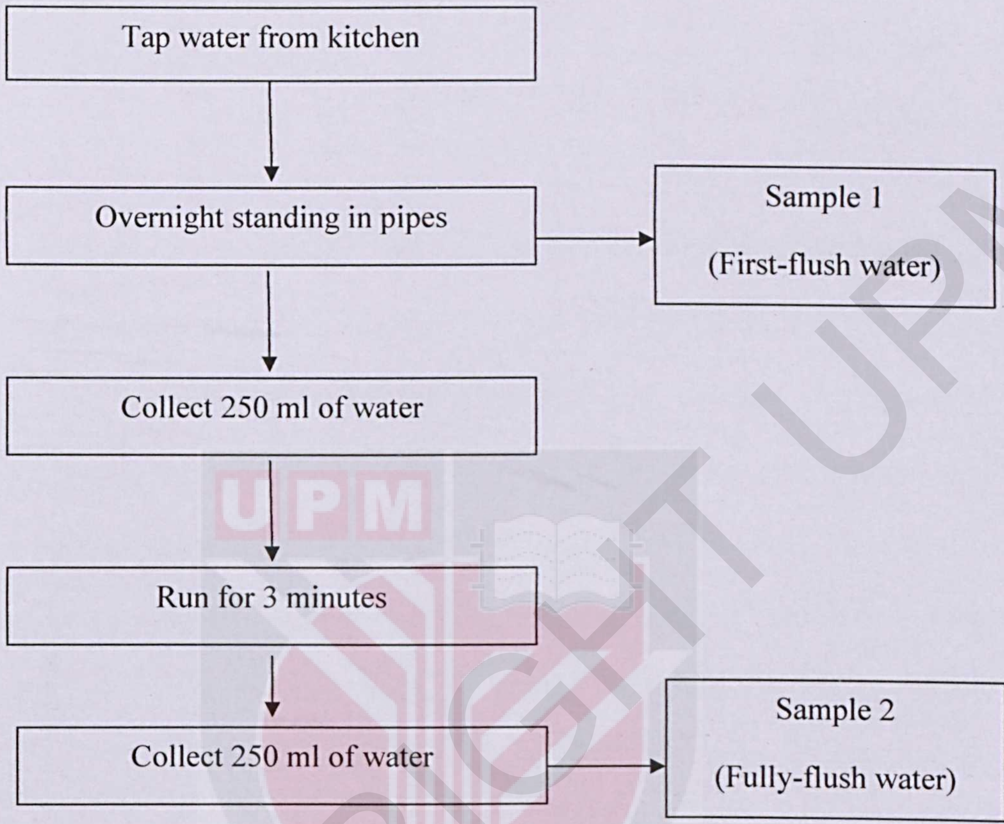


**Figure 3.2: Flow diagram of sampling water technique**

After collection of the water sample into HDPE bottles, 0.5 ml of 69% nitric acids was added to preserve the water samples to pH less than 2 (Kavcar et al., 2009). It is very important to preserve the sample to prevent biological or chemical reactions or both from occurring in the sample. All samples will be stored in the fridge at 4°C until analyzed.

#### 3.5.3.2 Water Sample Analysis

A PerkinElmer® AAnalyst™ 600 Graphite Furnace Atomic Absorption Spectrophotometer which equipped with the intuitive WinLab32™ for AA (Version 6.5) software was used to measure the lead concentration in water samples. This equipment is featured with all the tools to analyze samples, report and archive data. The instrument featured longitudinal Zeeman Effect background correction for graphite furnace analysis. The use of a transverse heated graphite atomizer (THGA) provides uniform temperature distribution across the entire length of the graphite tube (Sorajam, 2011).

Lead hollow cathode lamp is used as the radiation source. The operating conditions of lead hollow cathode is those recommended by the manufacturer, Perkin Elmer as shown in Table 1.1 and the graphite furnace temperature program is shown in Table 1.2.

Table 3.1: Operating conditions of Perkin Elmer AAnalisyst 800 GFAAS

| **Element** | **Plumbum, Pb** |
|---|---|
| Wavelength (nm) | 283.3 |
| Slit with (nm) | 0.7 |
| Mode | AA-BG |
| Current (mA) | 440 |
| Standards (µg/L) | 5.0, 10, 25 |
| Matrix modifier | 0.05 mg $NH_4H\ _2PO_4$ and 0.003 mg Mg $(NO_3)_2$ |

Source: (Sarojam, 2011)

Table 3.2: Graphite furnace temperature program

| **Element** | **Step** | **Temp, °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)

Besides, for the pH measurement, a pH-meter LAMOTTE TRACER ORP PockeTester was used. Basically, this instrument can read the pH instantly by dipping the probe into the water and it can measure the pH from 0.00 to 14.00 with an accuracy of ± 0.01. The readings also are not affected by sample color or turbidity.

## 3.6 Quality Control

### 3.6.1 Standard Operating Procedure (SOPs)

The water sample analysis using Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) model Perkin Elmer AAnalyst 600 follows the standard operating procedures as given by manufacturer. The pH meter also operates with the SOPs given by the manufacturer. The aim of following SOPs is actually to minimize analytical errors during analysis.

### 3.6.2 Calibration

All the instruments that were use in this study are calibrated before running. For GF-AAS Perkin Elmer AAnalyst 600, a calibration curve approximately 1 will be obtained prior to analysis of water samples so that the absorption of lead atom becomes more accurate.

### 3.6.3 Pre-testing

Pre-testing questionnaire was conducted on 10% of sample size before the data collection in order to ensure every question asked in the questionnaires is understood and can be answered by the respondents.

## 3.7 Risk Assessment

According to USEPA (1992), exposure assessment is the qualitative and quantitative determination of magnitude, frequency and duration of exposure and intestinal dose. There are three main routes of exposure which are ingestion, inhalation and dermal absorption. Basically, in this study the only focus is on ingestion route to assess exposure that is associated with lead in drinking water.

To estimate the daily exposure of an individual, USEPA (2005) suggest the average daily dose (ADD) as the exposure metric. The following equation is similar representation of daily exposure for ingestion route modified from the USEPA (1999).

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

Where, CDI = Chronic daily intake (μg/kg/day)

C = Lead concentration in water (mg/L)

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

BW = Body weight (kg)

Values of these three input variables, specific to each participant, were used to estimate the subject's individual chronic daily exposure level. The hazard index (HI) was calculated to estimate non-carcinogenic risk using equation below.

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

Where,

HI = Hazard index

CDI = Chronic daily intake ($\mu g kg^{-1} day^{-1}$)

RfD = Reference dose (mgkg-1 $Day^{-1}$)

A HI value of more than 1 implied a significant risk level. RfD value employed in this study is referred to Provisional Weekly Tolerable Intake (PWTI) of 25μg of lead per kg of body weight (equivalent to 3.5 μg/kg of body weight per day) established by WHO for infants and children but extended to all age groups in 1993 (WHO, 2004).

### 3.8 Ethical Issues

Before the data collection, permission to carry out the study was asked from the ethic committee, Faculty of Medicine and Health Sciences, UPM. The purpose of the study was explained to the respondent and a participation consent form was signed by them before collection of the water samples. The identity of the respondents including their personal information will remain confidential and individual statement or description will not be stated in any part of the study or publication.

### 3.9 Data Analysis

All data was analyzed by using Statistical Package for Social Science software (SPSS for Windows) version 19.0. For the descriptive data such as socio-demographic of the respondents, information regarding water consumption and results of water analysis, it was analyze using descriptive statistics in percentage, means, and standard deviation, ranges, percentiles, maximum and minimum values.

To compare two or more independent variables when underlying distribution was not normally distributed, Kruskal-Wallis test and Wilcoxon sign rank test was applied. Wilcoxon sign rank test was used to determine the differences of lead concentration between first-flush and fully-flush water samples. Besides, Spearmen-rho correlation was used to determine the relationship between two scale data when the data was not normally distributed. In this study, Spearmen-rho used to determine the relationship between lead concentration and other physical property of water such as pH.

## 3.10 Study Limitations

Local studies about lead exposure in drinking water are limited. Therefore, it was very difficult to predict current status regarding lead exposure in drinking water among local residents. Basically, humans are exposes to lead via ingestion, inhalation and dermal contact. However, in this study, only exposure by ingestion was studied.

Besides, this study was prone to recall bias which occurs when to determine the daily intake rate of water among respondents. It happened when each of the respondents had to recall back their water assumption in a day based on a standard cup. Apart from that, in this study there was no biological sample like blood taken from respondents to determine the blood lead level in the body. Thus, causal effect relationship between blood lead concentrations in the water cannot be developed. Furthermore, this study was a cross-sectional study which measure lead exposure during a specific period of time only.

# CHAPTER 4

# RESULTS

## 4.1 Socio-demographic of respondents

The study was conducted on 70 respondents from two villages; Kampung Tok Jembal and Kampung Pak Tijah which located in Kuala Terengganu who fulfilled the inclusive and exclusive criteria stated in the methodology part. The data collection was carried out in January 2012. The socio-demographic data of respondents were summarized in Table 4.1.

Based on sample size calculation, one hundred respondents were needed, however only 70 respondents were involved in this study due to several reasons. There were respondents who did not give cooperation and limited time frame on data collection. Besides, most of the residents in these two villages did not used water from municipal water supply. Instead, they used well water.

In this study, the mean age for respondents was 47.70 years old with a standard deviation of 15.80. The median age range of total respondents was from 21 to 90 years old. In terms of gender, there were 23 (32.9%) male respondents and 47 (67.1%) female respondents. All 70 respondents (100%) were Malay. In this study, 26 (37.1%) respondents had completed primary school education level (UPSR), 5 (7.1%) respondents did not receive any formal education and 14 (20%) respondents had completed their study up to Form Three (PMR). In this study, 19 (27.1%) respondents finished their secondary school (SPM) while 3 (4.3%) respondents had education level up to STPM/Diploma. Besides that, 3 (4.3%) respondents had the highest education level up to a degree holder.

From Table 4.1, 21 (30%) respondents were with monthly income of less than RM 750. 45 (64.3%) of them had monthly income between RM 750 to RM 1999 and the other 4 (5.7%) respondents had high monthly income of RM 2000 to RM 3999.

**Table 4.1: Socio-demographic information of respondents**

| Variable | Mean (SD) | | | Range |
|---|---|---|---|---|
| **Age** | 47.70 (15.80) | | | 21-90 |
| **Variable** | **Category** | **Frequency** | **Percentage, %** | **C. Frequency** |
| **Gender** | Male | 23 | 32.9 | 32.9 |
| | Female | 47 | 67.1 | 100 |
| **Races** | Malay | 70 | 100 | 100 |
| **Education** | None | 5 | 7.1 | 7.1 |
| **Level** | UPSR | 26 | 37.1 | 44.3 |
| | SRP/PMR | 14 | 20 | 64.3 |
| | SPM | 19 | 27.1 | 91.4 |
| | STPM/Diploma | 3 | 4.3 | 95.7 |
| | Degree | 3 | 4.3 | 100 |
| **Income** | <RM 750 | 21 | 30 | 30 |
| | RM 750-RM 1999 | 45 | 64.3 | 94.3 |
| | RM 2000-RM 3999 | 4 | 5.7 | 100 |

**N = 70**

## 4.2 Lead concentration and pH of water

Table 4.2 showed the result of lead concentration and pH of water sample. For lead concentration in the first flush samples, the results ranged from 0.019 μg/L to 20.52 μg/L. The mean (SD) of lead concentration was 2.24 (3.28) μg/L. In fully flush samples, the lead concentration ranged from 0.023 μg/L to 4.623 μg/L. The mean (SD) of lead concentration was 0.55 (0.86) μg/L. Meanwhile, the mean (SD) of pH was 7.26 (0.50). The range of pH value is from 5.35 to 8.14.

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

| Variable | Mean (SD) | Range |
|---|---|---|
| **First flush water sample (lead concentration)** | 2.24 (3.28) | 0.019 – 20.52 |
| **Fully flush water sample (lead concentration)** | 0.55 (0.86) | 0.023 – 4.623 |
| **pH** | 7.26 (0.50) | 5.35 - 8.14 |

**N=70**

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

Figure 4.1 showed that out of 70 first flushed water samples, only two samples were exceeded the permitted value of 10 μg/L as recommended in NSDWQ. Meanwhile, none of fully flushed water samples exceeded the permitted value in NSDWQ (Figure 4.2).

On the other hand, in term of pH, the National Standard of Drinking Water Quality (NSDWQ) was set the acceptable guideline value for pH is ranged from 6.5 to 9. None of the pH of water sample was exceeded the NSDWQ.

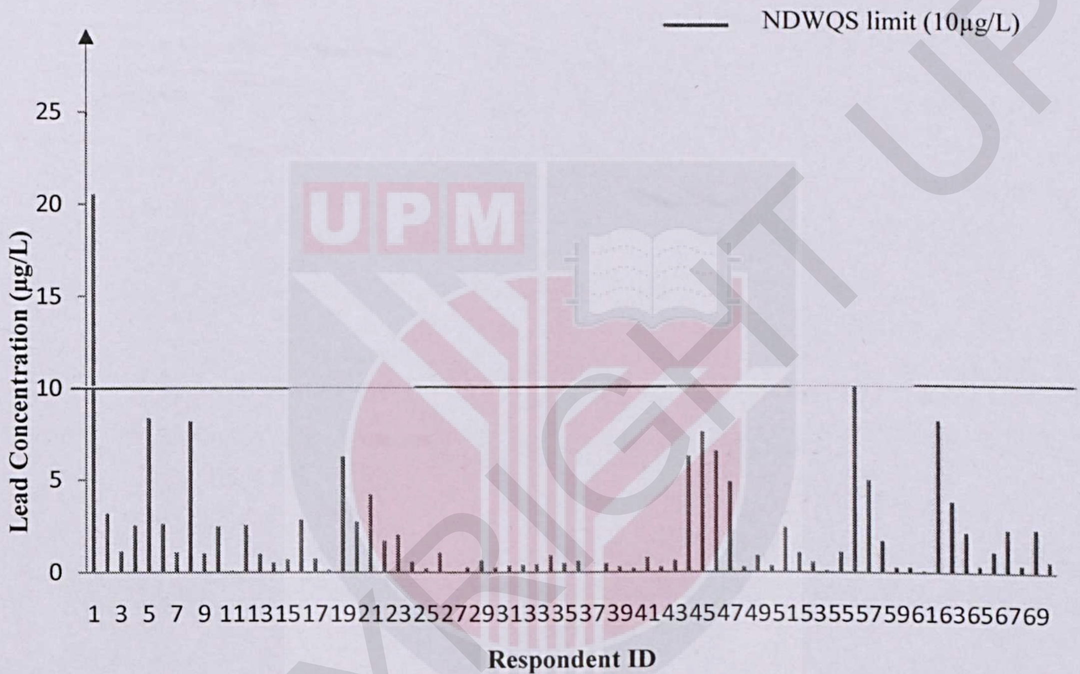


**Figure 4.1: Comparison of lead concentration in first flushed water sample with National Drinking Water Quality Standards (NDWQS)**

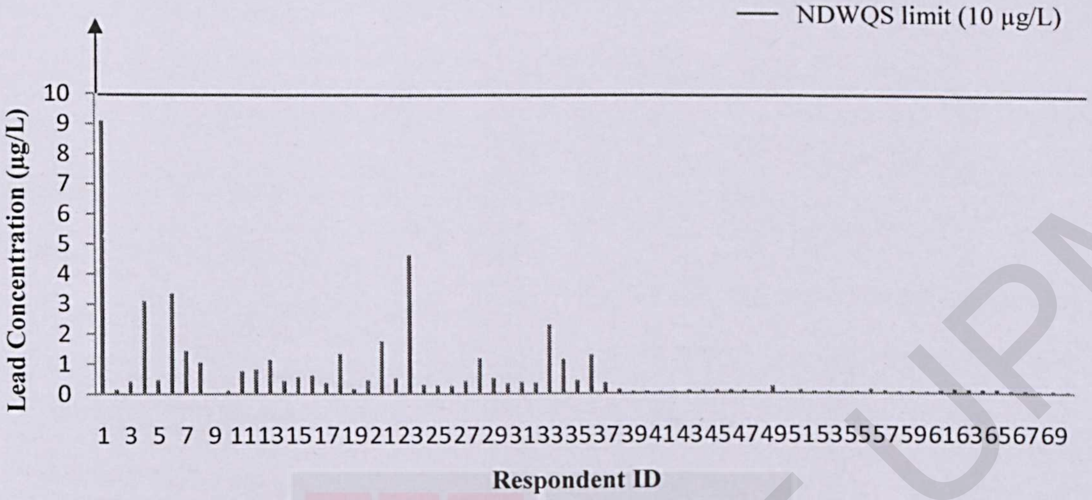


**Figure 4.2: Comparison of lead concentration in fully flushed water sample with National Drinking Water Quality Standards (NDWQS)**

## 4.4 Correlation of lead concentration with pH of water sample

Shapiro-Wilk test showed that the data was not normally distributed ($p < 0.05$), as shown in Table 4.3.

**Table 4.3: Normality test of lead concentration and pH of water sample**

| | Shapiro-Wilk | | |
|---|---|---|---|
| **Test [a]** | | | |
| **Variable** | **Statistic** | **df** | **Sig.** |
| **First flush of water sample** | 0.821 | 70 | 0.000 |
| **Fully flush of water sample** | 0.642 | 70 | 0.000 |
| **pH of water sample** | 0.621 | 70 | 0.000 |

N=70, Significant value at $p<0.05$

Since the data was not normally distributed, Spearman's Rank Order correlation test was run to determine the relationship between lead concentration and pH. The correlation test result was shown in Table 4.4. The test showed there was no correlation between lead concentration in fully flush with pH of water sample *(p>0.05)*.

**Table 4.4: Spearman Rank Order Correlation test of lead concentration with pH of water sample**

| **Variable** | **r** | **p** |
|---|---|---|
| **pH** | | |
| **a. Lead in fully flush water sample** | -0.040 | 0.740 |

**N=70**

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

From Table 4.5, a total of 53 samples had higher lead concentration in first flushed compare to fully flushed, while 17 samples had higher lead concentration in fully flushed compared to first flush samples. For Wilcoxon Signed-Rank Test, the results showed that there was a significance difference between lead concentration levels of first flushed and fully flushed water samples *($Z=-4.696$, $p<0.05$)*.

**Table 4.5: Wilcoxon Signed Ranks Test to compare lead concentration in first flush and fully flush water sample**

| Pair | Rank | N | Mean rank | Sum of ranks | Z | p |
|---|---|---|---|---|---|---|
| **Lead concentration (first flush – fully flush )** | Negative rank | 53[a] | 38.58 | 2045 | 4.696[d] | 0.000 |
| | Positive rank | 17[b] | 25.88 | 440 | | |
| | Ties | 0[c] | | | | |
| | Total | 60 | | | | |

**N=70**

a. Lead concentration (fully flush < first flush)

b. Lead concentration (fully flush > first flush)

c. Lead concentration (fully flush = first flush)

d. Based on positive rank

### 4.6 Exposure assessment

Table 4.6 showed the results for daily water intake (DI), body weight (W) and chronic daily intake (CDI) of respondents. For daily water intake, the mean (SD) was 1.48 (0.31) L/day while the range was from 0.40 L/day to 2.00 L/day.

For body weight, the mean (SD) was 57.16 (12.10) kg while the range was from 36 kg to 85 kg. On the other hand, for CDI, the mean (SD) was 0.078 (0.035) µg/kg/day while the range was between 0.01 µg/kg/day to 0.82 µg/kg/day.

**Table 4.6: Daily water intake of water (DI), Body weight (W) and CDI of respondent**

| | DI (L/day) | W(kg) | CDI (µg/kg/day) |
|---|---|---|---|
| **Mean** | 1.48 | 57.16 | 0.078 |
| **Median** | 1.60 | 56.00 | 0.035 |
| **SD** | 0.31 | 12.10 | 0.117 |
| **Min** | 0.40 | 36 | 0.01 |
| **Max** | 2.00 | 85 | 0.82 |

**N=70**

## 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 the potential for an adverse effect to occur. Table 4.7 showed the results of HI calculation of respondents. The range of HI was from 0.00 to 0.42, while the mean (SD) was 0.0442 (0.697) and the median was 0.0198. As showed in Table 4.8, all respondents had the HI of less than 1.

**Table 4.7: Hazard Index (HI) of respondent**

| HI | Frequency | % | Mean (SD) | Med(IQR) | Range |
|---|---|---|---|---|---|
| **<1** | 70 | 100 | 0.0442 (0.697) | 0.198(0.04) | 0.00-0.42 |
| **>1** | 0 | 0 | 0.0 (0.0) | 0.0(0.0) | - |

**N=70**

# CHAPTER 5

# DISCUSSION, CONCLUSION AND RECOMMENDATIONS

## 5.1 Socio demographic data of the respondents

According to the result as summarized in Table 4.1, there were 70 respondents involved in this study. The age of respondents ranged from 21 to 90 years old, with a mean of 47.70 years old and standard deviation of 15.80. The age group with highest number of respondents was 28-37 years old (26.8%). All in all, 90% of the respondents were below 67 years old.

According to Table 4.1, this study was involved all the Malay residents who is living in two villages in Kuala Terengganu. This study was comprised of more female respondents (67.1%) compared to the male because most of the time, the study was conducted during weekdays where only housewives and elderly were at home. In term of education level, most of the respondents (37.1%) have finished their primary school only.

**5.2 Lead concentration and pH of water**

The mean (SD) of lead concentration in first flush water samples was 2.24 (3.28) as showed in Table 4.2. The highest lead concentration was 20.52 µg/L where as the lowest lead concentration was 0.019 µg/L. In Germany, samples from all parts of the country were analyses in a representative study of the 18 to 69-year-old population in the years 1997 – 1999 (Becker et al., 2001). The mean lead concentration in the 4761 collected stagnation samples was 1.7 µg/L which slightly lower as compared to this study.

In fully flush samples, the mean (SD) of lead concentration was 0.55 (0.86) µg/L. There was a huge different between the concentration of lead in first flush and fully flush water samples. In fully flush water samples, the highest lead concentration was 0.023 µg/L while the lowest lead concentration was 4.623 µg/L. Meanwhile, the mean (SD) of pH was 7.26 (0.50) with median at 7.31. The range of pH value is from

5.35 to 8.14. The result was in line with similar study conducted by Deshommes et al., (2010) who found that the mean pH value of water samples was 7.65 which were indicated the pH was slightly basic.

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

The acceptable value for lead concentration in drinking water recommended by Ministry of Health in National Drinking Water Quality Standards for Malaysia (NDWQS) is 10μg/L. The study showed that 2 samples of first flush water had exceeded the standard value of 10μg/L. The highest concentration was found to be two times higher than the standard value, at 20.52μg/L. According to WHO (1996), high level of lead in water was very serious because lead was a toxic heavy metal that would affect human health in many aspects.

Furthermore, a study done in Sydney metropolitan area by Rajaratnam et al., (2001) found that the concentration of lead in first flush water sample was very high, with mean lead (SD) content at 29 (42) μg/L. They found that 60% of the first flush water samples collected were exceeded the Australian Drinking Water Guideline (ADWG) limit value of 10μg/L. As compared with this study, the mean lead concentration of Sydney was 14 times higher than Kuala Terengganu in first flush water samples. The huge difference of lead concentration between this study and Rajaratnam's study may be due to houses' age. Rajaratnam et al. (2001) focused on new houses only while this study did not take into consideration the age of houses as the inclusive criteria for sampling. New house less than 5 years old or residence in which recent plumbing renovation or repairs had been completed, has the potential of producing higher lead exposure than older housing (Sharrett et al., 1982).

A study done by Fertmann et al. (2004) showed the data from a recent representative survey in Germany found out 9.2% of 3226 samples of stagnant water range above the WHO-limit value of 10μg/L. Yet, in Lower Saxony 3.1% of 1434 tap water samples of stagnant water had lead concentrations of more than 10μg/L. Besides, in Berlin, out of 2109 households were sampled, the researchers found out that 7.1% of the samples were exceed10μg/L (Zietz et al. 2001).

However, lead concentration in fully flush water samples was lower compared to the first flush water samples. None of the water samples had exceeded the NDWSQ value of 1/L. Among 248 water samples collected in Hamburg, less than 25% of fresh water samples taken after 3 minutes of flushing had exceeded 10μg/L. It showed that lead concentration in fully flush water samples was low (Fertmann, 2004). Referring to the whole population, Conio et al. (1996) found 53% of tap water samples to be above the WHO value in the old town of Genoa (Italy) and 21% to be elevated in other zones of the town.

In term of pH as showed in Table 4.2, the mean (SD) was 7.26 (0.50) while it range from 5.35 to 8.14. The acceptable guideline value for pH according to NSDWQ ranged from 6.5 to 9. Thus, none of the sample exceeded the NSDWQ. A study done by Zietz et al., (2003) in Lower Saxony, Germany was in line with this study which the tap water was slightly basic and the mean pH value was 7.83.

### 5.4 Correlation of lead concentration with pH of water sample

Table 4.4 showed the correlation of lead concentrations with pH of water samples. The test showed no correlation between lead concentrations in first flush and fully flush with pH of water sample. Thus, the result was in line with the study done by Kim and Herrera (2011), which the researchers found that there was no significant correlation between lead concentration and pH. Le et al. (2003) also concluded that there was no correlation between lead in tap water and pH levels.

Previously, there was study proved that there was a relationship between lead concentration and pH of water. In a study of drinking water with a low alkalinity and a fairly low pH , high levels of lead were found in the drinking water of households that had lead plumbing (McFarren et al., 2007). The lead solubility of corrosion scale is strongly dependent on pH, increasing at low pH values and decreasing as pH increased (Kim et al., 2011). However, according to ATSDR (1999), lead concentration can be considerably higher at lower ph value ($<7$), particularly for low alkalinity water such as very soft water that common in upland areas.

## 5.5 Comparison of lead concentration in first flushed and fully flushed water sample

Table 4.5 showed that 53 samples had higher lead concentration in first flush compared to fully flush water. The results from Wilcoxon Signed Ranks Test showed that there was a significance difference between lead concentration levels of first flush and fully flush water samples ($Z=4.696$, $p<0.05$). Hence, the research hypothesis was not rejected.

One of the reasons which cause the first flush water to have higher lead concentration compared to fully flush was due to the standing time of water in the pipe. In this study, water standing time at least 6 hours was used as the criterion for an acceptable standing time. There were several studies found that first flush water had higher lead concentration than fully flush water because of standing time. Lead levels rapidly increase upon stagnation but ultimately approach a fairly constant equilibrium value after overnight stagnation (Schock et al., 1996). Lead levels increased rapidly with the stagnation time of the water, with the most critical period being during the first 20-24 hours (Schock et al., 1996).

According to ATSDR (1999), there is greater problem with longer lengths of lead piping than for shorter length, and for any given length of pipe, the lead released will be greater for large pipe diameter. Apart from that, the result of this study was in line with a study done in Sydney which the researchers found that lead concentration were significantly different in the three types of samples. Multiple-comparison tests showed that lead levels in first flush water were significantly higher than those in either post first flush or fully flush samples (Rajaratnam et al, 2001). Besides that, in New York City as of 2003 approximately 15% of all residences are estimated to have first draw tap water lead levels exceeding 10 mg/l. This estimation is based on a free testing programme offered by the city of New York to residents since early 1995 (Maas et al., 2005).

**5.6 Exposure assessment**

The daily water intake that obtained during data collection was showed in Table 4.6. According to USEPA, average of daily water intake is 2 L/day for an adult weight of 70 kg. It was to avoid overestimation or underestimation of population risk (Kavcar et al., 2006).

For the exposure assessment, chronic daily intake (CDI) were calculated for each respondent based on their daily drinking water intake, body weight and total lead concentration that was obtained in water sample. The range was from 0.01 to 0.82 µg/kg/day.

**5.7 Risk assessment**

In term of risk assessment, non-carcinogen risk was calculated using the hazard index (HI). Hazard index was calculated by dividing the CDI value with reference dose (RfD). Basically, RfD was not developed by USEPA IRIS, but a PTWI value developed by Joint FAO/WHO Expert Committee on Food Additives (JECFA) was used as the reference dose.

In this study, the hazard index level was ranged from 0 to 0.42. Hazard index that is greater than 1 indicate there is a potential for an adverse effect to occur or the need for further study (Kavcar, 2006). None of the hazard index had exceeded 1 in this study. It indicates that the non-carcinogen risk of exposure to lead in tap water among residents of two villages in Kuala Terengganu was negligible or the risk was acceptable.

## 5.7 Conclusion

In this study, out of 70 water samples collected, only 2 samples of first flushed were exceeded the standard value of 10µg/L as recommended by National Standard of Drinking Water Quality 2009 (NSDWQ) developed by Ministry of Health Malaysia. None of the fully flushed water samples were violated the standard value. Results showed that the concentration of lead was not related to the pH of water sample, and the lead concentrations in first flushed had a significantly higher than fully flushed of water samples.

For the health risk assessment in two villages in Kuala Terengganu, the calculation of hazard index, the value was less than 1. This means the concern of the exposed individual get adversely health effect is low.

## 5.8 Recommendations

Recently, communities were more concerned about health risks posed by contamination in drinking water. Hence, the preventive health behavior is one such measure can be used to minimize the lead exposure in drinking water. For instance, practicing of flushing household water supplies for three minutes after prolonged standing can effectively reduce lead contamination levels well below NDWQS guideline values.

In order to minimize 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 like Jabatan Bekalan Air (JBA) and District Health Office those are responsible to manage and check the quality of water treatment need to do some periodic monitoring of water quality at the residents homes, as well as at the water treatment plant.

Besides, Ministry of Health and District Health Office can organize lead prevention program to the publics by identify and carry out full replacement of all lead plumbing systems for resident's home who still used that 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.

In addition, in order to increase the awareness among public towards safe drinking water, the collaboration between related agencies such as Ministry of Health, District Health Office and mass media can be done by spread out the related health information to the public in various medium such as through pamphlet, poster, television advertisement and health campaign or health talk.

## REFERENCES


ATSDR, (1999), *Toxicological Profile for Lead.* Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, GA.

ATSDR, (2005), *Toxicological Profile for Lead.* Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, GA.

ATSDR, (2007), *Toxicological Profile for Lead.* Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, GA.

Becker K, Kaus S, Helm D, Krause C, Meyer E, Schulz C, Seiwert M. (2001). Umwelt-Survey – 1998, Band IV: Trinkwasser – Elementgehalte in Stagnationsproben des ha¨uslichen Trinkwassers der Bevo¨ lkerung in Deutschland. Berlin: WaBoLu-Hefte, Umweltbundesamt.

Calderon, R. L. (2000). The epidemiology of chemical contaminants of drinking water. *Food and Chemical Toxicology, 38* (Supplement 1), S13-S20

Clark, C. S., Rampal, K. G., Thuppil, V., Chen, C., Clark, R., & Roda, S. (2006). The lead content of currently available new residential paint in several asian countries. *Environmental Research, 102*(1), 9-12

Chiron, N., Guilet, R., &Deydier, E. (2003). Adsorption of cu (II) and pb (II) onto a grafted silica: Isotherms and kinetic models.*Water Research, 37*(130) 3079-3086

Chisolm JJ, Mellits ED, Barrett MB. (1976). Interrelationships among blood lead concentration, quantitative daily ALA-U and primary lead output following calcium EDTK. In: Nordberg GF, ed. Proceedings of third meeting of the subcommittee on the toxicology of metals under the Permanent Commission and International Association on Occupational Health, November 1974, Tokyo, Japan. Amsterdam, Netherlands: Elsevier Publishing Co., 416-433.

Conio O, Ottaviani M, Formentera V, Lasagna C, Palumbo F. (1996). Evaluation of the lead content in water for human consumption. Microchem J 54:355 – 359.

Deshommes. E., Laroche.L., Nour. S., Cartier. C. & Pre´vost. M. (2010). Source and occurrence of particulate lead in tap water. *Water Research 44*: 3734-3744

Fertmann, R., Hentschel, S., Dengler, D., Janben, U., & Lommel, A. (2004). Lead exposure by drinking water: An epidemiological study in Humburg, Germany. *International Journal of Hygiene and Environmental Health, 207*(3), 235-244

Francois, C., Meyer, M., Bucaille, A., Guilard, R. (2005). A molecular approach to remove lead from drinking water. *Journal of Molecular Liquids, 118*(2005), 89-99

Hayes, C. (2010). Guide for Small Community Water Suppliers and Local Health Officials on (Ed.), *Lead in Drinking Water*(pp.1-15). London: IWA Publishing

Hayes, C. R. & Skubala, N.D. (2009). Is there still a problem with lead in drinking water in the European Union. *Journal of Water and Health, 07*(4) 569-580.

International Water Association (IWA), (2010). Best Practice Guide on the Control of Lead in Drinking Water.In press, IWA Publishing. ISBN 9781843393696

Hisham, N. Z. (2010). Social Problems and its Relationship with Family Institution in Felda Settlements: the Local Perspective. *European Journal of Social Sciences – Volume 14, Number 3*.

Kavcar,P., Sofunglu, A., & Sofunglu S.C. (2009). A Health Risk Assessment for Exposure to Trace Metals via Drinking Water Ingestion Pathway. *International Journal Hygiene Environmnetal Health*, 212(2),216-227.

Kim, E. J., Herrera, J. E., Huggins, D., Braam, J., & Koshowski, S. (2011). Effect of pH on the concentrations of lead and trace contaminations in drinking water: A combined batch, pipe loop and sentinel home study. *Water Research, In Press, Accepted Manuscript*

Kirkwood, B. R., Sterne, J. A. C. & Kirkwood, B. R. (2009). *Essential Medical Statistics*

King, M., Ramachandran, V., Prengaman, R.D., DeVito, S. C., Breen, J., & Updated by Staff. (2000). *Lead and lead alloys* John Wiley & Sons, Inc.

Lanphear, B. P., Dietrich, K., Auinger, P., & Cox, C. (1998). Cognitive deficits associated with blood lead concentrations < 10 microg/Dl in US children and adolescent. Public Health Reports (Washington, D.C: 1974), 115(6), 521-529

Lansdown, R., Yule, W. (1986). *The Lead Debate: The Environment, Toxicology and Child Health*. Australia: British Library Cataloguing

Le, V., Gansky, S., & Newbrun, E. (2003). Fluoride and lead concentrations related to pH in drinking water. *32nd Annual Meeting and Exhibition of the AADR*

Lebowitz MD, O. M., Gordon S, M. D., & Buckley M, T. N. (1995). Population based exposure measurements in Arizona: a Phase I field study in support of the National Human Exposure Assessment Survey. *Journal of Exposure And Environmental Epidemiology*, 5: 297–326.

Maas R. P., Patch S. C., Morgan DM, Pandolfo TJ. (2005). Reducing lead exposure from drinking water: Recent history and current status. *Public Health Rep 120*:316 – 321.

Matte, T., & Jacobs, D. (2000). *Housing and health- Current issues and implications for research and programs* Springer New York.

Ministry of Health. (2009). *National Standard for Drinking Water Quality*. Malaysia:Percetakan National Malaysia Bhd.

National Research Council (NRC). (1989). Recommended dietary allowances, 10th ed. Washington, DC, National Academy Press,

Pacyna J. M & Pacyna, E. G. (2001): An assessment of global and regional emissions of trace metals to the atmosphere from anthropogenic sources worldwide. *Environmetal Reviews* 9: 269-298

Payne, M. (2008). Lead in drinking water. CMAJ: *Canadian Medical Association Journal, 179*(3), 253-254

Paustenbach, D. J. (1989). *The Risk Assessment of Environmental and Human Hazard: A Textbook of Case Study* . United States: A Wiley-Interscience Publication.

Rajaratnam, G., Winder, C., &An, M. (2000). Metals in drinking water from new housing estates in the Sydney area. *Environmental Research, 89(2),* 165-170

Ratcliffe, J.M. (1981). *Lead in Man and Environment.* London: Ellis Horwood Limited.

Richardson, G., M., Garret, R., Mitchell, I., Mah-Poulson, M., & Hackbarth, T. (2001). Critical Review on natural global and regional emissions of six trace metals tp the atmosphere. *Prepared for the International Lead Zink Research Organisation, the International Copper Association, and the Nickel Procedures Environmental Research Association*

Sarojam, Praveen (2011, September 9). Analysis of Pb, Cd and As in Tea Leaves Using Graphite Furnace Atomic Absorption Spectrophotometry. SciTopics. Retrieved May 23, 2012, from http://www.scitopics.com/Analysis_of_Pb_Cd_and_As_in_Tea_Leaves_Using_Graphite_Furnace_Atomic_Absorption_Spectrophotometry.html

Sharrett, A. R., Carter, A. P., Orheimt, R. M., & Feinleib, M. (1982). Daily intake of lead, cadmium, copper, and zinc from drinking water: The seattle study of trace metal exposure. Environmental Reserach, 28(2), 456-475

Schock, M. R., Wanger, I., & Oliphant, R. (1996). The corrosion and solubility of lead in drinking water. *International Corrosion of Water Distribution Systems*, 131-230.

Undang-undang Malaysia. (1971). *Akta Umur Dewasa.* Malaysia.

United State Environmental Protection Agency (1992). Guidelines for Exposure Assessment. EPA/600/ Z-92/001. US Environmental Protection Agency, Risk Assessment Forum, Washington, DC.

United State Environmental Protection Agency. (1999). Guidance for Performing Aggregate Exposure and Risk Assessments. US Environmental Protection Agency, Office of Pesticide Programs, Washington, DC.

United State Environmental Protection Agency. (2005). *Guidelines for Carcinogen Risk Assessment,* EPA/630/P-03/001F. US Environmental Protection Agency, Risk Assessment Forum, Washington, DC.

World Health Organization. (1996). *Guidelines for drinking water quality.vol 2, health criteria and other supporting information.* World Health Organization.

World Health Organization. (2004). *Guidelines for Drinking Water Quality.* Third Edition, Volume 1, Recommendations, World Health Organization, Geneva.

World Health Organization. (2007). *Health risk of heavy metals from long-range transboundary air pollution.* Regional Office for Europe., & Joint WHO/Convenction Task Force on the Health Aspects of Air Pollution. Copenhagen: World Health Organization Regional Office Europe.

Zietz. B. P., Lass, J. D., Kevekordes, S., Dunkelberg, H. (2001). Lead contamination in tap water of households with children in Lower Saxony, Germany. *The Science of the Total Environment 275*: 19-26

Zietz. B. P., Dassel de Vergara, J., & Dunkelberg, H. (2003). Copper concentrations in tap water and possible effects on infant's health- Result of a study in Lower Saxony, Germany. *Environmental Research, 92*(2): 129-138

Zietz, B. P., Lass, J., Dunkelberg, H., & Suchenwirth, R. (2009). Lead pollution of drinking water in lower Saxony from corrosion of pipe materials. Journal *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)), 71*(5), 265-274

Zietz B. P, Lab, J., & Suchenwirth R., D. H. (2010). Lead in Drinking Water as a Public Health Challenge. *Environmental Health Perspectives*, p. 154.

FAKULTI PERUBATAN DAN SAINS KESIHATAN
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SELANGOR, MALAYSIA

# PENERANGAN KEPADA PESERTA

**TAJUK KAJIAN:**

**Kajian Risiko Kesihatan terhadap Pendedahan Plumbum di dalam Air Minum di Dua Buah Kampung di Kuala Terengganu, Terengganu.**

**Terima kasih kerana membantu kami di dalam kajian ini.**

**1. Apakah kajian ini?**

**Kajian ini adalah berkaitan dengan risiko kesihatan terhadap plumbum di dalam air minum di kalangan responden. Kandungan plumbum dalam air minum boleh menyebabkan kesan kesihatan terhadap sistem saraf pusat serta penyebab kepada pencapaian IQ yang rendah terutamanya di kalangan kanak-kanak.**

**2. Apakah tujuan kajian ini?**

**Kajian ini dijalankan bertujuan untuk mengkaji risiko kesihatan terhadap pendedahan plumbum di dalam air minum. 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 di Kampung Tok Jembal dan Kampung Pak Tijah, Kuala Terengganu. Seramai 70 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 penyelidik.**

**5. Adakah bayaran dikenakan?**

**Penyelidik 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 penyelidik.

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.

MAISARAH BINTI ZAKARIAH

Penyelidik

B. Sc. Kesihatan Persekitaran dan Pekerjaan

Unit Kesihatan Persekitaran dan Pekerjaan

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**BORANG PERSETUJUAN RESPONDEN**

**TAJUK KAJIAN: Kajian Risiko Kesihatan Terhadap Pendedahan Plumbum di dalam Air Minum di Dua Buah Kampung di Kuala Terengganu, Terengganu.**

**PENYELIDIK: MAISARAH BINTI ZAKARIAH**

Saya……………………………………………………………………No.K/P……………………………………
alamat di ………………………………………………………………………………………………………………
……………………………………………………… 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 mengkaji risiko kesihatan terhadap pendedahan plumbum di dalam air minum di kalangan penduduk di dua buah kampong di Kuala Terengganu, Terengganu.

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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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 ……………………………………… (Penyelidik)

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 Negeri Sembilan ☐ 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 domestik
   ☐ 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

**Terima kasih atas kerjasama anda.**

**TAMAT**