UNIVERSITI PUTRA MALAYSIA

RISK ASSESSMENT OF ALUMINIUM RESIDUE CONCERNTRA TION IN DAILY INTAKE BY HUMAN FROM DRINKING TAP WATER, FELDA JENDERAK SELATAN, TEMERLOH, PAHANG

BY
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ABSTRACT

RISK ASSESSMENT OF ALUMINIUM RESIDUE CONCERNTRATION IN DAILY INTAKE BY HUMAN FROM DRINKING TAP WATER, FELDA JENDERAK SELATAN, TEMERLOH, PAHANG

NUR AQMA MADIHA MAZELAN

Introduction: Aluminium sulphate or alum is widely used in the purification of waste water as well as raw water from rivers, lakes and reservoirs. It is a flocculating agent with the capacity to coagulate and trap solid matter that may be floating in the water, such as algae and other organic and non-organic matter. The main objective in this study is to determine health risk assessment of exposure to aluminium levels in drinking water at Felda Jenderak Selatan, Temerloh, Pahang. **Methodology:** This cross-sectional study was conducted in Felda Jenderak Selatan, Temerloh, Pahang. To participate in this study, 95 respondents were selected. Two water samples were taken from each respondent's house. The water samples were preserved using nitric acid and then analysed using a Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) to determine aluminium levels in each water sample. Body weight of respondents was also measured using a Tanita Body Weight Scale and an interview session was conducted in order to gather information on the respondents' water daily intake and socio-demographic background. The health risk was calculated using equation based on the information given by the respondents. **Results:** The results showed that 84.2% of water samples exceeded the safe limit of National Drinking Water Quality Standard of Malaysia for aluminium is 0.2mg/L. The value of mean $\pm$ SD for aluminium levels in water samples was 0.3955 ± 0.2264 mg/L. The value of mean $\pm$ SD for pH level in water samples was 6.87 ± 0.2334. There was a significance difference between aluminium level and Malaysian Drinking Water Quality Standard ($Z = 0.02$, $p<0.05$). Pearson Correlation test showed that was a significant relationship between aluminium levels in water samples and pH level. After calculating health risk to aluminium exposure in drinking water, the health index (HI) value is less than 1, showing that there was no risk or the risk was acceptable.

Keywords: **Risk assessment, aluminium, human, drinking tap water, Felda Jenderak Selatan.**

ABSTRAK

KAJIAN RISIKO KESIHATAN TERHADAP PARAS SISA ALUMINIUM DIDALAM AIR MINUM HARIAN DI FELDA JENDERAK SELATAN, TEMERLOH, PAHANG

NUR AQMA MADIHA MAZELAN

Pendahuluan: Aluminium sulfat atau alum digunakan secara meluas dalam penulenan air kumbahan serta air dari sungai, tasik dan takungan. Ia adalah ejen flokulasi dengan kapasiti untuk bergumpal dan memerangkap bahan pepejal yang boleh terapung di dalam air, seperti alga dan perkara lain organik dan bukan organik. Objektif utama dalam kajian ini adalah untuk menentukan penilaian risiko kesihatan pendedahan kepada tahap aluminium di dalam air minuman di Felda Jenderak Selatan, Temerloh, Pahang**. Kaedah:** Kajian keratan rentas ini telah dijalankan di Felda Jenderak Selatan, Temerloh, Pahang. Seramai 95 orang responden telah dipilih untuk mengambil bahagian dalam kajian ini. Dua sampel air telah diambil dari setiap rumah responden, bagi mengekalkan sampel air, asid nitrik telah digunakan dan sample air telah dianalisis menggunakan Spektrometer Serapan Atom Relau Grafit (GFAAS) dalam menentukan tahap aluminium dalam setiap sampel air. Selain itu, berat badan responden juga mengukur menggunakan Skala Berat Badan TANITA dan sesi temubual juga dilakukan untuk mengetahui pengambilan air responden harian, latar belakang sosio-demografi dan status kualit bekalan air. Risiko kesihatan telah dikira untuk setiap responden menggunakan persamaan yang berdasarkan maklumat yang diberikan oleh responden. **Keputusan:** Hasilnya menunjukkan bahawa 84.2% daripada sampel air telah melebihi had atas Standard Kualiti Air Minum Kebangsaan Malaysia (> 0.2mg / L). Nilai bermakna + SD untuk tahap aluminium dalam sampel air min 0,3955 ± 0,2264 mg / L. Nilai bermakna + SD untuk paras pH dalam sampel air adalah 6,87 ± 0,2334. Terdapat perbezaan yang signifikan antara tahap aluminium dan Standard Kualiti Air Minum Malaysia dengan ($Z = 0.02$, $p < 0.05$). Ujian korelasi Pearson juga menunjukkan bahawa terdapat hubungan yang signifikan antara tahap aluminium dalam sampel air dan tahap pH. Setelah membuat pengiraan risiko kesihatan pendedahan aluminium di dalam air minuman, didapati tiada risiko atau risiko adalah boleh diterima.

***Kata Kunci:* Risiko kesihatan, aluminium, manusia, air minuman, Felda Jenderak Selatan.**

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LIST OF ACRONYMS AND ABBREVIATIONS

Al	Aluminium
AD	Alzheimer's Disease
ADWG	Australian Drinking Water Guidelines
ATDSR	Agency for Toxic Substances and Disease Registry
CDI	Chronic Daily Intake
HI	Hazard Index
IST	Individual Septic Tanks
mg/L	milligram per liter
NSDWQ	National Standard for Drinking Water Quality
RfD	Reference Dose
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
$\mu g/m^3$	microgram per meter cubic

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia has a high abundant rainfall, averaging 3,000mm annually, the equivalent of 990 billion cubic meters of water over the country, thanks to its equatorial climate. It is also a country with an extensive river system consisting of more than 150 river that provide the country with more than 25,000 cubic meters of renewable water per capita per year according to an Edge report in June 2002. Renewable water is water that comes down as rain and flows down rivers every year. The amount of renewable water that Malaysia receives far exceeds that of many other parts of the world (Ministry of Energy, Green Technology and Water, 2009).

In Malaysia extensive use has been made of primary treatment systems such as communal septic tanks and imhoff tanks and unreliable low cost secondary systems such as oxidation ponds. In addition, large urban areas utilize Individual Septic Tanks (IST). It is estimated that there are over one million individual septic tanks in Malaysia. These tanks only partially treat sewage, discharging an effluent still rich in organic material. This has the potential to create public health and environmental problems, particularly in urban areas (Indah Water Konsortium Sdn. Bhd., 2011).

Residual in the treated water may bring adverse health effects to human beings that consume the tap water daily. Especially in coagulation process, $Al_2(SO_4)_3$ (alum) plays a vital role in coagulating sediments. Despite the usefulness of Aluminium (Al), it is undeniably a powerful neurotoxicant that may play a role in the aetiology or pathologenesis of Alzheimer's disease (AD) (Flaten, 2001).

Al has been shown to play a causal role in dialysis encephalopathy and epidemiological studies suggest a possible link between exposure to this metal and a higher prevalence of AD (Flaten, 2001). This association dependent on the duration of Al exposure and only becomes significant if an individual has resided in an area with high Al in drinking water (>100 Ag/L) for several years (Becaria et al, 2005). The potential of Al as a major cause of neurological disease was not realised until approximately 15 years after the emergence, in the early 1960's, of haemodialysis as a successful treatment for patients with end stage renal disease (Altmann, 2001).

Al is released to the environment mainly by natural processes. Several factors influence Al mobility and subsequent transport within the environment. These include hydrological flow paths, soil–water interactions, and the composition of the underlying geological materials. Acid environments caused by acid mine drainage or acid rain can cause an increase in the dissolved Al content of the surrounding waters (WHO, 1998).

The concentration of Al in natural waters can vary significantly depending on various physicochemical and mineralogical factors. Dissolved Al concentrations in waters with near-neutral pH values usually range from 0.001 to 0.05 mg/litre but rise to 0.5–1mg/litre in more acidic waters or water rich in organic matter. At the extreme acidity of waters affected by acid mine drainage, dissolved Al concentrations of up to 90mg/litre have been measured. Al levels in drinking-water vary according to the levels found in the source water and whether Al coagulants are used during water treatment (WHO, 1998).

The permitted level of Al in drinking water must not surpass 0.2 mg/L (or 200μg/L), according to World Health Organisation (1998). The United States Environmental Protection Agency (USEPA, 1992), through its Secondary Drinking Water Regulations, has put a 0.05 to 0.2mg/L limit to Al concentration in drinking water. The Malaysia Ministry of Health established the National Standard for

Drinking Water Quality (NSDWQ) in 1983, with limit of Al concentration 0.05 to 0.2mg/L in drinking water (MOH, 2004).

1.2 Problem Statement

Al or iron residues from coagulation may create aesthetic quality issues downstream of treatment. In the early 1990s, Al used for water treatment was implicated as a contributory cause of senile dementia (Alzheimer's disease). Although a causal link does not seem to have been proven, as a result many water utilities came under pressure from consumers to eliminate the use of Al chemicals as coagulants, despite their effectiveness at ensuring high microbiological quality (Bates, 2000).

Residual Al in treated water is due to a portion of the alum added to the raw water is not removed during treatment. The occurrence of Al in treated water has been considered for many years to be an undesirable aspect of treatment practice. This has become a great concern throughout the world over the levels of Al found in raw water and treated drinking water (Srinivasan et al, 1999).

With the development of modern industry, acid precipitation is becoming more and more common. This has led to a large amount of Al dissolving from soil to natural waters, which may increase the concentration of residual Al in drinking waters. Moreover, Al salts are widely used as coagulants in drinking water treatment processes. Although they are effective for removing turbidity, Al-based coagulants may result in high Al concentration in treated water (Wang et al, 2009).

1.3 Study Justification

High Al concentrations in drinking water distribution systems can cause high turbidity (Srinivasan et al., 1999), pipe wall deposition, and disinfection inhibition (Letterman and Driscoll, 1988). Health problems such as neurological disorders have also been associated with the presence of Al in drinking water. In order to control the content of residual Al in drinking water, various strategies has been proposed (Wang et al, 2009).

McLachlan et al. (1991) concluded that various toxilogic, biochemical, epidemiologic, and chelation studies support the hypothesis that Al is an important risk factor in Alzheimer's disease. They recommend lowering the Al drinking water standard to 50 μg/L with a long-term goal of 10 μg/L. Smith (1992) contends that the studies linking Alzheimer's disease and Al are flawed and do not show a reproducible cause and effect relationship. At present, regulatory agencies (WHO, HWC, USEPA) do not have sufficient human and animal evidence to establish a standard for Al in drinking water based on health effects (International Aluminium Institute, 2012).

There are many other methods of controlling Al toxicity in water. This study is to see if the controlling method used is enough to reduce Al residue. It is believed that this will be the first study on risk assessment of Al concentration in drinking water in Felda Jenderak Selatan, Temerloh, Pahang. Also, this study will provide an overview regarding the Al concentration in drinking water in the studied area. Moreover, it is to obtain the quantitative and qualitative data on Al exposure risk assessment in Felda Jenderak Selatan, Temerloh, Pahang.

1.4 Conceptual Framework of Aluminium flow from usage to residue

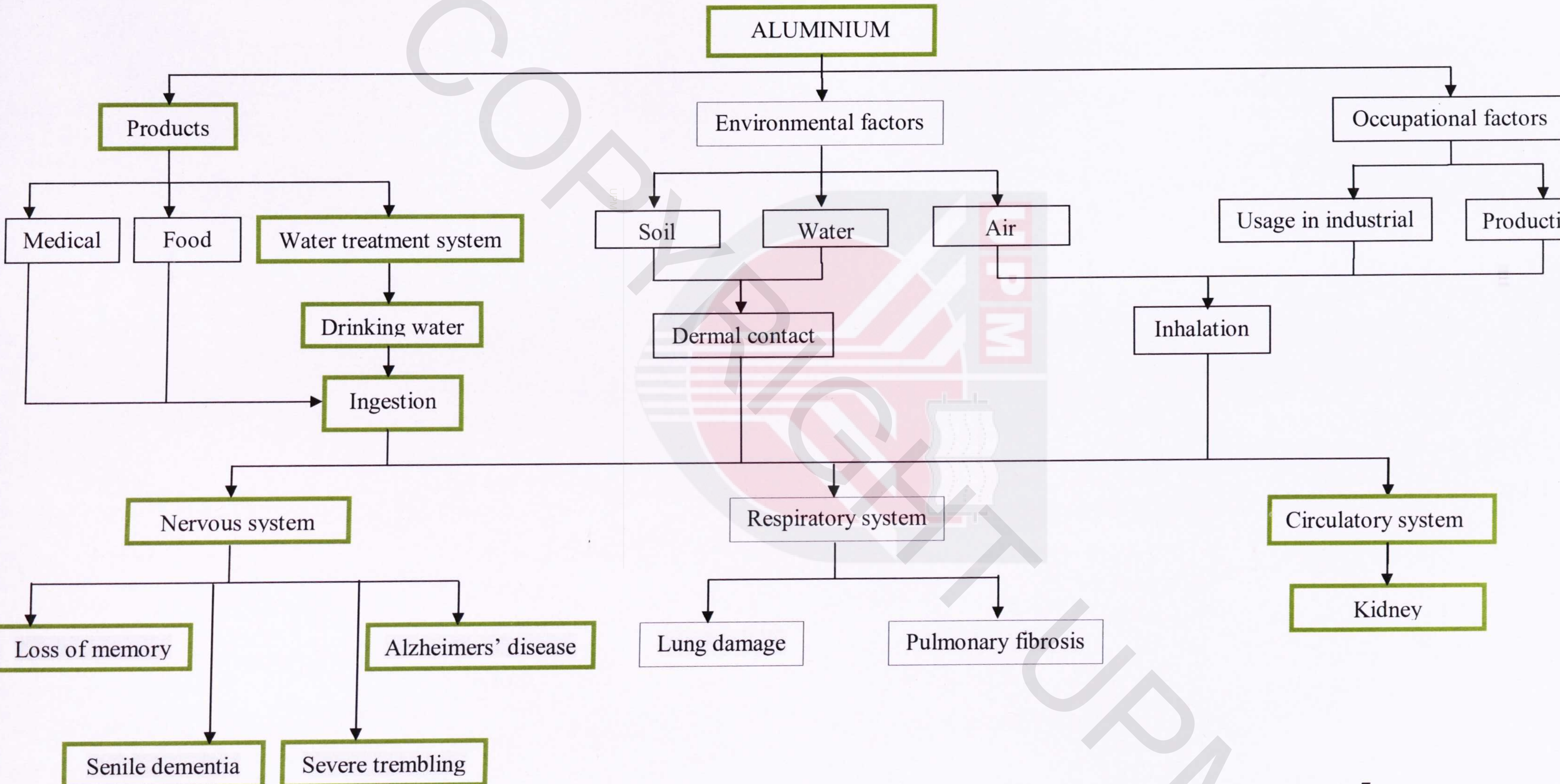

Figure 1.1: Conceptual framework of Aluminium flow from usage to residue

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 (USEPA, 2012).

b) Aluminium

Al metal is light in weight and silvery-white in appearance. Al is used for beverage cans, pots and pans, airplanes, siding and roofing, and foil. Al is often mixed with small amounts of other metals to form Al alloys, which are stronger and harder. Al compounds have many different uses, for example, as alums in water-treatment and alumina in abrasives and furnace linings. They are also found in consumer products such as antacids, astringents, buffered aspirin, food additives, and antiperspirants (ATSDR, 2012).

c) Tap water

Tap water is water that is supplied through a water distribution system and intended for human consumption. (Skipton, 2010).

d) Reference Dose (RfD)

An estimate of a daily oral exposure for an acute duration (24 hours or less) to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime. It is derived from a BMDL, a NOAEL, a LOAEL, or another suitable point of departure, with uncertainty/variability factors applied to reflect limitations of the data used (USEPA, 2012).

e) Hazard Index

A summation of the hazard quotients for all chemicals to which an individual is exposed. A hazard index value of 1.0 or less than 1.0 indicates that no adverse human health effects (noncancer) are expected to occur.

f) Chronic Daily Index

An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. CDI are specifically developed to be protective for long-term exposure to a compound (as a Superfund program guideline, seven years to lifetime) (USEPA).

1.5.2 Operational Definition

a) Risk assessment

Chronic daily intake (CDI) will estimate the exposure of individual to Al through ingestion as the exposure metric.

b) Aluminium

The concentration of lead in water was determined by using Perkin-Elmer Lambda 25/35/45 UV/Vis Spectrophotometer in the unit of μg/L.

c) Tap water

The tap water samples were collected from the kitchen tap using 250 ml high density polyethylene (HDPE) bottles. The tap water will be taken after the pipe was turned on for 5 minutes to have steady, medium strength flow, the bottles will not be rinsed.

d) Reference Dose (RfD)

Reference dose for aluminium used in this study is as suggested by World Health Organization, which recommends a tolerable weekly intake of 7mg/kg body weight (WHO, 1998).

e) Hazard Index

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

Where; HI = Hazard Index

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

RfD = Reference dose (mg/kg/day)

f) Chronic Daily Index

$$\textbf{Chronic Daily Intake} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where; C = Concentration of Al in drinking water (mg/L)

IR = Intake/Ingestion Rate (upper-bound value) (L/day)

EF =Exposure Frequency (upper-bound value) (day/year)

ED =Exposure Duration (upper-bound value) (year)

BW =Body Weight (average value) (kg)

AT = Averaging Time (D x 365 days/year)

*note: Ingestion rate was obtained by:

-the respondent was shown a cup with the volume of 200ml.

-then the respondent was asked comparing with the cup, how many of that cup they drink per day.

-thus, the ingestion rate was calculated from that value.

1.6 Objective

1.6.1 General Objective:

To study the risk assessment of Al concentration in daily intake by residents of Felda Jenderak Selatan from drinking taps water.

1.6.2 Specific Objectives:

i. To determine the socio-demographic data of the respondents in Felda Jenderak Selatan.
ii. To determine Al concentration and pH level of Felda Jenderak Selatan tap water samples.
iii. To determine the relationship of Al concentration with pH level of water samples.
iv. To determine the difference between Al concentrations of tap water samples in Felda Jenderak Selatan with Malaysia standards.
v. To calculate the Chronic Daily Intake (CDI) and Hazard Index (HI).

1.6.3 Hypothesis

i. There is significant difference between Al in drinking water and Malaysia standard.
ii. There is significant relationship between Al concentration and pH levels of tap water samples in Felda Jenderak Selatan with available standards.
iii. There is health risk of Al exposure among respondents, whom HI is more than one.

CHAPTER 2

LITERATURE REVIEW

2.1 Aluminium

The metal originally obtained its name from the Latin word for alum, *allumen.* The name *alumina* was proposed by L. B. G. de Moreveau who discovered the possibility of isolating the Al element which was foreseen first by Sir Humphry Davy of the Royal Institute of London (Federico, 1985). In 1807, the English chemist Sir Humphrey Davy established the existence of Al – although the name only came into common usage some time later. In 1825, the Danish physicist, H.C. Oersted produced the first nodules of Al (European Aluminium Organisation, 2011).

2.1.1 Physiochemical Properties

Al is the most abundant metallic element and third constituent of the Earth's crust (8% weight) after oxygen (47%) and silicon (28%). It is never found in the form of metal in its natural state: it is very reactive always combined with other elements. The compounds the most common oxides (alumina) and hydroxides mainly from bauxite, silicates from the clay and mica, and complexes to soluble forms sulphate (alum), nitrates, chlorides in the presence of dissolved organic matter (Gourier-Fréry, 2004).

Physical Properties

Density/Specific Gravity (g.cm-3 at 20°C)	**2.70**
Melting Point (°C)	660
Specific heat at 100 °C, cal.g-1K-1 (Jkg-1K-1)	0.2241 (938)
Latent heat of fusion, cal.g-1 (kJ.kg-1)	94.7 (397.0)
Electrical conductivity at 20°C (% of international annealed copper standard)	64.94
Thermal conductivity (cal.sec-1cm-1K-1)	0.5
Thermal emmisivity at 100°F (%)	3.0
Reflectivity for light, tungsten filament (%)	90.0
Water solubility (g/litre)	insoluble

Figure 2.1: Physical Properties of Aluminium (International Aluminium Institute, 2012)

2.1.2 Major Uses

Al metal is used as a structural material in the construction, automotive, and aircraft industries, in the production of metal alloys, in the electric industry, in cooking utensils, and in food packaging (WHO, 1998). Al compounds are used as antacids, antiperspirants, and food additives (ATSDR, 2011). Al salts are also widely used in water treatment as coagulants to reduce organic matter, colour, turbidity, and microorganism levels. The process usually consists of addition of an Al salt (often sulfate) at optimum pH and dosage, followed by flocculation, sedimentation, and filtration (Health Canada, 2012).

Medical Treatment: Antacids

Al hydroxide is widely used as an antacid to relieve gastric irritation and assist in the healing of peptic ulcers. It has good acid neutralising capacity and also has the ability to absorb and reduce the activity of pepsin (International Aluminium Institute, 2012).

Catalyst

Al nitrate is used as a chemical reagent (catalyst), in the leather tanning industry, as an antiperspirant, as a corrosion inhibitor, and in the manufacture of abrasives, refractories, ceramics, electric insulation, catalysts, paper, candles, pots, artificial precious stones and heat-resistant fibres. It is also used as adsorbent in chromatography for the production of filter membranes, in radiation protection dosimetry in the uranium extraction sector, and as a nitrating agent in the food industry (Health Canada, 2012). Al chloride is used in either anhydrous or hydrated form. In the anhydrous form, it is used as a catalyst, in Friedel-Crafts reactions, in the manufacture of rubber, the cracking of petroleum, and the manufacture of lubricants (International Aluminium Institute, 2012).

Antiperspirants

Soluble Al compounds have been used for many years as antiperspirants. Al chloride was the first compound used as an antiperspirant although currently Alchlorohydrate which is much less acidic, is the major antiperspirant compound. The action mechanism is still under investigation but it appears to act by forming a plug of Al hydroxide within the sweat duct (Germain et al. 2000).

Antigenic properties

In 1926 alum-precipitation diphtheria toxoid was discovered to have greater antigenic properties (for stimulating the production of antibodies) than the toxoid alone. The enhancement of diphtheria toxoid by the adjuvant (beneficial additive) Al hydroxide is typical of the use of an Al salt to increase the level and duration of immunity afforded by a vaccine. Al salts are the most widely used type of adjuvant due to its reputation for safety in humans (International Aluminium Institute, 2012). In its hydrated form, it is used by the pharmaceutical industry as an active ingredient in deodorants and antiperspirants, as well as in wood preservation, and in the manufacture of adhesives, paint pigments, resins, fertilizers and astringents (Germain et al. 2000).

Water treatment

Al performs a valuable role in the treatment of water. Al sulphate (alum) function as coagulant by forming positively charged Al species adsorb to negatively charged natural particles resulting in charge neutralization (Firdaus, 2006). Alum is widely used in the purification of waste water as well as water from rivers, lakes and reservoirs. It is a flocculating agent with the capacity to coagulate and trap solid matter that may be floating in the water, such as algae and other organic and non-organic matter (International Aluminium Institute, 2011).

2.2 Sources Of Aluminium In The Environment

2.2.1 Natural Sources

Al sulphate minerals such as aluminite and alunite occur naturally in Canada in certain restricted geological environments. Al chloride and Al nitrate do not occur naturally in the environment. Al can be released from natural Al sulphate minerals. Since Al is a common constituent of rocks, where it occurs dominantly in alumino silicate minerals (e.g., kaolinite, boehmite, clay, gibbsite, feldspar, etc.), weathering can slowly release Al to the surface environment (Health Canada, 2012). Foods naturally high in Al include potatoes, spinach, and tea (WHO, 1998).

2.2.2 Anthropogenic Sources

According to European Food Safety Authority (EFSA), (2008) Al is also released due to anthropogenic activities such as mining and industrial uses, in the production of Al metal and other Al compounds.

Al is present in foods naturally or from the use of Al-containing food additives. The use of Al cookware, utensils, and wrappings can increase the amount of Al in food; however, the magnitude of this increase is generally not of practical importance. Processed dairy products, flour, and infant formula may be high in Al if they contain Al-based food additives (WHO, 1998).

2.3 Exposure to Aluminium

Al present in surface waters due to human activities cannot be distinguished from natural Al released during weathering of Al-bearing minerals (Health Canada, 2012).

Use of Al salts as coagulants in water treatment may lead to increased concentrations of Al in finished water. Where residual concentrations are high, Al may be deposited in the distribution system. Disturbance of the deposits by change in flow rate may increase Al levels at the tap and lead to undesirable colour and turbidity (WHO, 1998). Concentrations of Al at which such problems may occur are highly dependent on a number of water quality parameters and operational factors at the water treatment plant (WHO, 1998).

2.4 Aluminium In Drinking/ Groundwater

Both alum ($Al_2(SO_4)_3$) and sodium aluminate ($Na_2Al_2O_4$) are highly effective coagulants and flocculants that adsorb and precipitate soluble phosphorus and other compounds such as organic matter, forming clumps that settle to the bottom of the lake (Health Canada, 2012). At present there is a WHO guideline for the maximum level of Al in drinking water of 0.2mg total Al per litre. This is essentially set for the visual effect and taste. No health-based criteria have been proposed for aluminium levels in drinking water by the World Health Organisation (International Aluminium Institute, 2012).

Al sulphate is added in the treatment of drinking water to coagulate and remove the suspended particles in raw water through sedimentation and filtration. Al oxides precipitate in water pipes and may be disturbed by a sudden change inflow rate resulting in discoloration of the tap water. This usually occurs if the Al concentration is greater than 100 μg/L. The WHO considers Al in water to be non-toxic and has set a guideline of 200 μg/L. This level represents a compromise between discoloration and the continued use of Alas a coagulant (WHO 1998). Similarly, the United States Environmental Protection Agency (USEPA, 2012) has set a secondary maximum contaminant level (SMCL) for Al in drinking water at 50 to 200 μg/L based on aesthetic reasons.

McLachlan et al. (1991) concluded that various toxilogic, biochemical, epidemiologic, and chelation studies support the hypothesis that Al is an important risk factor in Alzheimer's disease. They recommend lowering the Al drinking water standard to 50 μg/L with a long-term goal of 10 μg/L. Smith (1992) contends that the studies linking Alzheimer's disease and Al are flawed and do not show a reproducible cause and effect relationship. At present, regulatory agencies (WHO, HWC, USEPA) do not have sufficient human and animal evidence to establish a standard for Al in drinking water based on health effects (International Aluminium Institute, 2012).

2.5 HEALTH EFFECTS

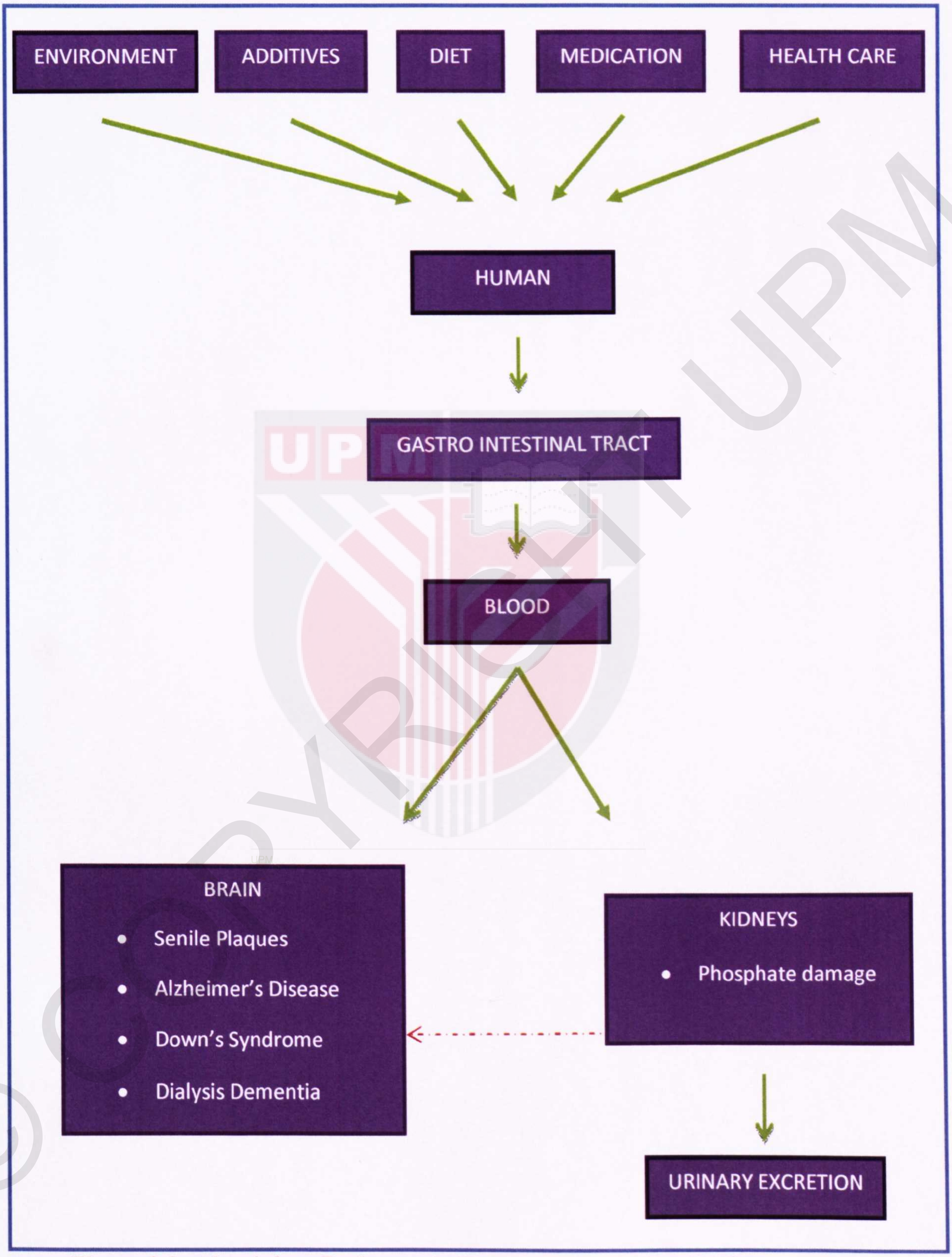

Figure 2.2: Aluminium Pathways in Humans (Massey R., 1988)

Three organ systems are clearly implicated in the toxic effects of Al; the haematopoietic system, the nervous system and bone. A sector of toxicity which has attracted attention in recent years, has been uptake of Al in excessive quantities in people treated with haemodialysis for pre-existing renal disease. The early haemodialysis process exposed people to high levels of Al which produced amicrocytic, hypochromic anaemia without iron deficiency, followed by encephalopathy. These dialysis patients also progressed to a painful osteomalacia (National Environmental Health Forum, 1995).

2.5.1 Neurological

The uptake of Al can take place through food, through breathing and by skin contact. Long lasting uptakes of significant concentrations of Al can lead to serious health effects, such as:

i. Damage to the central nervous system

ii. Dementia

iii. Loss of memory

iv. Listlessness

v. Severe trembling

(Lenntech, 2011)

Al has been shown to play a causal role in dialysis encephalopathy and epidemiological studies suggest a possible link between exposure to this metal and a higher prevalence of AD. This association is dependent on the duration of Al exposure and only becomes significant if an individual has resided in an area with high Al in drinking water (>100 Ag/L) for several years (Becaria, 2006).

Al has shown neurotoxicity in patients undergoing dialysis and thereby chronically exposed parenterally to high concentrations of Al. It has been suggested that Al is implicated in the aetiology of Alzheimer's disease and associated with other neurodegenerative diseases in humans. However, these hypotheses remain controversial. Based on the available scientific data, the Panel does not consider exposure to Al via food to constitute a risk for developing Alzheimer's disease (EFSA, 2008).

Alzheimer's disease (AD) is a chronic condition that is characterized by progressive loss of memory and other brain functions of daily living. It is the most common type of dementia and most cases occur after the age of 65. The specific diagnosis of AD can be difficult. A certain diagnosis can only be confirmed by associated with damage to nerve cells called Neurofibriallary Tangles (NFT) and scars called Senile Plaques (S.P.) (European Aluminium Association, 2011).

Symptoms like memory loss, fatigue, depression, behavioural changes, and learning impairment were reported in five children who, over a 5-days period, consumed drinking water containing unknown levels of Al sulphate, which was accidentally placed in a water-treatment facility in England (Ward, 1989).

2.5.2 Renal

In the early 1960s, when long-term artificial kidney treatment began it utilized very basic equipment and pharmaceutical grade chemicals weight-out on the spot and mixed in tap water. People were reasonably pleased with the immediate results because without this treatment the patient died within a few weeks. Even so, an impressive catalogue of disparate ailments was apparent even then. The idea that Al might be poisonous in this context did not become widely current until after 1970. Familiarity with Al hydroxide therapy for both gastrointestinal upset and reducing absorption of ingested phosphate bred a kind of complacency. However, a syndrome began to be recognized in occurrence (Massey R., 1988).

After absorption, Al distributes unequally to all tissues in humans and accumulates in some. Al has also been found in human skin, lower gastrointestinal tract, lymph nodes, adrenals, parathyroid glands, and in most soft tissue organs. In rats accumulation of Al was higher in the spleen, liver, bone, and kidneys than in the brain, muscle, heart, or lung. It has also been reported that Al can reach the placenta and fetus and to some extent distribute to the milk of lactating mothers. Al levels have been found to increase with ageing in a number of tissues and organs (bone, muscle, lung, liver, and kidney) of experimental animals (EFSA, 2008).

Although significant alterations in acquisition and retention of learned behaviour were documented, the possible role of organ damage (kidney, liver, immunological) due to Al was incompletely evaluated in these studies (WHO, 1998).

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).

2.6.1 Hazard Identification

Hazard identification is the first and important step. Determination of substances of concern, their adverse effects, target populations, and conditions of exposure, taking into account toxicity data and knowledge of effects on human health, other organisms and their environment. 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.

Al is one of the most widely used metals and also one of the most frequently found compounds in the earth's crust. Due to these facts, Al is commonly known as an innocent compound. But still, when one is exposed to high concentrations, it can cause health problems. The water-soluble form of Al causes the harmful effects, these particles are called ions. They are usually found in a solution of Al in combination with other ions, for instance as Al chlorine (Lenntech, 2011).

2.6.2 Dose-Response Assessment

Aluminium phosphide pellets and tablets (Phastoxin) are used as fumigants for wheat and other grains (Dieterich et al., 1967). Upon exposure to moisture in the air, they immediately decompose to phosphine gas, with little trace residue of phosphide remaining, which could be lost in handling of the grain.

A chronic feeding study of aluminium phosphide-fumigated chow fed to 30 rats was conducted by Hackenburg (1972). The average concentration was 0.51 mg phosphine/kg food for a 2-year period. At the end of the treatment period, there were no differences between treated and control rats in blood or urine chemistry, or histologic parameters.

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 7 mg of Al 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, 2011).

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.

The EPA Center for Exposure Assessment Modeling (CEAM) was established in 1987 to meet the scientific and technical exposure assessment needs of the United States Environmental Protection Agency (U.S. EPA) as well as state environmental and resource management agencies. CEAM provides proven predictive exposure assessment techniques for aquatic, terrestrial, and multimedia pathways for organic chemicals and metals (2011).

In this study, the route of exposure that was considered is through ingestion only which is drinking water. When only oral ingestion is 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

Risk characterization, the last step in risk assessment, is the starting point for risk management considerations and the foundation for regulatory decision-making, but it is only one of several important components in such decisions. As the last step in risk assessment, the risk characterization identifies and highlights the noteworthy risk conclusions and related uncertainties. 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, 2000).

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

CHAPTER 3

METHODOLOGY

3.1 Study Location

This study was conducted in an estate known as Felda Jenderak Selatan. It is an estate located in the state of Pahang, Malaysia (Figure 3.1). It is an area under Temerloh Municipal Council (MPT). Temerloh District is located in the middle of Pahang. It is located adjacent to the District Maran on the east, Bentong District to the west, Depok District in the north and south Bera District.

Temerloh District Area equals 2.250 sq. km 225.070 hectare. Overall, this area is divided into two main categories: Municipal Council Area 1442 square km. square (64.08%), and the area outside the Municipal area of 808 km. square (35.92%).

Felda Jenderak Selatan receives its water supply from Jabatan Bekalan Air Temerloh and their main water source is from Pahang River. Results from the 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). It is chosen as the study location because there is no study on Al in the drinking water been done yet in this area.

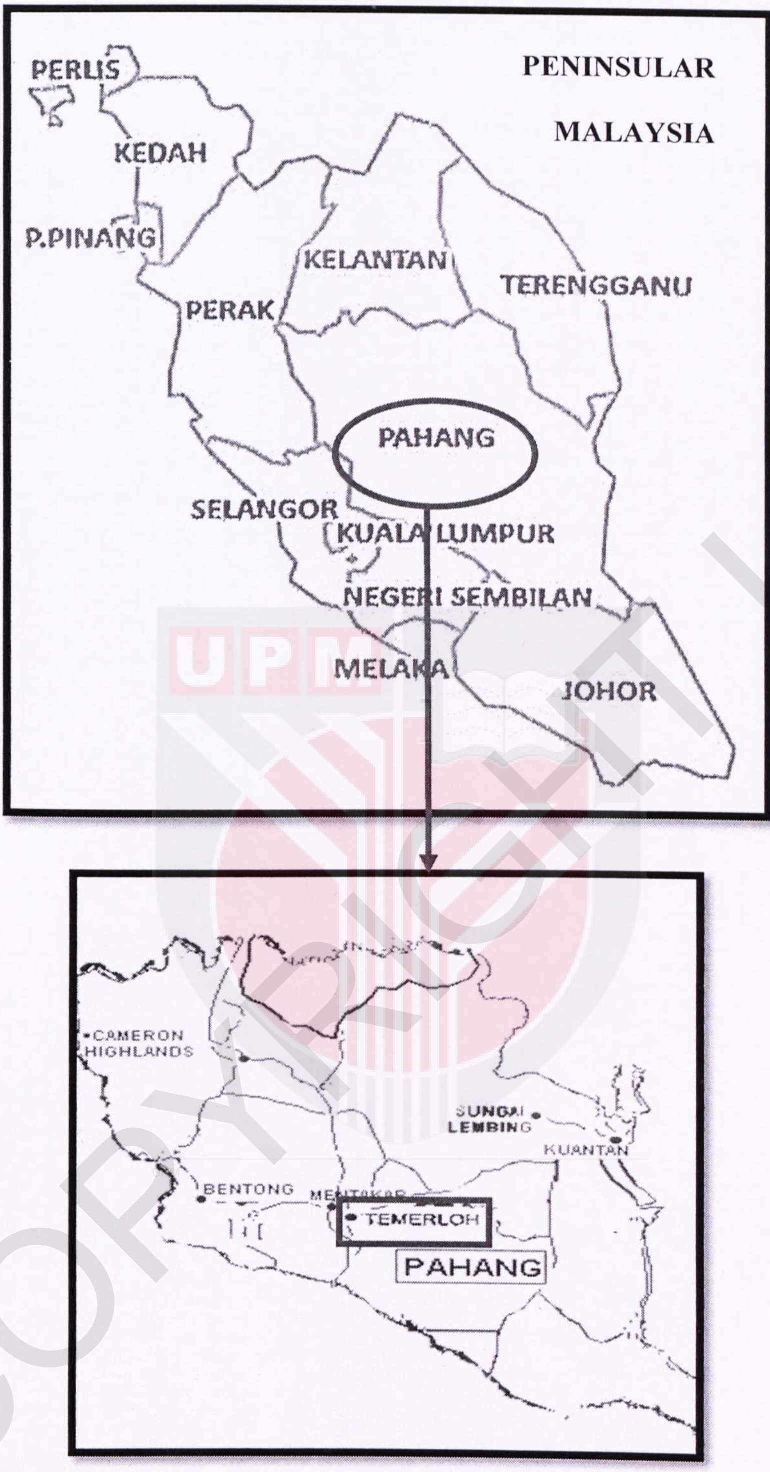

Figure 3.1: Study Area – Felda Jenderak Selatan, Temerloh, Pahang

3.2 Study Design

A cross-sectional study was conducted in Felda Jenderak Selatan for a risk assessment of Al concentrations in tap water.

A cross-sectional study design is used when;

- The purpose of the study is to find the prevalence of the outcome of interest, for the population or subgroups within the population at a given time point.

Cross-sectional studies are sometimes carried out to investigate associations between risk factors and the outcome of interest. They are limited, however, by the fact that they are carried out at one time point and give no indication of the sequence of events — whether exposure occurred before, after or during the onset of the disease outcome. This being so, it is impossible to infer causality (Kate Ann Levin, 2007)

3.3 Study Population

The study population was either male or female adults in Felda Jenderak Selatan who consumed treated tap water as the main source of drinking water.

3.4 Sample

3.4.1 Sample Size

Sample size determination was calculated using Kirkwood and Sterne (2009), formula; with the equation:

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

Where;

N = sample size

P = prevalence

e = probability error

According to Qaiyum et al. (2009), P: 49%

For a 95% of level of confidence, the margin error is ± 2 time the standard errors. Therefore the error, e = 0.05.

The prevalence rate of houses with representative sample was 70% (Qaiyum et al., 2009). By substituting P with 0.7, the sample size will be:

$$N = \frac{0.7\,(1-0.7)}{(0.05)^2} = 84\%$$

Therefore, the sample size is 84. But, the sample size is being increased 20% which is 16.8 as to take into account non responsive respondents, missing data and errors. So the total size of respondents for this study is 100 people.

3.4.2 Sampling Method

The respondents was selected using a list of houses provided by the head of the village or "Ketua Kampung", using the method purposive sampling as only individual who fulfil the inclusive characteristics are selected from this area until the required sample size was reached. The inclusive criteria will be used: male or female respondents, aged 18 years old and above and use of treated water as their main source of drinking water. While the exclusion criteria are: respondents that use bottled water or well water as their main source of drinking water. Each house will represent by one respondent.

3.4.3 Sampling Unit

The sampling unit was a resident living in Felda Jenderak Selatan who fulfilled the inclusive criteria. The inclusive criteria are, an adult Malaysian whose age 18 years old and above and consume treated tap water as main source of drinking water. Residents who consume water other than municipal water supply and use personal filtration system at home were excluded.

3.5 Study Instrumentation And Data Collection

3.5.1 Questionnaire

Interview-based questionnaire was used to obtain the socio-demographic and occupational information of the study population. The questionnaire was categorised into several parts which subject background, socio economic status, health status including subject weight and height to calculate BMI. The questionnaire was based on previous research and some adjustment was designed to make suits with this study. Also, the questionnaire was in Malay language as to facilitate the respondents to understand the questions.

3.5.2 Perkin Elmer Aanalyst 600 Atomic Absorption Spectrophotometer (GFAAS)

Measurement of Al concentrations in water samples were performed using a Perkin Elmer AAnalyst 600 Atomic Absorption Spectrophotometer. This technique was based on elemental selectivity. The samples were analysed using Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) because the detection limit is low. It can detect part per billion (ppb) of Al concentration in water samples (HACH 2003).

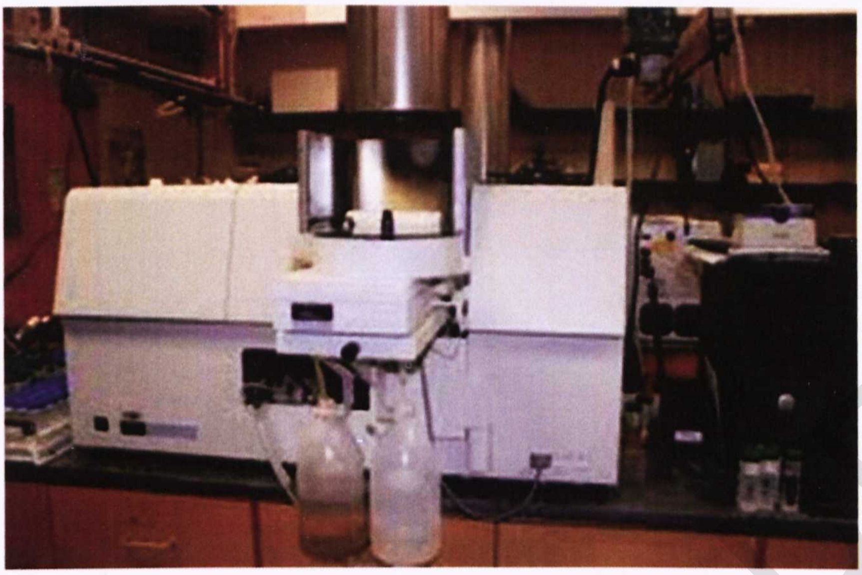

Figure 3.2: Perkin Elmer AAnalyst 600 Atomic Absorption Spectrophotometer (perkinelmer.com, 2011)

3.5.3 Water Sample Collection

3.5.3.1 Water Sampling

Two replicates of water samples were taken directly from the pipe located in the kitchen of each house. The water was to be run for 5 min before collection of the sample in 250-ml HDPE bottles, which were pre-washed with concentrated nitric acid (1:1) and deionised water several times prior to use (Mora et al., 2009). The water tap flow will be slowed down to medium strength flow but do not rinse the bottles (Kavcar et al., 2009). The sample water bottles will be filled completely and capped tightly (Mora et al., 2009).

The flow diagram of sampling technique is shown in Figure 3.2. The pH of the samples collected will be measured directly on sites after the HDPE bottled being collected from respondents. Then, all the samples will be preserved by adding 5 drops of nitric acid with 69% concentration. Preservation is essential to prevent biological or chemical reactions or both from occurring in the samples taken (HACH, 2003). Preserved samples could be stored up to six months (HACH, 2003) before they were analyzed in the laboratory. As this study will be conducted in a rural area, this preservation step is very crucial. All samples will be stored in the fridge at 4 degree Celsius until analyzed.

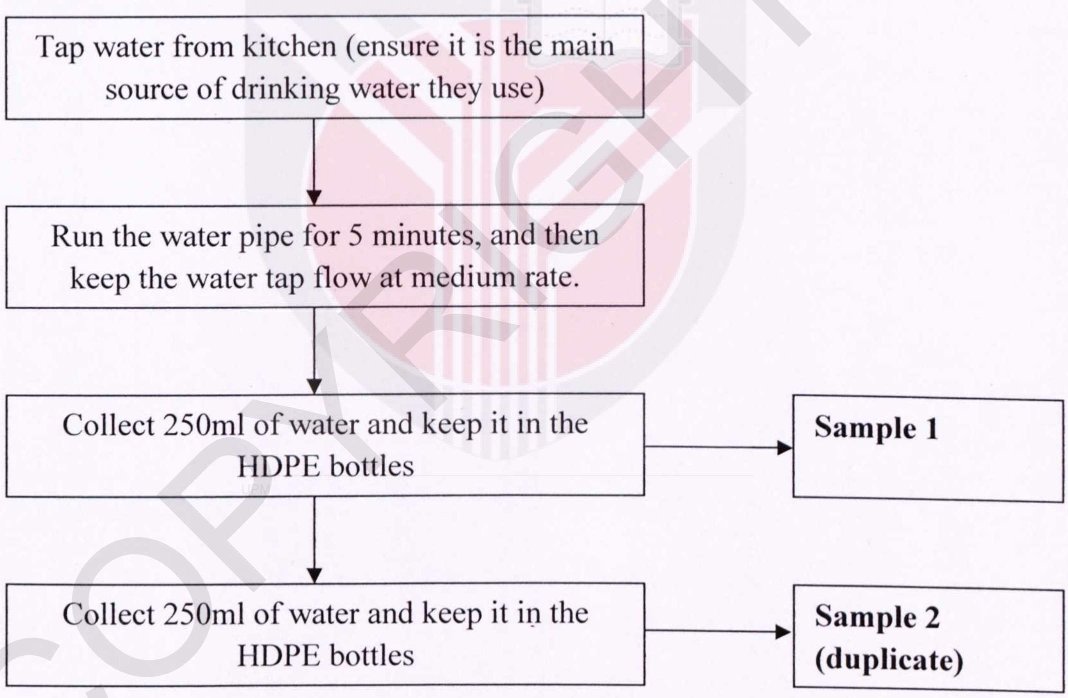

Figure 3.3 Flow diagram of sampling technique (Kavcar et. Al, 2008)

3.5.3.2 Water Sample Analysis

Drinking water samples will be analysed for its pH and Al concentration. A pH meter, Lamotte Tracer ORP Pocket Tester will be used to measure pH. While, LAMBDA™25/35/45 UV/Vis Spectrophotometers will be used for the analyses of Al.

Figure 3.4: Lamotte Tracer ORP Pocket Tester (Lamote.com, 2011)

3.6 Quality Control

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

3.6.1 Standard Operating Procedures (SOPS) Of Equipment Used In Study

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

The body weight of the respondents was measured using Tanita Digital Weight Scales. The readings were taken three times and then averaged.

Standard Operating Procedures (SOP) for Graphite Furnace Atomic Absorption Spectrometer (GFAAS), the operation condition were as below;

Element: Aluminium

Wavelength (nm): 309.3

Slit Width (nm): 0.7

Hollow cathode lamp (mA): 25

3.6.2 Calibration

All the instruments; weighing machine and pH-meter were calibrated before being used for this study. Calibration procedures for the Graphite Furnace Atomic Absorption Spectrometer (GFAAS) 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.

This equipment calibrated with a known standard. Furthermore, the pH meter LAMOTTE TRACER ORP PockeTester will enter an Automatic Calibration Mode when turn on. So, it can be directly calibrated before every use.

3.6.3 Pre-Tests

Pre-tests for questionnaire were done for respondents at Kampung Raya in Puchong as representative for community in Felda Jenderak Selatan. A total of 10 respondents (10% of sample size calculated) were selected for the test. The pre-tests were done before data collection. The purpose of pre-tests are to ensure that every questions ask in questionnaire could be understood and answered by the respondents.

3.7 Risk Assessment

The exposure of the respondents was first estimated by using the chronic daily intake formula. According to USEPA (1991), the exposure metric suggested is in following equation so that the result represents an exposure scenario that is both protective and reasonable; not the worst possible case:

$$\textbf{Intake} = \frac{\textbf{C x IR x EF X ED}}{\textbf{BW X AT}}$$

Where; C = Concentration of Al in drinking water (mg/L)

IR = Intake/Ingestion Rate (upper-bound value) (L/day)

EF =Exposure Frequency (upper-bound value) (day/year)

ED =Exposure Duration (upper-bound value) (year)

BW =Body Weight (average value) (kg)

AT = Averaging Time (D x 365 days/year)

*note: Ingestion rate was obtained by:

-the respondent was shown a cup with the volume of 200ml.

-then the respondent was asked comparing with the cup, how many of that cup they drink per day.

-thus, the ingestion rate was calculated from that value.

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). To conclude the significant exposure and overall potential for non-carcinogenic health effects posed by aluminium in drinking water, the HI is calculated as follows:

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

Where; HI = Hazard Index

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

RfD = Reference dose (mg/kg/day)

World Health Organization (WHO) recommends a tolerable weekly intake of 7mg/kg/day body weight (FAO/WHO, 1989). If the HI exceeds 1 the possibility that exposed individuals may experience adverse health effects cannot be ruled out. If the HI is higher, the concern of the individual gets adverse health effects also higher (Cao et al., 2010).

3.8 Ethical Clearance

Before this study was being conducted, permission from the board of committee of Ethical, Faculty of Medicine and Health Sciences of Universiti Putra Malaysia was obtained. As for permission to carry out the study in Felda Jenderak Selatan, it was requested from the home owners before conducting the study. The purpose of this study was explained to the respondent and a participation consent form was signed by the respondents. The identity and personal information of the respondents were kept confidential and no individual statement or descriptions were stated in any part of the study or publication.

3.9 Data Analysis

All the data that were collected was analysed by using Statistical Package of The Social Sciences (SPSS) for Windows version 18 software. All part in the questionnaire was analyzed by using this software. Descriptive statistics was used to analyze descriptive data in percentage, mean, standard deviation, range, maximum and minimum value. The variables analysed are gender, marital status, education level, monthly income, age, weight, height and body mass index.

The normality test was done according to P value more than 0.05, indicate that the data was normally distributed such as the Al concentrations in Felda Jenderak Selatan. This was analysed by using Kolmogorov-Smirnov test.

Spearman correlation was used to determine the relationship between two scale data which are not normally distributed. For this study, the Spearman correlation was used to determine the relationship between Al concentration and pH of the water. P value less than 0.05 was considered as significant value in this study.

Wilcoxon sign rank test was used to determine the difference significant difference between continuous variables. It is applied to the following examples:

- The difference between Al concentration in tap water and Al acceptable value according to NSDWQ.
- The difference between pH in tap water and acceptable value for pH according to NSDWQ.

3.10 Study Limitations

i. There were a recall bias as the respondent Chronic Daily Intake were asked based on the standard cup, 200ml to estimate the daily intake of the drinking water per day.
ii. This health risk assessment was specific to Al concentrations in tap water source. Risks arising from any other environmental and occupational sources of Al were not studied.
iii. This study took only drinking water. No biological samples were taken from the respondent to determine the actual Al level in the body.
iv. The health risk assessment was specific to Al concentration in drinking water source. Risks arising from other sources of Al will not be studied.

CHAPTER 4

RESULTS

4.1 Socio-Demographic Data of Respondents

A total of 95 respondents from Felda Jenderak Selatan housing area in Temerloh were involved in this study. The socio-demographic of respondents are shown in Table 4.1.

From the 95 respondents, there were 28 (29.5%) male and 67 (70.5%) female respondents. All of the respondents were Malays, 95 (100%). From that, 75 (78.9%) respondents were married, 6 (6.3%) were single, and 14 (14.7%) were widowed.

As for educational level, it was found that most of the respondent only studied until primary school level, 45 (47.4%), followed by until Sijil Penilaian Rendah (SRP) or Penilaian Menengah Rendah (PMR) 18 (18.9%), Malaysian Certification Examination (MCE) or Sijil Pelajaran Malaysia (SPM) 15 (15.8%), never been to school 13 (13.7%), and lastly until diploma or matriculation 4 (4.2%).

For monthly income, more than half of the respondents studied which were 50 (52.6%) with monthly income between the range of RM750 - RM1999. Followed by RM 2000 – RM 3999 33 (34.7%), below RM750 9 (9.5%) and lastly RM 4000 and above 3 (3.2%).

Age of respondents in this study ranges from 20 to 78 years old among the 95 respondents. The median for age of respondents in this study is 54.00 years old and on the other hand, the mean is 50.35 ± 15.78 years old.

It was found that the range of body weight (BW) of the respondents studied ranges from 31.2kg to 104.0kg among the 95 respondents. The median for the respondents' body weight was 62.20kg and mean of 63.45 ± 13.40kg.

Table 4.1: Socio-demographic distribution of respondents in Felda Jenderak Selatan

Variable	Category	Frequency	Percentage, %
Gender	Male	28	29.5
	Female	67	70.5
Race	Malay	95	100
Marital Status	Single	6	6.3
	Married	75	78.9
	Widowed	14	14.7
Education Level	Never been to school	13	13.7
	Primary school	45	47.4
	SRP/PMR	18	18.9
	MCE/SPM	15	15.8
	Diploma/Matriculation	4	4.2
Monthly Income	<RM750	9	9.5
	>RM750 – RM1999	50	52.6
	RM2000 – RM3999	33	34.7
	RM4000 and above	3	3.2

Variables	Mean ± SD	Median	Minimum	Maximum
Age	50.35 ± 15.78	54.00	20	78
Weight (kg)	63.45 ± 13.40	62.20	31.20	104.00

N=100

4.2 Aluminium Concentration and Ph Level In Water Samples From Felda Jenderak Selatan

From this study, it was found that Al concentrations in Felda Jenderak Selatan drinking water ranged from 0.0308 mg/L to 0.9928 mg/L, with mean of 0.3955 ± 0.2264 mg/L and a median of 0.3716 mg/L. The range and mean ± standard deviation for Al concentrations is shown in Table 4.2. The distribution of Al concentration in drinking water of Felda Jenderak Selatan is as shown in Figure 4.1.

Another reading taken from the water samples was pH level and the pH level for water samples in Felda Jenderak Selatan range from 6.34 to 7.50. The mean was 6.87 ± 0.2334 and with a median of 6.88. The range and mean ± standard deviation for pH level is shown in Table 4.2. The distribution of pH level in drinking water of Felda Jenderak Selatan is as shown in Figure 4.2.

Table 4.2: Range and mean ± standard deviation for pH level and aluminium concentration in Felde Jenderak Selatan drinking water

Variables	N=95	
	Range	Mean ± SD
Al concentration (mg/L)	0.0308 – 0.9620	0.3955 ± 0.2264
pH level	6.34 – 7.50	6.87 ± 0.2334

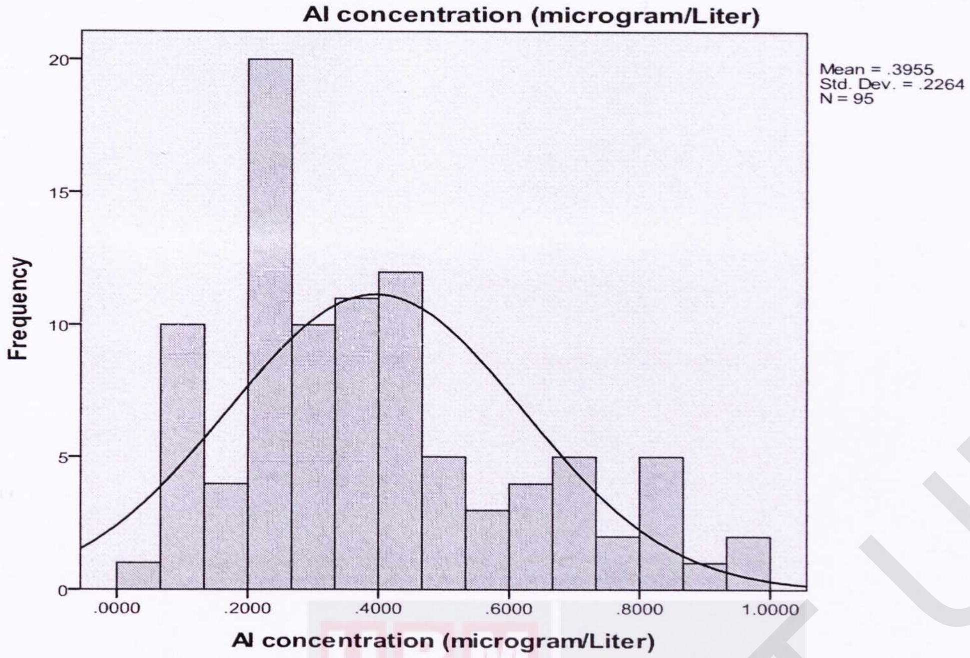

Figure 4.1: Distribution of aluminium concentrations in water samples in Felda Jenderak Selatan

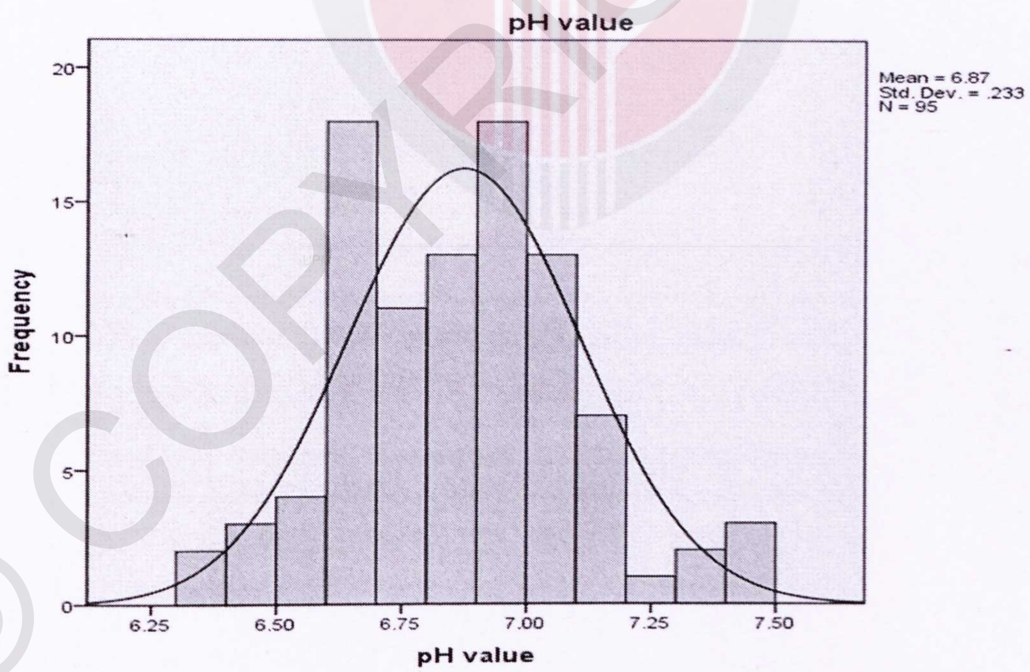

Figure 4.2: Distribution of pH level in water samples in Felda Jenderak Selatan

4.3 The relationship of aluminium concentration and pH level in water samples from Felda Jenderak Selatan

As discussed previously, the Al concentration and pH level were determined. Kolmogorov-Smirnov Test was carried out and the result showed that the al concentration in Felda Jenderak Selatan was not normally distributed and so as the pH level ($p < 0.05$) as shown in Table 4.3.

Thus, the Spearman-rho correlation test which a non-parametric test was carried out to determine the relationship between Al concentration and pH level (Table 4.4). There was a negative correlation between Al concentration and pH level in water samples from Felda Jenderak Selatan (r_s = -0.108, $p < 0.05$). To simplify this result, it means, the higher the Al concentration the lower the pH level or the more acidic the water sample was.

Table 4.3: Normality test for aluminium concentration in water samples in Felde Jenderak Selatan

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Al concentration (mg/L)	.126	95	.200*

N=95

*This is a lower bound of the true significance

Table 4.4: Spearman-rho Correlation of aluminium concentration and pH level in water samples in Felda Jenderak Selatan

Al concentration in drinking water (mg/L)	**pH**
Correlation coefficient	-0.108
Sig. (2-tailed)	0.297

N=95

4.4 Difference between Al concentrations in tap water samples in Felda Jenderak Selatan with NSDWQ.

From this study, it was found that the Al concentrations in Felda Jenderak Selatan drinking water ranged from 0.0308 mg/L to 0.9928 mg/L, with mean of 0.3955 ± 0.2264 mg/L (Table 4.5). Mean of Al concentrations in drinking water was above the acceptable values of National Drinking Water Quality Standards for Malaysia (NDWQS) showing most of the water samples exceeded the standards. A total of 80 water samples exceeded the acceptable value of NSDWQ, which is 0.2 mg/L. Figure 4.3 and 4.4 showed that from 95 water samples, 80 samples (84.2%) had exceeded the drinking water quality standards.

Mean of Al concentrations in drinking water was above the acceptable values of NSDWQ. A total of 80 water samples exceeded acceptable value of NSDWQ, which was 0.2 mg/L. According to Wilcoxon Signed Rank Test (Table 4.5), there was a significant difference between acceptable values (NSDWQ) and al concentrations in Felda Jenderak Selatan drinking water ($Z = -6.874$, $p < .05$).

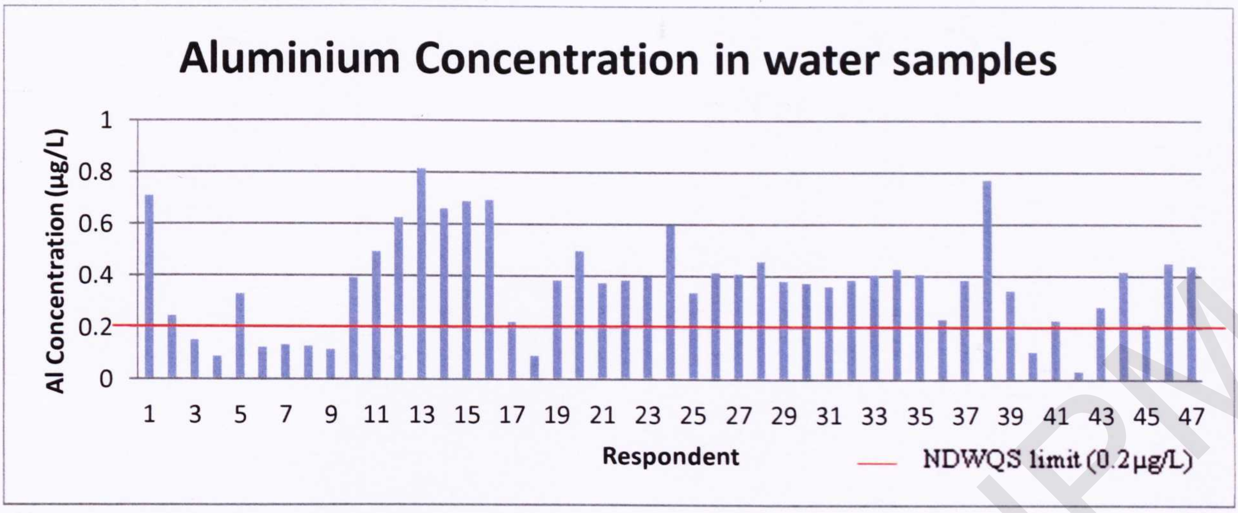

Figure 4.3: Comparison of aluminium concentration in water samples (1-47) with National Drinking Water Quality Standards (NDWQS)

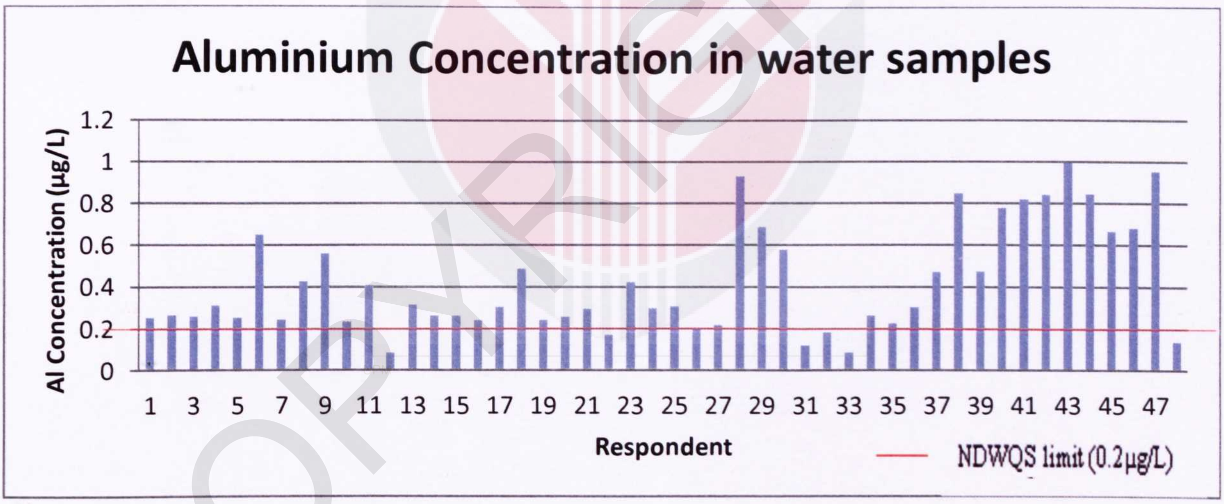

Figure 4.4: Comparison of aluminium concentration in water sample (48-95) with National Drinking Water Quality Standards (NDWQS)

Table 4.5: Wilcoxon Signed Ranks Tests for aluminium concentration in drinking water and aluminium acceptable value according to NSDWQ

Pair	Ranks	N	Mean Rank	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
Al concentaration in drinking water – NSDWQ for Al	Negative	80[a]	51.65	4132.00	-6.874[c]	.000
	Positive	15[b]	28.53	428.00		

[a]Al concentration in drinking water > NSDWQ acceptable values for Al

[b] Al concentration in drinking water < NSDWQ acceptable values for Al

[c]Based on positive ranks

4.5 Chronic Daily Intake (CDI) and Hazard Index (HI)

Chronic Daily Intake (CDI) was calculated for each respondent using their actual Daily Intake (DI) and Body Weight (BW) (Table 4.6) using the equation 3.1 as mentioned in Chapter 3. CDI of respondent ranged from 0.04 $mgday^{-1}kg^{-1}$ to 4.07 $mgday^{-1}kg^{-1}$. Mean and median of CDI fro respondents studied were 0.5980 ± SD 0.6771 $mgday^{-1}kg^{-1}$ and 0.3772 $mgday^{-1}kg^{-1}$ respectively. The distributions of CDI were shown in Figure 4.5.

Hazard Index (HI) for each respondent was calculated using the equation 3.2 mentioned in Chapter 3 by using the CDI of the respondents calculated earlier. Minimum HI calculated was 0.0056 and maximum was 0.5812. The mean and median for HI of respondents of Felda Jenderak Selatan were 0.0854 ± SD 0.0967 and 0.05389 respectively. HI of all respondents was found to be in acceptable value, which was less than 1. The distributions of HI are shown in Figure 4.6.

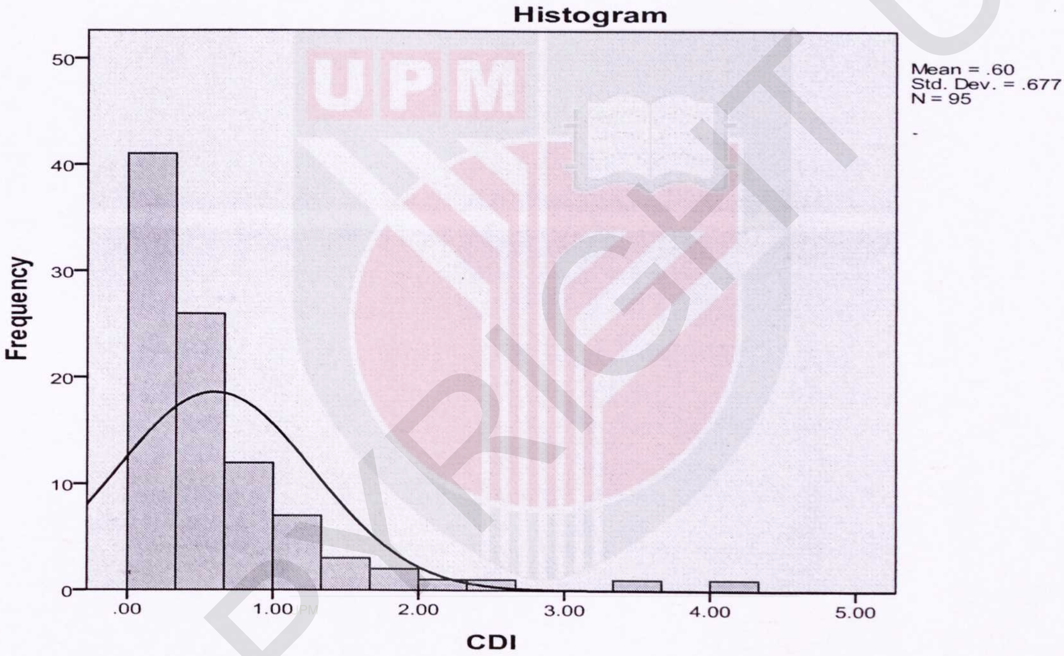

Figure 4.5: Distribution of Chronic Daily Intake for aluminium exposure in drinking water for respondents in Felda Jenderak Selatan

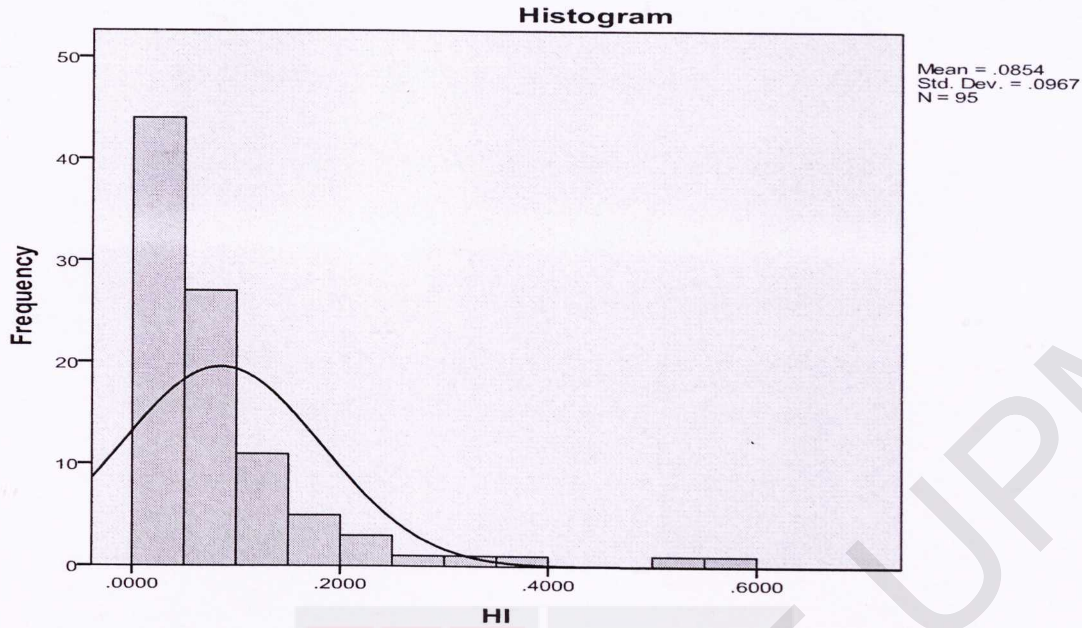

Figure 4.6: Distribution of Hazard Index for respondents in Felda Jenderak Selatan

Table 4.6: Range and mean ± standard deviation for CDI and HI for respondents in Felde Jenderak Selatan drinking water

Variables	N=95		
	Range	Mean ± SD	Median
CDI ($mgday^{-1}kg^{-1}$)	0.04 - 4.07	0.5980 ± 0.6771	0.3772
HI	0.0056 – 0.5812	0.0854 ± 0.0967	0.05389

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Socio-demographic of respondents

A total of 95 respondents from Felda Jenderak Selatan housing area in Temerloh were involved in this study as discussed in previous chapter, the total size of respondents for this study was supposed to be 84 people. But, the sample size is being increased 20% which is 16.8 as to take into account non responsive respondents, missing data and errors. So the total size of respondents for this study is 100 people.

This study used the method purposive sampling as only individual who exhibit certain visible characteristics are selected from this area until the required sample size was reached.

From the total of 95 respondents, there were 28 (29.5%) male and 67 (70.5%) female respondents. All of the respondents were Malays, 95 (100%). The majority of the settlers in FELDA were Malays (Hisham et al., 2010). From that, 75 (78.9%) respondents are married, 6 (6.3%) were single, and 14 (14.7%) were widowed.

Age of respondents in this study ranges from 20 to 78 years old among the 95 respondents. The median for age of respondents in this study is 54 years old and on the other hand, the mean is 50.35 ± 15.78 years old. The group age with highest number of respondents was 50 – 59 years old 32 (29.1%), followed by 60 – 69 years old 28 (25.5%), 30 – 39 years old 16 (14.5%), 20 – 29 years old 15 (13.6%), 40 – 49 years old 11 (10.0%) and lastly 70 – 79 years old 8 (7.3%). Majority of the respondents are second generation of Felda Jenderak Selatan settlers which has been living there for more than at least 15 years.

As for educational level it was found that most of the respondent only studied until primary school level, 45 (47.4%), followed by until Sijil Penilaian Rendah (SRP) or Penilaian Menengah Rendah (PMR) 18 (18.9%), Malaysian Certification Examination (MCE) or Sijil Pelajaran Malaysia (SPM) 15 (15.8%), never been to school 13 (13.7%), and lastly until diploma or matriculation 4 (4.2%). As mentioned earlier, most of the respondents are second generation settlers, most of them were from the era where education was very expensive. So education was their least priority.

For monthly income, more than half (50, 52.6%) of the respondents have an income between RM750 - RM1999, followed by RM 2000 – RM 3999, (33, 34.7%), below RM750, (9, 9.5%) and lastly RM 4000 and above (3, 3.2%). Most of the respondents do not work, so they very much depend on the monthly allowance by Felda authority. As for others, they mostly opened a food stall to increase their monthly income and some of them do other businesses like tailoring.

5.1.2 Aluminium concentration and pH level in water samples from Felda Jenderak Selatan

Al concentrations in Felda Jenderak Selatan drinking water ranged from 0.0308 mg/L to 0.9928 mg/L, with mean of 0.3955 ± 0.2264 mg/L and a median of 0.3716 mg/L. The range and mean ± standard deviation for al concentrations was shown in Table 4.2.

These results were similar with previous studies done by Rondeau et al. (1999) and Rubenos et al. (2005). Al levels in water supplies ranged from 0.001 to 0.459 mg/L, with a median value of 0.009 mg/liter in a 8 year follow-up study (Rondeau et al., 1999). The median concentration obtained in this study was 412 times larger than the value reported by Rondeau et al. (1999). Similarly, Al levels in water supplies reported by Rubenos et al. (2005) ranged from 0.008 to 0.650 mg/L. Both indicate that the overall Al concentrations in Felda Jenderak Selatan were slightly higher than the two studies mentioned.

Mean and median of Al concentrations were 0.3955 ± 0.2264 mg/L and 0.3716 mg/L respectively (Table 4.2). These values of mean and median of Al concentration in Felda Jenderak Selatan drinking water showed an unacceptable quality of water supply and 80 (84.21%) of water samples were above the acceptable value of NSDWQ, 0.2 mg/L and only 15 (15.79%) were below the acceptable value. From observation done, almost all the pipe that connected to each respondent's houses was metal. It can be assumed here that Al residues from the metal pipe being absorbed into the water, thus being distributed at each house.

Also, from observation and interview done at Felda Jenderak Selatan, the water supplied to each house always turbid and from the process of water before being distributed, known that raw water will be added alum or aluminium sulphate to purify the water as, alum is a flocculating agent with the capacity to coagulate and trap solid matter that may be floating in the water. More turbid the water, more amount of alum will be used, so more Al residue it is.

Al levels in drinking-water vary according to the levels found in the source water and whether Al coagulants are used during water treatment. In pure water, Al has a minimum solubility in the pH range 5.5–6.0; concentrations of total dissolved Al increase at higher and lower pH values (WHO, 2010). Al is widely used in water treatment as a coagulant, to reduce the number of small particles and to improve the colour of the water (Flaten, 2001).

In a study conducted by McLachlan et al. (1996), it was found that a relationship did exist between the number of diagnosed AD cases and the level of Al present in the drinking water supply. This study concluded that between 15,180 and 26,910 of the estimated 66,000 to 117,000 cases of AD might have been prevented if the Al concentration in the municipal water supply had been kept below 100 micrograms per litre. Study by Rondeau et al. (1999) revealed that high levels in drinking water ($\geq$ 0.1mg/L) were associated with a threshold effect around 0.1mg/L.

According to National Drinking Water Quality Standards for Malaysia (NDWQS) by Ministry of Health, the acceptable values for water pH level is range from 6.5 to 9.0. The pH level for water samples in Felda Jenderak Selatan, ranges from 6.34 to 7.50. The mean was 6.87 ± 0.2334 and with a median of 6.88. The range and mean ± standard deviation for pH level was shown in Table 4.2. There were 5 (4.5%) violations of pH levels at Felda Jenderak Selatan with value 6.34 to 6.48.

5.1.3 The relationship of aluminium concentration and pH level in water samples from Felda Jenderak Selatan

Between Al concentrations and pH of water samples, there was negative correlation between al concentration and pH level in water samples from Felda Jenderak Selatan (r_s = -0.108, $p < 0.05$) as shown in Table 4.4. A study by Flaten, 1990 found a consistent association across the pH range. The negative correlation here means that there was a weak relationship between pH and Al concentrations, the higher the pH value of a water sample, the lower the Al concentration.

The presence of Al in water for domestic supplies is due either to the addition of Al salts in the course of coagulation and flocculation treatment, or is caused by a low pH (pH = 5.5± 0.5) value of either surface or ground waters (Srivinasan, 1999). But, Al is also known as amphoteric elements, which means, either the water is acidic or alkaline, the level of Al concentration may be high.

Regular Al concentrations in groundwater are about 0.4 ppm, because it is present in soils as water insoluble hydroxide. At pH values below 4.5, solubility rapidly increases, causing Al concentrations to rise above 5 ppm (Lenntech, 2011). This may also occur at very high pH values. It has been shown that other water parameter especially water pH affects the solubility behaviour and the absorption of Al in the gastrointestinal tract (Rubinos et al., 2005).

5.1.4 The difference between Al concentrations of tap water samples in Felda Jenderak Selatan with NSDWQ

Mean of al concentrations in drinking water was above the acceptable values of NSDWQ. A total of 80 water samples were exceeded acceptable value of NSDWQ, which was 0.2 mg/L. According to Wilcoxon Signed Rank Test (Table 4.5), there was a significant difference between acceptable values (NSDWQ) and al concentrations in Felda Jenderak Selatan drinking water ($Z = -6.874$, $p < .05$).

From observation done during the data collection at Felda Jenderak Selatan, founded that all the piping from house to house are metal pipes. This may be one of the reasons why a total of 80 water samples from 95 water samples taken, exceeded the acceptable value of NSDWQ.

According to the National Drinking Water Quality Standards for Malaysia (NDWQS) by Ministry of Health, the acceptable values for water pH level ranged from 6.5 to 9.0. The pH level for water samples in Felda Jenderak Selatan, ranged from 6.34 to 7.50. The mean was 6.87 ± 0.2334 and with a median of 6.88. The range and mean ± standard deviation for pH level is shown in Table 4. There were 5 (4.5%) violations of pH levels at Felda Jenderak Selatan with value 6.34 to 6.48.

These results studied in Felda Jenderak was similar with previous study done by Qaiyum et al. (2011). From binomial test, there was significant difference ($p < 0.05$, $z = 0.50$) between Al levels in drinking water at Parit Raja with the Malaysia Drinking Water Standard (Qaiyum et al., 2011).

5.1.5 Chronic Daily Intake (CDI) and Hazard Index (HI)

Amongst three main route of exposure, (ingestion, inhalation and dermal) only ingestion route was taken into consideration in this study (Kavcar, 2009). Chronic Daily Intake (CDI) was calculated for each respondent using their actual Daily Intake (DI) and Body Weight (BW) (Table 4.6) using the equation 3.1 as mentioned in chapter 3. CDI of respondent were ranged from 0.04 $mgday^{-1}kg^{-1}$ to 4.07 $mgday^{-1}kg^{-1}$. Mean and median of CDI fro respondents studied were $0.5980 \pm$ SD 0.6771 $mgday^{-1}kg^{-1}$ and 0.3772 $mgday^{-1}kg^{-1}$ respectively.

The CDI of Al intake in Felda Jenderak Selatan was higher than CDI in Mukim Parit Lubok, which was in ranged of 0.00303 mg/kg/day to 0.01158 mg/kg/day, and in Parit Raja, where the CDI ranged from 0.0027 mg/kg/day to 0.01274 mg/kg/day (Qaiyum et al., 2011).

This is because due to high Al levels measured in drinking water in Felda Jenderak Selatan compared to study at Mukim Parit Lubok and Parit Raja, since the main factor in CDI equation is Al levels rather than other factors such as respondents' body weight and exposure duration to Al in drinking water.

Hazard Index (HI) values greater than 1 indicate a potential for an adverse effect to occur or the need to further study (Kavcar, 2005). HI for each respondent was calculated using the equation 3.2 mentioned in chapter 3 by using the CDI of the respondents calculated earlier. Minimum HI calculated was 0.0056 and maximum was 0.5812. The mean and median for HI of respondents of Felda Jenderak Selatan were 0.0854 ± SD 0.0967 and 0.05389 respectively. HI of all respondents was found to be in acceptable value, which was less than 1.

5.2 Conclusion

The main objective of this study which was to determine health risk assessment of exposure to Al levels in drinking water at Felda Jenderak Selatan was achieved.

The first hypothesis was failed to be rejected because Wilcoxon Signed Ranks tests showed that there was a significant difference between Al concentrations in drinking water and Al limit value of National Standard for Drinking Water Quality.

From this study, it was found that the mean of Al concentrations in drinking water was above the acceptable values of National Drinking Water Quality Standards for Malaysia (NDWQS) showing most of the water samples exceeded the standards (Table 5). A total of 80 water samples exceeded the acceptable value of NSDWQ, which is 0.2 mg/L. Figure 1 and 2 showed that from 95 water samples, 80 samples (84.2%) had exceeded the drinking water quality standards.

The second hypothesis was failed to be rejected. There was a negative correlation between Al concentration and pH level in water samples from Felda Jenderak Selatan (r_s = -0.108, $p < 0.05$), according to Guilford rule of thumb. To simplify this result, it means, the higher the Al concentration the lower the pH level or the more acidic the water sample was.

The value of mean $\pm$ SD for pH level in water samples was 6.87 ± 0.2334. There was a significance difference between Al level and Malaysian Drinking Water Quality Standard ($Z = 0.02$, $p<0.05$). Pearson Correlation test showed that was a significant relationship between Al levels in water samples and pH level.

Health risk assessment determined by calculating CDI and HI of respondents in this study, and founded that the CDI of water sample was lower than the Aluminium Reference Dose (Rfd) of 7 mg/kg/day. For this study, hazard index was used as the tool to determine the risk of residents getting exposed with Al through drinking water. Hazard index will be calculated by dividing CDI with RfD. If the value of hazard index is more than 1, it shown potential for an adverse health effect towards the respondents.

Minimum HI calculated was 0.0056 and maximum was 0.5812. After calculating health risk to Al exposure in drinking water, the health index (HI) value is less than 1, showing that there was no risk or the risk was acceptable. The mean and median for HI of respondents of Felda Jenderak Selatan were 0.0854 ± SD

0.0967 and 0.05389 respectively. HI of all respondents was found to be in acceptable value, which was less than 1. The third hypothesis was rejected.

5.3 Recommendation

As discussed earlier, 80 (85.21%) water samples has exceeds or violates the Al limit value of NSDWQ. Exposure to Al has been implicated in dialysis dementia, Parkinson and AD. Drinking water containing Al was considered to be one of the main sources of Al intake into human body (Mohd Nasir O. et al., 2010). For this reason, actions to reduce the Al level in drinking water must be taken into consideration by water treatment company in Malaysia to ensure the quality and safety of treated water for the community.

All water treatment plant should be periodically and regularly surveyed especially for the water treatment plant that uses alum (aluminium sulphate) coagulant. This is to ensure that the Al concentration will always be monitored so that it would not exceed the limit value. Removal of Al can be carried out by several methods such as cation exchange resin, reverse osmosis and electrodialysis. Process such as coagulation, sedimentation and filtration as well as lime softening are moderately effective in Al removal. The pH range 4-9 for Iontosorb Oxin (IO) and 5-8 for polyhydromxamic acid (PHA) is very suitable for the removal of Al from the drinking water (Mohd Nasir O. et al., 2010). McLachlan et al. (1996), suggest decreasing the amount of the Al with the trivalent chelating agent desferrioxamine (DFO).

Because Al is ubiquitous in the environment, exposure of the general population to this element is hardly avoidable. In addition, such exposure is sustained over the lifetime, resulting in the potential for accumulation of a substantial body burden of Al. humans are vulnerable to Al toxicity and although the potential link between environment Al exposure and some serious neurodegenerative disorders such as AD (Gomez et al., 1996). Thus, other contributors to Al exposure to the community should be avoided.

Some of the other contributors are in foods naturally or from the use of aluminium-containing food additives. The use of Al cookware, utensils and wrappings can increase the amount of Al in food; however, the magnitude of this increase is generally not of practical importance. Foods naturally high in Al include potatoes, spinach and tea. Processed dairy products, flour and infant formula may be high in Al if they contain aluminium-based food additives (WHO, 2010).

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APPENDIXES

APPENDIX 1

APPENDIX 2

APPENDIX 3

BORANG SOAL SELIDIK

BAHAGIAN A

No Kad Pengenalan :

Nama:

Alamat:

No Tel. Rumah:

Bimbit:

1. Jantina
   Lelaki ☐ Perempuan ☐

2. Bangsa
   Melayu ☐ Cina ☐
   India ☐ Lain-lain ☐
   ....(Nyatakan)

3. Tahap pendidikan
   Sekolah Rendah ☐ PMR ☐
   Tidak belajar ☐ SPM ☐
   Pengajian Tinggi ☐ Lain-lain ☐
   ....(nyatakan)

4. Jumlah pendapatan isi rumah
   .... (Nyatakan)

BAHAGIAN B

5. Berapa lama tinggal di kawasan ini?
   ....(Tahun).........(bulan)

6. Apakah bekalan air yang digunakan
   Paip air JBA ☐
   Telaga ☐
   Gabungan diatas ☐
   Lain-lain ☐
   ....(Nyatakan)

7. Berapa lama anda menerima bekalan air paip
   ....(Tahun).........(bulan)

8. Berapa gelas air yang anda minum sehari
   ....Gelas sehari

9. Pernahkah air paip berbau?
   Ya
   Tidak

10. Pernahkah air paip mengalami kekeruhan
    ☐ Ya ☐ Tidak

11. Apakah sumber air yang anda kerap gunakan?

Air paip ☐
Air botol ☐

BAHAGIAN C: Kegunaan penyelidikkan

12. Berat badan responden

…………..KG

13. Kepekatan Al dalam air

…………..Mg/L

14. Adakah seringkali anda bersifat pelupa?

☐ Ya ☐ Tidak

15. Adakah ahli keluarga anda mempunyai sejarah penyakit Alzheimer (penyakit nyanyuk)?

☐ Ya ☐ Tidak

*Baseline, descriptive and time, National Human Exposure Assessment Survey (NHEXAS)-Arizona study (Kavcar et al., 2008)

APPENDIX 4

FAKULTI PERUBATAN DAN SAINS KESIHATAN

FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG, SELANGOR, MALAYSIA

PENERANGAN KEPADA PESERTA

TAJUK KAJIAN:

Kajian Risiko Kesihatan terhadap Pendedahan Baki Al di dalam Air Minum di Kawasan Felda Jenderak Selatan, Temerloh, Pahang.

Terima kasih kerana membantu kami di dalam kajian ini.

1. Apakah kajian ini?

   Kajian ini adalah berkaitan dengan risiko kesihatan terhadap air minum di kalangan responden. Kandungan alumium yang tinggi dalam air minum boleh menyebabkan kesan kesihatan seperti penyakit Alzaimer atau dikenali sebagai nyanyuk.

2. Apakah tujuan kajian ini?

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

3. Berapa ramai responden yang terpilih?

   Responden akan dipilih dari kalangan penduduk Felda Jenderak Selatan, Temerloh, Pahang. Seramai 100 orang responden akan dipilih untuk kajian ini.

4. Apakah jenis ujian yang akan dijalankan?

   Semua responden akan diminta menjawab soalan yang dikemukakan oleh penyelidik berdasarkan borang soal selidik. Selain daripada itu, sampel air minum dari paip air di bahagian dapur akan diambil bagi proses analisis sampel air. Berat badan serta jumlah pengambilan air minum sehari untuk setiap respondent akan diambil dan dicatat oleh pengkaji.

5. Adakah bayaran dikenakan?

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

6. Adakah maklumat dijamin sulit?

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

7. Adakah hak anda?

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

8. Apakah yang harus anda lakukan?

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

Terima kasih atas kerjasama dan bantuan anda.

NUR AQMA MADIHA MAZELAN

Penyelidik

B. Sc. Kesihatan Persekitaran dan Pekerjaan

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APPENDIX 5

FAKULTI PERUBATAN DAN SAINS KESIHATAN

FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

BORANG PERSETUJUAN RESPONDEN

TAJUK KAJIAN : **Kajian Risiko Kesihatan Terhadap Pendedahan Baki Al di dalam Air Minum di Kawasan Felda Jenderak Selatan, Temerloh, Pahang.**

PENYELIDIK : **NUR AQMA MADIHA BINTI MAZELAN**

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

Saya telah membaca dan memahami isi kandungan kajian berdasarkan apa yang telah dinyatakan di dalam 'PENERANGAN KEPADA PESERTA' yang telah dilampirkan dan penerangan tambahan daripada penyelidik. Saya faham bahawa kajian ini dijalankan untuk mengenalpasti risiko kesihatan terhadap pendedahan baki Al di dalam air minum di kawasan Felda palong , Negeri Sembilan.

Saya juga faham bahawa segala maklumat yang diberikan dan segala keputusan yang saya perolehi adalah sulit dan hanya akan digunakan untuk tujuan penyelidikan dan rujukan penyelidik. Saya faham bahawa saya mempunyai hak untuk menarik diri pada bila-bila masa dan tiada sebarang tindakan boleh dikenakan ke atas saya atas tindakan tersebut.

Tandatangan: ……………………………………… Tarikh :………………………………

(*Responden*)

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

Tandatangan : …………………………………… Tarikh: ………………………………………

(*Penyelidik*)

APPENDIX 6

List of respondents's ID, age, weight, Al concentration, pH level, CDI and HI

Respondents' ID	Age	Weight (kg)	Al concentration (mg/L)	pH level	CDI	HI
1	54	80.20	0.7086	7.10	2.15	0.3067
2	52	71.40	0.2422	7.16	0.26	0.0378
3	40	68.00	0.1494	7.07	0.26	0.0377
4	77	57.80	0.0870	7.16	0.35	0.0497
5	38	61.40	0.3290	7.16	0.92	0.1309
6	64	53.40	0.1220	7.07	0.22	0.0313
7	26	53.00	0.1315	6.73	0.10	0.0138
8	52	58.00	0.1266	6.93	0.17	0.0243
9	41	65.80	0.1146	6.73	0.04	0.0061
10	47	81.80	0.3908	6.68	0.67	0.0962
11	36	71.40	0.4934	6.88	0.17	0.0249
12	34	60.80	0.6252	6.70	0.52	0.0749
13	34	71.60	0.8144	6.45	0.58	0.0829
14	43	67.40	0.6606	6.64	1.26	0.1806
15	64	70.60	0.6866	6.67	1.87	0.2667
16	66	31.20	0.6914	7.07	0.73	0.1045
17	45	59.40	0.2200	7.12	0.33	0.0476
18	64	53.60	0.0896	6.69	0.32	0.0459
19	23	68.00	0.3808	7.16	0.58	0.0828
20	62	53.00	0.4942	6.80	1.73	0.2478
21	54	54.40	0.3720	7.13	1.66	0.2374
22	60	79.60	0.3826	6.82	0.43	0.0618
23	55	67.20	0.3974	6.94	1.63	0.2323
24	59	39.00	0.5976	6.82	4.07	0.5812
25	23	64.40	0.3328	6.78	0.18	0.0255
26	60	53.20	0.4128	6.88	0.23	0.0333
27	54	58.00	0.4070	6.58	1.14	0.1624
28	67	69.00	0.4544	6.44	1.32	0.1891
29	55	45.40	0.3786	6.70	0.46	0.0655
30	58	96.60	0.3716	6.48	0.22	0.0319
31	62	44.20	0.3580	6.67	0.20	0.0287
32	27	81.80	0.3832	6.77	0.19	0.0271
33	24	54.80	0.4042	6.67	0.27	0.0379
34	59	47.20	0.4284	6.72	0.32	0.0459
35	30	76.00	0.4068	6.68	0.48	0.0688
36	64	82.30	0.2328	6.66	1.09	0.1552
37	24	39.00	0.3854	6.70	0.36	0.0508
38	48	62.60	0.7714	6.34	0.89	0.1267
39	53	75.80	0.3442	6.61	0.14	0.0206

40	60	75.80	0.1059	6.74	0.38	0.0539
41	54	70.00	0.2284	6.59	0.18	0.0252
42	53	54.20	0.0308	6.73	0.05	0.0065
43	61	59.20	0.2810	6.56	0.43	0.0620
44	57	65.80	0.4164	6.75	0.54	0.0773
45	56	50.00	0.2122	6.65	0.71	0.1019
46	39	87.20	0.4508	6.34	0.12	0.0173
47	65	52.40	0.4410	6.65	0.44	0.0625
48	67	64.00	0.2514	6.65	0.39	0.0564
49	26	55.00	0.2636	6.53	0.56	0.0801
50	23	59.80	0.2580	6.64	0.15	0.0213
51	24	63.20	0.3114	6.67	0.24	0.0338
52	54	57.60	0.2508	6.93	0.47	0.0672
53	67	52.80	0.6512	6.78	2.48	0.3541
54	37	84.20	0.2420	6.96	0.32	0.0456
55	31	54.00	0.4260	7.50	0.37	0.0524
56	74	61.00	0.5604	7.20	0.82	0.1165
57	64	57.80	0.2316	7.30	0.38	0.0550
58	61	67.80	0.4058	7.43	0.37	0.0522
59	27	39.60	0.0814	7.33	0.04	0.0056
60	51	75.80	0.3118	6.86	0.94	0.1349
61	75	54.00	0.2618	6.97	0.55	0.0779
62	62	61.60	0.2594	6.96	0.05	0.0075
63	63	43.20	0.2382	7.01	0.17	0.0248
64	28	58.00	0.3022	6.99	0.07	0.0104
65	59	62.20	0.4846	6.86	0.69	0.0985
66	67	60.80	0.2394	6.97	0.40	0.0565
67	65	48.40	0.2538	7.01	0.17	0.0243
68	27	85.20	0.2930	6.75	0.09	0.0133
69	58	78.60	0.1664	7.06	0.74	0.1052
70	20	59.60	0.4180	6.98	0.10	0.0140
71	54	83.40	0.2942	6.92	0.08	0.0109
72	60	66.20	0.3054	7.01	0.42	0.0593
73	55	104.00	0.2054	6.99	0.33	0.0466
74	60	70.40	0.2142	7.02	0.27	0.0391
75	38	81.00	0.9266	6.68	0.33	0.0466
76	75	76.00	0.6842	6.87	0.68	0.0965
77	27	38.00	0.5756	6.86	0.33	0.0467
78	78	46.00	0.1161	6.88	0.14	0.0197
79	42	59.40	0.1813	6.94	0.10	0.0137
80	31	85.00	0.0834	6.84	0.05	0.0065

81	60	52.00	0.2590	7.31	0.30	0.0427
82	63	63.00	0.2232	6.99	0.45	0.0638
83	37	61.80	0.3022	7.04	0.27	0.0388
84	58	55.60	0.4682	6.98	0.34	0.0488
85	21	57.00	0.8454	7.01	0.93	0.1335
86	71	50.00	0.4714	6.90	0.67	0.0956
87	53	79.40	0.7764	6.97	1.04	0.1481
88	42	62.20	0.8172	7.01	0.39	0.0552
89	32	79.00	0.8404	7.01	1.36	0.1945
90	38	74.60	0.8442	6.93	0.30	0.0430
91	73	64.80	0.6656	6.89	1.05	0.1500
92	58	70.40	0.6800	7.45	0.39	0.0560
93	75	48.00	0.9508	7.00	1.04	0.1486
94	59	70.00	0.1368	6.99	0.12	0.0165
95	54	80.20	0.7086	7.10	2.15	0.3067