UNIVERSITI PUTRA MALAYSIA

CROSS-SECTIONAL STUDY ON ALUMINIUM IN GROUNDWATER AND HEALTH RISK ASSESSMENT IN ORANG ASLI VILLAGE IN BATU 28, JENDERAM HILIR, SELANGOR

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CROSS-SECTIONAL STUDY ON ALUMINIUM IN GROUNDWATER AND HEALTH RISK ASSESSMENT IN ORANG ASLI VILLAGE AT BATU 28, JENDERAM HILIR SELANGOR.

BY

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ABSTRACT

CROSS-SECTIONAL STUDY ON ALUMINIUM IN GROUNDWATER AND HEALTH RISK ASSESSMENT IN ORANG ASLI VILLAGE IN BATU 28, JENDERAM HILIR, SELANGOR

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Introduction: The water supply from groundwater is not free from the impurities as there is no series of treatment process occurred since there was no maintenance available for this time being. Since the water supply is directly consumed from the source, there is potential effect of aluminium to be contained in the drinking water as a result of natural process. Chronic toxicity of aluminium in drinking water is related with the diseases associated with nerves system (dementia) such as Alzheimer's disease. The limit concentration of aluminium in drinking water set by Ministry of Health Malaysia in National Standard of Drinking Water Quality is 0.2 mg/L. **Objective:** To determine level of aluminium in drinking water in groundwater related to health risk assessment among population at Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor. **Methodology**: A cross-sectional survey had been conducted at Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor at one village with 100 respondents. The study population involved male and female respondents aged 18 and above, who used groundwater as their daily drinking water without any filtration in their houses. 200ml of drinking water from respondents' house was taken as sample, together with their body weight measurement. Inductively coupled plasma mass spectrometry (ICP-MS) was used to analyze aluminium concentration and LAMOTTE TRACER ORP PockeTester for measuring pH level. Statistical Package for Social Science (SPSS) was used to analyze the data. **Results and Discussions:** The range of aluminium concentration was 0.046 - 0.19 mg/L, hence aluminium level in drinking water was below the standard value. The HI<1, thus there was no health risk of Al exposure in drinking water and there was a significant relationship between aluminium and pH value in drinking water. **Conclusion:** The study found that the level of aluminium concentration did not exceed the standard. Even though the pH level was found acidic, since HI<1, therefore, the study area was considered safe from having risk associated with nervous system.

Keywords: Aluminium, Alzheimer's Disease, pH, drinking water, groundwater, Hazard Index

ABSTRAK

KAJIAN KERATAN RENTAS MENGENAI ALUMINIUM DALAM AIR BAWAH TANAH DAN PENILAIAN RISIKO KESIHATAN DI PERKAMPUNGAN ORANG ASLI, BATU 28, JENDERAM HILIR SELANGOR

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Pengenalan: Bekalan air bawah tanah tidak bebas daripada sebarang kekotoran kerana tiada siri proses rawatan air yang berlaku disebabkan tiada penyelenggaraan pada masa ini. Oleh kerana air dari bawah tanah langsung diminium, potensi untuk aluminium untuk berada di dalam air minuman adalah positif disebabkan oleh kejadian semula jadi. Ketoksikan kronik aluminium dalam air minuman adalah berkaitan dengan penyakit yang melibatkan system saraf (demensia) seperti penyakit Alzeimer. Kepekatan had aluminium dalam air minuman yang ditetapkan oleh Kementerian Kesihatan Malaysia dalam Standard Kebangsaan Kualiti Air Minuman adalah 0.2 mg / L. **Objektif:** Untuk menentukan tahap kandungan aluminium dalam air minuman dari bawah tanah yang berkaitan dengan penilaian risiko kesihatan dalam kalangan orang asli di Perkampungan Orang Asli Batu 28 Jenderam Hilir, Selangor. **Metodologi**: Satu kajian keratan rentas telah dijalankan di Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor dengan 100 responden. Populasi yang terlibat ialah responden lelaki dan perempuan yang berumur 18 tahun ke atas, yang menggunakan air bawah tanah sebagai air minuman harian mereka tanpa sebarang penapisan dalam rumah mereka. 200ml air minuman dari rumah responden telah diambil sebagai sampel, bersama-sama dengan ukuran berat badan mereka. Induktif ditambah massa plasma spektrometri (ICP -MS) telah digunakan untuk menganalisis kepekatan aluminium dan Lamotte TRACER ORP PockeTester untuk mengukur tahap pH. Pakej Statistik Untuk Sains Sosial (SPSS) digunakan untuk menganalisis data. **Keputusan dan Perbincangan:** Kadar kepekatan aluminum adalah di antara 0.046 - 0.19 mg/L, maka Tahap aluminium dalam air minuman dalam di bawah nilai standard. HI<1, oleh itu tiada risiko kesihatan yang disebabkan oleh pendedahan kepada Aluminium dan tiada risiki kesihatan disebabkan oleh terdedah kepada aluminium dan terdapat hubungan yang signifikan di antara aluminium dan nilai pH dalam air minuman. **Kesimpulan:** Kajian mendapati bahawa aluminium tidak melebihi piawaian. Walaupun tahap pH itu ditemui berasid ,oleh kerana HI < 1 , oleh itu, kawasan kajian telah dianggap selamat daripada mempunyai risiko yang berkaitan dengan sistem saraf.

Kata kunci: Aluminium, Penyakit Alzeimer, pH, air minuman, air bawah tanah, Index Hazad

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LIST OF ABBREVIATIONS

AD	Alzheimer's Disease
Al	Aluminium
ATSDR	Agency for Toxic Substances Diseases and Registry
BW	Body Weight
C	Concentration
CDI	Chronic Daily Intake
CCME	Canadian Council of Ministers of the Environment
DI	Daily Intake
EPA	Environmental Protection Agency
EPU	Economic Planning Unit
GI	Gastrointestinal
HDPE	High-density Polyethylene
HI	Hazard Index
ICP-MS	Inductively coupled plasma mass spectrometry
IRIS	Integrated Risk Information System
JAKOA	Jabatan Kemajuan Orang Asli
JHEOA	Jabatan Hal Ehwal Orang Asli
JKEUPM	Jawatankuasa Etika Universiti Putra Malaysia
MDPE	Medium-density Polyethylene
MRL	Minimal Risk Level
MWA	Malaysian Water Association
NOAEL	No Observed Adverse Effect Level
PVC	Polyvinyl Chloride

LIST OF ABBREVIATIONS

RfC	Reference Concentration
RfD	Reference Dose
SYABAS	Syarikat Bekalan Air Selangor Sdn. Bhd.
UNDP	United Nation Development Programme
UNICEF	United Nation Children's Emergency Fund
WHO	World Health Organization

Chapter 1

INTRODUCTION

1.0 Introduction

1.1 Background

World Health Organization (WHO, 2014) stated that the safety and accessibility of drinking-water are major concerns throughout the world. Consumption of water contaminated with infectious agents, toxic chemicals, and radiological hazards may cause health risk. However, to have a positive impact to health, thus the access to safe-drinking water need to be improved. From the research that has been conducted, by the end of 2011 the percentage of the world population that used drinking-water source that has been recovered is 89% and 55% of the population has the chance to have the convenience and associated health benefits from a piped supply on premise. There are 768 million people who did not use an improved source for drinking-water in 2011 and 185 million depend on surface water to fulfill their daily drinking-water needs. An "improved drinking-water source" is one that by the nature of its construction adequately protects the source from outside contamination, in particular from faecal matter (UNICEF & WHO, 2014).

Groundwater source is one of the sources of water that can be consumed as a drinking water. A movement of water under the earth's surface in fracture soil and rocks is called groundwater flow. Each drop of rain that permeate into soils, move downward the water table, which is the water level in the groundwater reservoir. According to Malaysian Water Association (MWA), groundwater is well-established as a reliable source of water overseas, with high levels of exploitation in countries such as Denmark (99%), Austria (98%), Switzerland (83%) and Thailand (80%) (The Star, 2014). Thus, since groundwater is the only water source available at Kampung Orang Asli Batu 28, Jenderam Hilir Selangor, the consumer especially Orang Asli, consume pure water from the groundwater which is not free from any impurities since there was no maintenance conducted at the pump house for filtration process.

Safe drinking water as defined by World Health Organization (WHO, 2014), does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Since access to safe drinking water is a must to develop good health impact, groundwater in Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor is being observed as there is no treatment of water for the water supply to the community. Investment and sanitation to water supply can result in economic benefit as the adverse health impact can be prevented but to this community, the investment to the water supply is not good enough as there is no water pipe using in this community. Thus, the water supply may contain high level of unknown metals, impurities or other foreign particles that may cause impact to their health. According to UNICEF, major cause of illness and mortality is lack of safe drinking water, as a result of exposure to infectious agents, chemical pollutants and poor hygiene. UNICEF also stated that source of economic disadvantage is inadequate access to water in the home. This indicator provides a proxy measure both of exposure, in terms of access to safe drinking water and the effectiveness of actions to improve access (WHO & UNICEF, 2014).

Aluminium level is one of the contaminants that will be measured to indicate the condition of the water supply and as the relation to the health impact of Orang Asli at Batu 28 Jenderam Hilir Selangor.

1.2 Problem Statement

Health status is really related to the water supply; whether the water supply is in a good condition or full of impurities that may cause severe health effects. From the journal of Toxicology and Environmental Health, the researchers stated that aluminium may be designated as crustal in origin, and thus surface soils at uncontaminated sites constitute a source of soluble aluminium species in surface water and aluminium-containing particulates in sediments and ambient-air aerosols (Krewski et al., 2011). Naturally, aluminium levels in surface water is usually really low which is less than 0.1mg/L. However, the concentration of soluble aluminium is increasing when acidic waters or water high in humic or fulvic acid content due to the increased solubility of aluminum oxide and aluminum salts (WHO, 2003).

The problem to be highlighted is water supply in Perkampungan Orang Asli Bukit Batu 28, Jenderam Hilir Selangor is not properly treated as there is no maintenance conducted at the pump house. Therefore, there was no filtration occur before the groundwater being transported to the houses. Thus, it is also will be related to the health impact to the consumer, especially the population of Orang Asli who consume water directly from groundwater source in their house.

1.3 Conceptual Framework

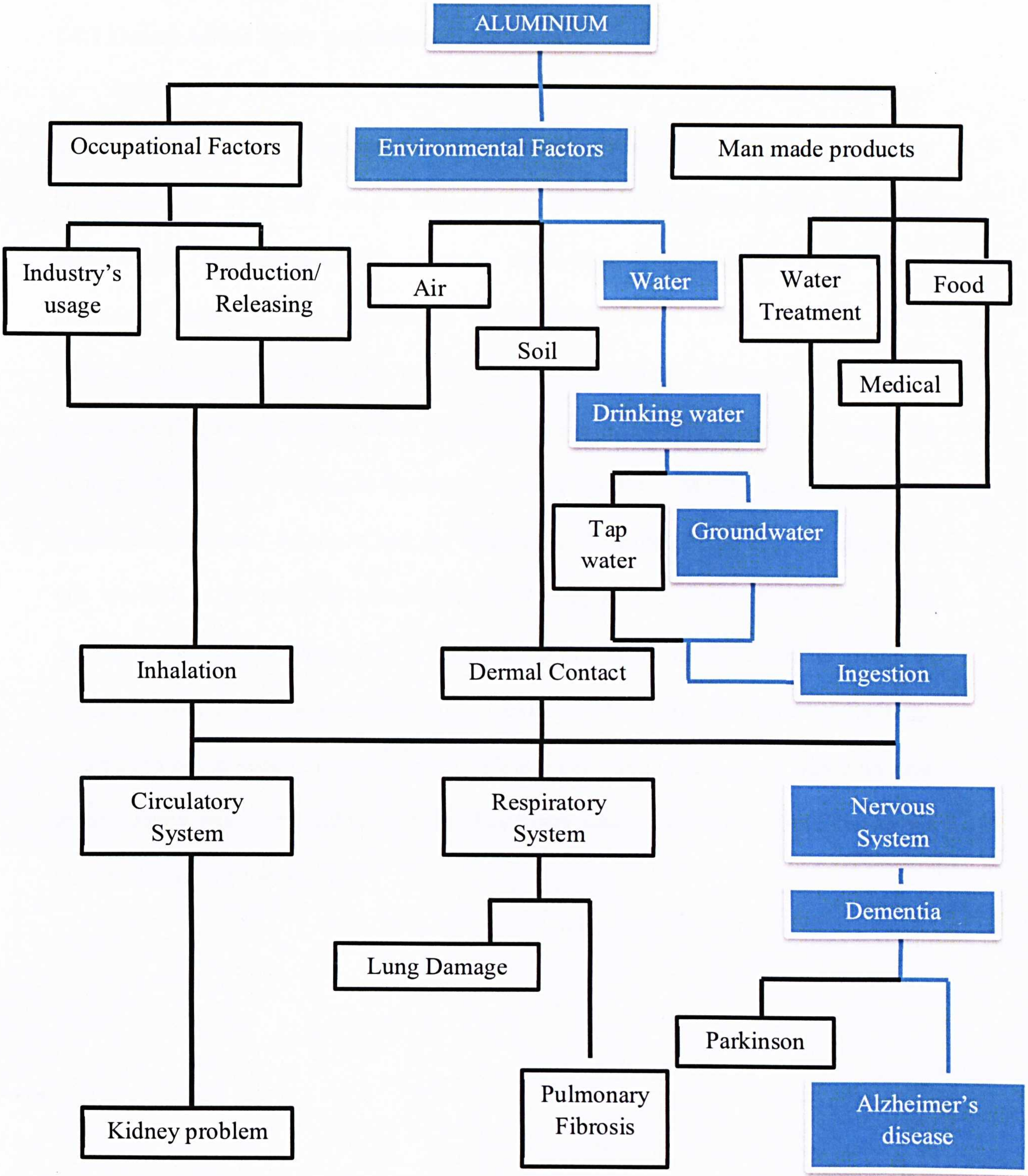

Figure 1.1: Conceptual framework

1.4 Study Justification

1.4.1 Orang Asli as study population of the research

According to United Nations Development Programme (UNDP) Malaysia, it states that the 2004 Population Survey of the Department of Aboriginal Affairs estimated the total population of Orang Asli in Malaysia at 141,230. Semang (Negrito), Senoi and Proto Malay (Aboriginal Malay) are three main tribal groups of the Orang Asli of Peninsular Malaysia and consists of 19 ethnic (Bellwood, 1997; Nicholas, 2000; JHEOA, 2002; Nicholas, 2005) which make up only 0.6% of the total Malaysian population (Figure 1). Communities of Orang Asli is differently in different states; the Senoi predominantly residing in Perak and Pahang, the Proto Malays in Pahang, Johor, Negeri Sembilan and Selangor, and the Negritos in Kelantan, Perak and Pahang. Since this research is focusing on communities of Orang Asli in Batu 28, Jenderam Hilir Selangor, it is because Orang Asli is classified as one of the most vulnerable groups in Malaysia, with a disproportionately high incidence of poverty and hardcore poverty. Apart from being extremely poor, Orang Asli also categorized as a group which has low immunization amongst children and also has lower educational level. Groundwater via tube well does not cost much.

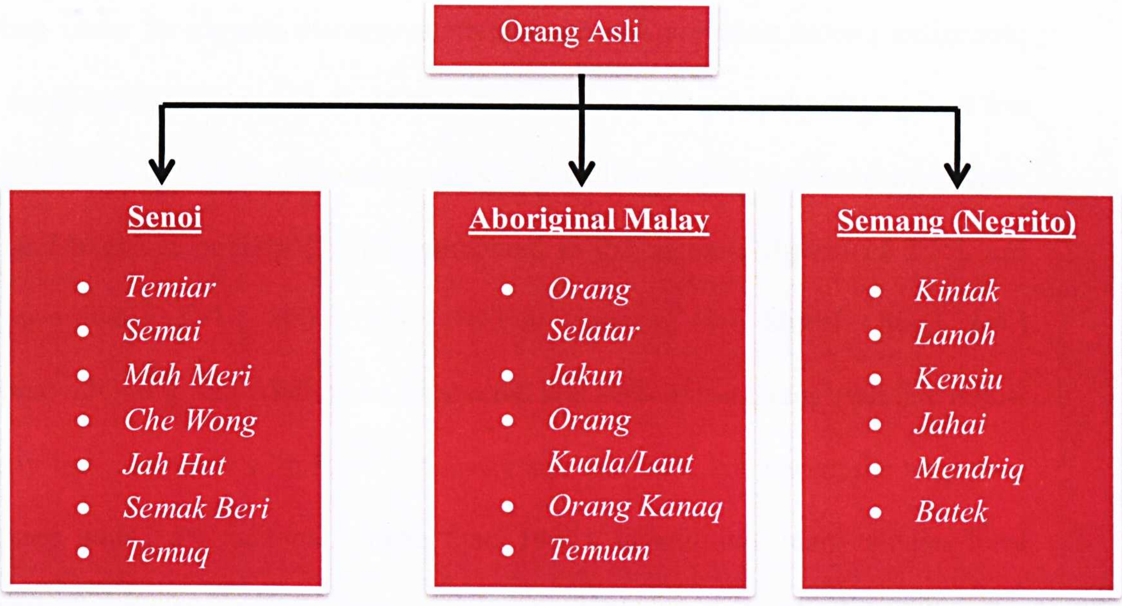

Figure 1.2: Categories of ethnics of Orang Asli in Peninsular Malaysia

Source: Masron et al., 2010

According to Masron, Masami, and Ismail (2010), Orang Asli are the indigenous or which exist naturally in particular region communities in Peninsular Malaysia. The Orang Asli villages are now more opened and accessible compared to the previous years. There are also more services that provided by the government sector nowadays such as general healthcare, maternity and infant care, dental care, police security, communication and education. There is also a place for them to provide services to the Orang Asli in the village respectively. Unfortunately, there is a major problem in the coordination within each of the organization. Each department's visits to the Orang Asli village are not well synchronized and many data are not shared. Besides that, there is population problem in the community and among them often leads to the neglect of their health and of essential needs like proper clothing and nutritious foods for the whole family (Masron, Masami, & Ismail, 2010).

Risk factor for chronic diseases is poverty and it is prevalent among indigenous peoples worldwide (Damman et al., 2008). Similarly in Malaysia, the Orang Asli has been identified as one of the poorest groups and with a higher incidence of poverty (50.9%) and hardcore poverty (15.4%) compared to the national figures of 7.5% and 1.4%, respectively (EPU, 2007). The JHEOA (Jabatan Hal Ehwal Orang Asli) (Department of Orang Asli Affair) has discovered that 80% of the Orang Asli live below the poverty line compared with 8.5% nationally and that 50% are among the very poor as compared with 2.5% nationally (The Star, 1997). In addition, many studies have shown that the prevalence of chronic diseases is high among aboriginal peoples worldwide (Anand, et al., 2001; James, et al., 2001; Uauy, et al., 2001; Ring & Brown, 2003; Vanasse, et al., 2006; Hayati, et al., 2007). In term of health, Orang Asli has showed the lower health status compared to the general population.

In Peninsular Malaysia, the responsibility of looking into the schooling needs of indigenous communities from the JHEOA has been taken by the Education Ministry and it is hoped that the quality of education and the facilities provided will improve. As it is 66% of the Orang Asli is not knowing how to read and write or illiterate (The Star, 1997). In the Orang Asli's development programmes, education is the main agenda and as a key instrument in the effort to recover their quality of life (Mohd Tap, 1990). However, the educational programme managed by the JHEOA was a major failure (Ikram, 1997). The JHEOA field staffs were not officially trained and most of them had a low level of education themselves.

Hence, this research will help to increase their awareness and give baseline information of groundwater and health impact related to groundwater at their village.

1.4.2 Groundwater is chosen for the research

According to Natural Resources and Environment Minister Datuk Seri G.Palanive, groundwater can be an alternative fresh water source if its extraction is done appropriately without adversely affecting the environment (The Malaysian Insider, 2014). Humic acid content and pH of the water would influence the difference in dissolved aluminium concentrations in surface and groundwater. Low pH would cause high aluminium concentration in natural water. Therefore, the concentration of aluminium in surface water was very low.

There were three problems that had been dominated by groundwater. One of the problems was depletion of the groundwater use due to the overuse of the groundwater. Secondly, water logging and salinization due to insufficient conjunctive use and inadequate drainage. The third problem was pollution that had been caused by human activities, agriculture and industrial activities. Focusing on pollution, there was no such activities that can be related to the releasing of aluminium in the groundwater by human activities.

Groundwater is the water contained in the saturated zone and water table is the top layer of the highest saturated zone. Recharge water is the process of water entering the groundwater system and discharge water is the process of water leaving the system.

Generally, source of water can be obtained through water river, lake, water surface, gravity feed water system and tube well. Focusing on tube well, generally, the groundwater used tube well that had been drilled 100 meter depth. The water then being pumped out to the raw water tank and undergo filtration processes. There were few types of filter which were glass, UV, chlorine and cell that was located in the pump house. After filtration processes, the treated water then was being pumped to the individual tank at each houses of the users.

Unfortunately, there was no filtration processes available at the study location. Referring to the JAKOA, there was no maintenance at the pump house conducted during the period of time. The maintenance should be handled weekly for cleaning the pump house, checking the piping system, backwash and running some tests.

Sadly, there is only using PVC pipe to let water through it directly to the houses of Orang Asli without going through those processes. The source of water is from groundwater thus the water that is consumed by Orang Asli is probably highly contaminated with impurities such as dissolved minerals, organic matter, minerals in rocks and living organisms

1.4.3 Aluminium content in drinking water

Orang Asli in Kampung Batu 28, Jenderam Hilir Selangor are directly consumed water after the water supply is being transported via pipe system from groundwater to their houses' water tank. Naturally, water can only be contaminated by aluminium content if there are mining activities, grinding and other related activities which will activate the releasing of aluminium to the water sources.

However, the situation at this village is different as there are no such activities have been done at the water sources. Groundwater system that has been built in Kampung Batu 28 Jenderam Hilir has been built together with the pump house for the filtration process before the water being distributed to the consumer, but the pump house did not functioning since there was no maintenance available during this period of time. Thus, since the water supply is directly consumed from the source, there is potential effect of aluminium to be contained in the drinking water as a result of natural process of acid rain which will then increase the level of aluminium in the water. From the research that has been done, the concentration of soluble aluminium is increasing when acidic waters or water high in humic or fulvic acid content due to the increased solubility of aluminium oxide and aluminium salts.

1.5 Definition

1.5.1 Conceptual Definition

1.5.1.1 Drinking Water

Drinking water is defined as water for ingestion, basic personal and domestic hygiene and cooking. It excludes water for clothes washing, an activity that frequently happens at the water source, water point, in rivers or streams (WHO & UNICEF, 2014). Drinking water also can be defined as improved drinking water which is safe enough for drinking and food preparation.

1.5.1.2 Aluminium Level

According to ATSDR intermediate-duration oral minimal risk level (MRL) for aluminium is 1mg Al/kg/day. ATSDR also has derived chronic-duration oral MRL of 1mg Al/kg/day for aluminium. According to Regulations and Advisories, the international and national guideline regarding aluminium and aluminium compounds in air, water and other media; it stated that EPA has not derived a reference dose (RfD) or reference concentration (RfC) for aluminium but has derived RfD for aluminium phosphide 4×10^{-4} mg/kg/day based on NOAEL of 0.51 mg/kg of food or 0.025 mg/kg/day (phosphine) (IRIS 2008).

1.5.1.3 Health Risk Assessment

Health risk assessments are used to estimate whether current or future chemical exposures will pose health risks to a broad population, such as a city or a community

(California Environmental Protection Agency, 2001). There are four steps of Health Risk Assessment which are;

I. Hazard identification
II. Exposure assessment
III. Dose-response assessment
IV. Risk characterization

1.5.2 Operational Definition

1.5.2.1 Drinking Water

Drinking water samples are taken from the sources at the respondents' houses after directly gets the water supply from groundwater. The water samples are poured within one to two inch from the top into plastic bottles that have been cleaned using acid bases.

1.6 Study Objective

1.6.1 General Objective

To determine level of aluminium in drinking water in groundwater related to health risk assessment among population at Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor.

1.6.2 Specific Objective

- To determine the sociodemographic of residence at Kampung Orang Asli Batu 28, Jenderam Hilir, Selangor.
- To determine aluminium level and pH value in groundwater.
- To compare aluminium level in groundwater with national standard (0.2 mg/L).
- To determine the relationship between aluminium level and water pH
- To calculate the CDI of aluminium exposure among respondents.
- To determine HI with health risk effect of aluminium exposure in groundwater among the respondents

$$HI = CDI/RfD,$$

Where;

HI = Health Index

CDI = Chronic Daily Intake (mg/kg/day)

RfD = Reference Dose (mg/kg/day)

1.7 Study Hypothesis

- The standard level for consuming aluminium is less than 0.2 mg/L

  If aluminium is consume more than 0.2 mg/L the possibility to have Alzheimer is high.

- There is a significant difference between standard aluminium level and measured aluminium level in drinking water.
- HI is less than 1
- There is a relationship between pH and aluminium level in drinking water.

Chapter 2

LITERATURE REVIEW

2.0 Literature Review

2.1 Location of the study

Perkampungan Orang Asli Batu 28 Jenderam Hilir is located at Jenderam Hilir, Selangor. This study location has no industrial activities and mining activities nearby. The water source available is groundwater and it is directly supplied to the community without any treatment processes as there is no maintenance conducted at the pump house for this time being.

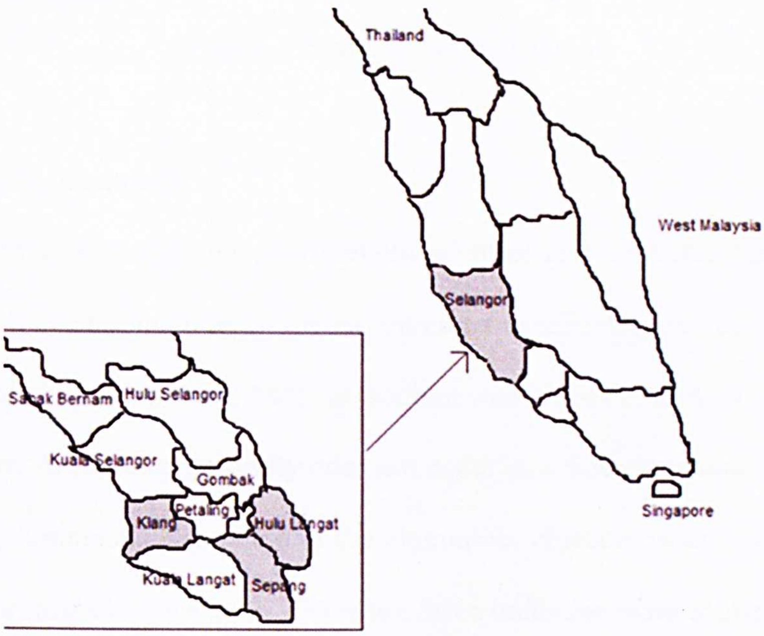

Figure 2.1: Map of Selangor and Sepang District

Figure 2.2: Map of study location

2.2 Identity of Aluminium

Aluminium is the most abundant metallic element and constitutes about 8% of the Earth's crust. It occurs naturally in the environment as silicates, oxides, and hydroxides, combined with other elements, such as sodium and fluoride, and as complexes with organic matter. Aluminium naturally does not occur as a free elemental metal form such as feldspars (aluminosilicates). One of the aluminium characteristics is it is insoluble in water under normal circumstances. There are three oxidation state of Al; +1, +2 and +3. Al occurs as free Al^{3+} in surface and groundwater which it is at low pH and when at high pH (pH>6), it may forms in the very insoluble $Al(OH)_3$ solid (gibbsite) (WHO, 2003)

Table 2.1: Identity of Aluminium

Compound	CAS No.	Molecular formula
Aluminium	7429-90-5	Al
Aluminium chloride	7446-70-0	AlC13
Aluminium hydroxide	21645-51-2	Al(OH)3
Aluminium oxide	1344-28-1	Al_2O3
Aluminium sulfate	10043-01-3	$Al_2(SO4)3$

Table 2.2: Psychochemical properties of Aluminium (Lide, 1993)

Property	Al	AlC13	Al(OH)3	Al_2O3	$Al_2(SO4)3$
Melting point (^0C)	660	190	300	2072	770 (d)
Boiling point (^0C)	2467	262 (d)	-	2980	-
Density at 20^0C g/m3	2.70	2.44	2.42	3.97	2.71
Water solubility (g/litre)	(i)	69.9	(i)	(i)	31.3 at 0^0C

d, decomposes; i, insoluble

Aluminium presents in drinking water as one of the trace inorganic metals. In addition, Al-based coagulants especially Al_2 (SO4)3 (alum) has been used to the naturally occurring aluminium in raw waters which leads to an increase of Al concentration in treated water. According to WHO Food Additive Series 24, aluminium concentration in fresh (untreated) water is usually low, as it may be 0.001 to 1 mg/l. High concentration of aluminium which is 3.6 to 6 mg/l may precipitate as aluminium hydroxide that will increase the consumer complaints. Aluminium will undergo various transformations which also called 'specification' of aluminium during conventional water treatment process. This process is influenced by factors such as pH, turbidity, temperature of water source, and the organic and inorganic ligands present in water. The efficient methods used to remove Aluminium from water are chemical precipitation, electrodialysis, reverse osmosis and cation exchange method.

2.2.1 Major uses of Aluminium

Aluminium 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. Aluminium compounds are used as antacids, antiperspirants, and food additives (ATSDR, 1992). Aluminium 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 aluminium salt (often sulfate) at optimum pH and dosage, followed by flocculation, sedimentation, and filtration (Health Canada, 1993).

2.2.2 Releasing of Aluminium to the environment

Aluminium is released to the environment mainly by natural processes. Several factors influence aluminium mobility and subsequent transport within the environment. These include chemical speciation, hydrological flow paths, soil–water interactions, and the composition of the underlying geological materials. Acid mine drainage or acid rain can cause an increase in the dissolved aluminium content of the surrounding waters which will cause acid environments (ATSDR, 1992; WHO, 1997). Aluminium can occur in a number of different forms in water. It can form monomeric and polymeric hydroxy species, colloidal polymeric solutions and gels, and precipitates, all based on aquated positive ions or hydroxylated aluminates. In addition, it can form complexes with various organic compounds (e.g. humic or fulvic acids) and inorganic ligands (e.g. fluoride, chloride, and sulfate), most but not all of which are soluble. The chemistry of aluminium in water is complex, and many chemical parameters, including pH, determine which aluminium species are present in aqueous solutions. In pure water, aluminium has a minimum solubility in the pH range 5.5–6.0; concentrations of total dissolved aluminium increase at higher and lower pH values (CCME, 1988; ISO, 1994).

Mineral weathering is one of the factors which contributed of Al^{3+} in surface and groundwater. Since aluminium in not mobile in the most natural water's pH, Al can be mobilized in acidic waters (pH<4) by dissolution of gibbsite and the accelerated weathering of both clay minerals and rock-forming minerals. However, due to extreme low solubility of Al-bearing minerals, it said that the concentration of aluminium is at very low level. Concentrations in groundwater are strongly pH dependent (Nordstrom, 1982). From the previous study that has been conducted by the researchers, the increasing aluminium concentration is highly linked to acidic conditions such as rainfall acidity and acid mine drainage.

2.2.3 Aluminium and its association to human health impact

Aluminium have the potential to be a toxicant to the central nervous, skeletal and haematopoietic systems which has been shown in animal and human (Jeffery et al. 1996 & 1997; Health Canada 1998; ATSDR 1999; California EPA 2000; Cannata Andı'a 2000). There are ideas of aluminium-induced nephrotoxicity and pulmonary fibrosis (Jeffery et al. 1996 &1997; ATSDR 1999). Aluminium is a neurotoxicant. Rising in systemic aluminium from aluminium-contaminated dialysates and intravenous fluids, oral consumption of large amounts of aluminium containing antacids/phosphate binders by people with significantly impaired or no renal function and irrigation of the urinary bladder with massive amounts of alum to stop haemorrhaging can produce an encephalopathy. Encephalopathy from aluminium exposures that cause large increases in systemic aluminium has greatly decreased, but not disappeared, over the past two decades. It has been suggested that low level long-term exposure to aluminium may be a contributing factor in Alzheimer's disease and related disorders. The results of some epidemiological studies of the association between drinking water contained aluminium and Alzheimer's disease are consistent with this hypothesis while some others are not (Health Canada 1998; California EPA 1999; Yokel 2000). Similarly, only some of the studies that determined aluminium in bulk brain, neurofibrillary tangles and senile plaques of victims of Alzheimer's disease and related disorders are consistent with this hypothesis (Yokel, 2000). Negative effects of aluminium on neurobehavioural development has been something to concern with (Golub & Domingo 1996 & 1997). Even though aluminium contamination of dialysates has showed decreasing statistic over the past two decades, aluminium is said to be a major causative agent in the low bone turnover diseases, osteomalacia and adynamic bone in those with impaired renal function (Cannata Andı́a, 2000). Aluminium's source is mainly from drinking water which it is naturally present and from water treatment method.

People who experienced kidney disease will store a lot of aluminium in their body as it will affect the decrease in amount of aluminium to be removed from the body through urine. These people will sometimes develop bone or brain disease that is predicted from exposing to excess level of aluminium. A degenerative neurological syndrome, dialysis encephalopathy, has been observed in patients of kidney failure who had been exposed to very high level of aluminium in contaminated. There are several experiments that have been conducted using some animal to observe the effect of aluminium in drinking water to their body system. As a result, the animals died when they have been given very large amount of aluminium in water and others gain less weight than normal.

Based on the available scientific literature, level of aluminium which the general public is typically exposed is not expected to have neurotoxic effects. A recent guideline study has proven mild neurological effects in rats exposed to high levels of aluminium. These effects were only observed at aluminium levels a thousand-fold higher than what is typically found in treated drinking water and food (Flarend et al., 2001). For Alzheimer's Disease, the evidence from the research still could not support the relation between primary role of aluminium to Alzheimer's Disease.

To associate the relationship between aluminium and pH value, once the water has been contaminated with aluminium, the pH value will be less than 6.5 ($pH<6.5$) which means, the water is in acidic condition. For comparison, the pH of pure water (H_2O) is 7 at 25^0C, but the pH will be 5.2 when it is exposed to the carbon dioxide in the atmosphere, as the equilibrium result.

2.3 Groundwater and Health Risk Assessment of Aluminium

A water supply distribution system may be divided into three types:

I. Gravity system
II. Pumped system; and
III. Combination gravity and pumped system

(Elojali, 2011)

Figure 2.3 shows the differences between the three types of water supply. The choice of type of water supply distribution system depends on the topography, location and extent of the distribution area, elevation and site conditions (Elojali, 2011)

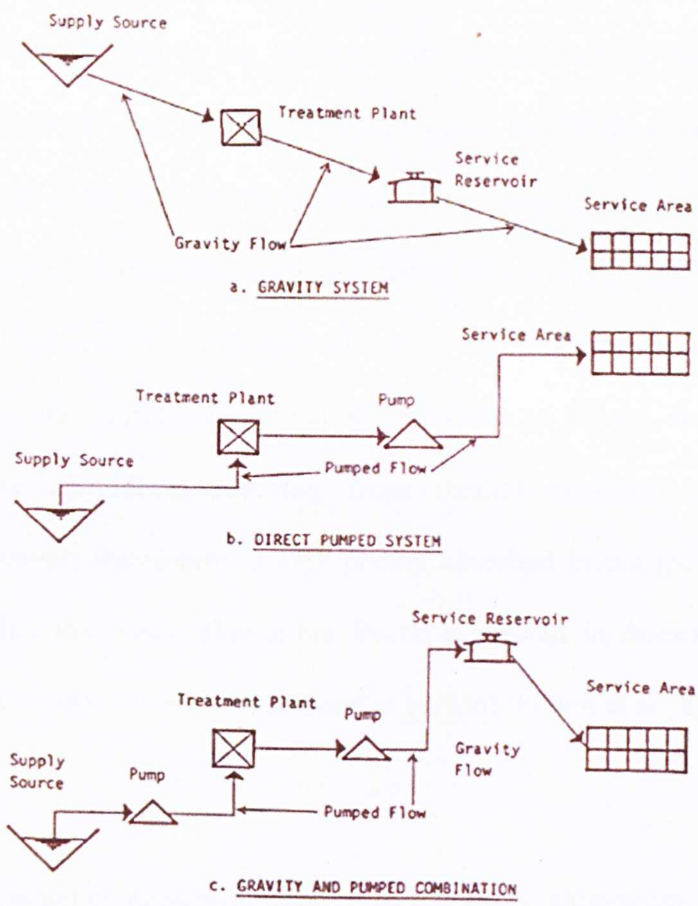

Figure 2.3: Three types of water supply system (Elojali, 2011)

Groundwater system, especially in study location which is Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor was not properly built as there was no treatment processes involved. The water supply that directly flows through PVC pipe with the water being pumped out has highly potential to be contaminated with impurities. The system, however, is due to the maintenance that had not been managed during this period of time.

Aluminium is clearly a strong neurotoxicant. Considerable proof exists that aluminium may play a role in the aetiology or pathogenesis of Alzheimer's disease (AD), but whether the link is causal is still open to debate (Flaten et al, 2001). Aluminium levels in surface water is usually very low (<0.1 mg/L); however, the concentration of soluble aluminum increases due to the increased solubility of aluminum oxide and aluminum salts, in acidic waters or water high in humic or fulvic acid content, (ATSDR). Thus, the water supply via groundwater to Orang Asli is said to be contaminated by aluminium resulting from natural occurrence of aluminium's production. However, aluminium is very poorly absorbed in the gastrointestinal tract, and the possibility that some aluminium fractions present in drinking water may be particularly bioavailable cannot be dismissed at present (Flaten et al., 2001)

For drinking water contaminant, which is in this study, aluminium, the following risk assessment shall be followed:

I. Source of contaminant
II. Route of exposure
III. Frequency, duration and magnitude of the exposure
IV. The ability to document an actual internal dose
V. The ability to document the dose to the target organ

Other risk factors of health effect must be measured in the conduct of these studies. (Flaten, T.P., 2001)

2.3.1 Hazard Identification

A base for hazard identification use epidemiological data derived from the exposed population. Non-occupational studies of populations exposed to aluminium in food and drinking water include the epidemiological information base of aluminium (Krewski et al., 2007).

2.3.2 Dose Response

Evaluation of human health risks, health effects, exposure characterization seeks to quantitatively evaluate the dose-response relationship information for outcomes having either strong or modest supporting evidence. For proof of an effect to be strong, the dominance of epidemiological data must be positive, with at least some coming from multiple studies with modest or large sample size and reasonably sound design (Krewski et al., 2007).

Sound design is where;

I. its sample size is broad enough to detect an effect of moderate magnitude
II. it controls potential confounding effects sufficiently to ensure that their introduction of a false association is at most modest
III. it quantifies exposure to aluminium among subjects or groups of study subjects

2.3.3 Exposure Assessment

Within each exposure route, the following health endpoints have been considered: 1) acute toxicity, 2) irritation, 3) corrosivity, 4) sensitization, 5) repeated dose toxicity, 6) mutagenicity, 7) carcinogenicity, 8) reproductive toxicity, and 9) other forms of toxicity, as described by the European Commission (2003).

Since this study is to examine the drinking water, internal exposure following oral exposure depends on absorption and retention of aluminium, effects described here depend on health status. For irritation effect, from the previous research, in 1998, 20,000 individuals are said to be exposed to an error of drinking water treatment which the levels of aluminium sulphate is increasing in their drinking water for three days. Although members of the population reported GI disturbances and oral ulcerations, the role of aluminium could not be isolated because of other associated changes in water chemistry, including a decrease in pH and elevation in the concentrations of copper, zinc, and lead (dissolved from domestic plumbing fixtures) (Krewski et al., 2007). The researchers also said that animal data do not support the potential for oral and GI effects. Therefore, the evidence that aluminium can cause irritation via ingestion of drinking water which contained aluminium is limited.

For carcinogenicity effect, the previous research used no human data and for animal data, it showed negative result. Thus, there is no clear evidence for the carcinogenicity of aluminium by oral ingestion.

The other health effect includes reproductive or developmental effects. There are no epidemiological data on reproductive or developmental outcomes following oral exposure to aluminium. However, Effects on Laboratory Mammals and In Vitro Test Systems, Reproductive and Developmental Toxicity, describes a substantial number of rodent bioassays investigating the effect of aluminium exposure via oral administration. The results from the animal studies shows that the effects depend strongly on the bioavailability of the aluminium species. Species that are water soluble have been shown to have adverse effects, including aluminium nitrate (Paternain et al., 1988; Albina et al., 2000), aluminium chloride (Cranmer et al., 1986; Misawa & Shigeta, 1993; Colomina et al., 1999;), or or aluminium lactate (Golub et al., 1987; Gonda et al., 1996; Poulos et al., 1996), although these effects may be directly related to aluminium exposure or the result of a secondary consequence. Based on the animal data than has been obtained in previous research by the researchers, they conclude that the evidence for this health effect is modest; although they considered that it is highly dependent on aluminium species, most likely because of differences in bioavailability.

For neurological effect, Forbes et al. (1991 & 1992) reported that men living in areas with high aluminium concentrations in drinking water were less likely to be cognitively normal. However, the result of previous research is stated that neurological impact to human health is due to combination of both aluminium and fluoride exposure. Jacqmin et al. (1994) and Jacqmin-Gadda et al. (1996) reported the relationship between cognitive impairment and aluminium and silica drinking water concentrations considered jointly. McLachlan et al. (1996) reported an increasing risk of Alzheimer's disease among individuals exposed to higher levels of aluminium in drinking water. However, the study did not control for fluoride, silica, or pH; nor did it control for other potential confounders.

Bone toxicity also related to ingestion of aluminium in drinking water. The researcher used animal to investigate the bone toxicity's impact. As a result, none of the experimented animals showed an adverse effect. Among members of the population with normal kidney function, there is limited proof that exposures to high levels of aluminium can result in accumulation of aluminium in bone tissue (Krewski et al., 2007). However, the previous studies that have been conducted have been limited in size and there is no adverse effect shown. Thus, there is no clear evidence for this bone toxicity impact via ingestion of aluminium in drinking water.

2.3.4 Risk Characterization

Based on previous research, for oral exposure, two health effects have been identified which are reproductive toxicity and neurological effects (an increase of risk of development of Alzheimer's Disease), exposure to aluminium in drinking water (0.1 mg/L). This level of 0.1 mg/L is less than the recommended limits established by the

WHO, the European Union, and Australia. Secondary drinking water regulations in the U.S. establish a limit of 0.05 to 0.2 mg/L for aluminium.

Chapter 3

METHODOLOGY

3.0 Methodology

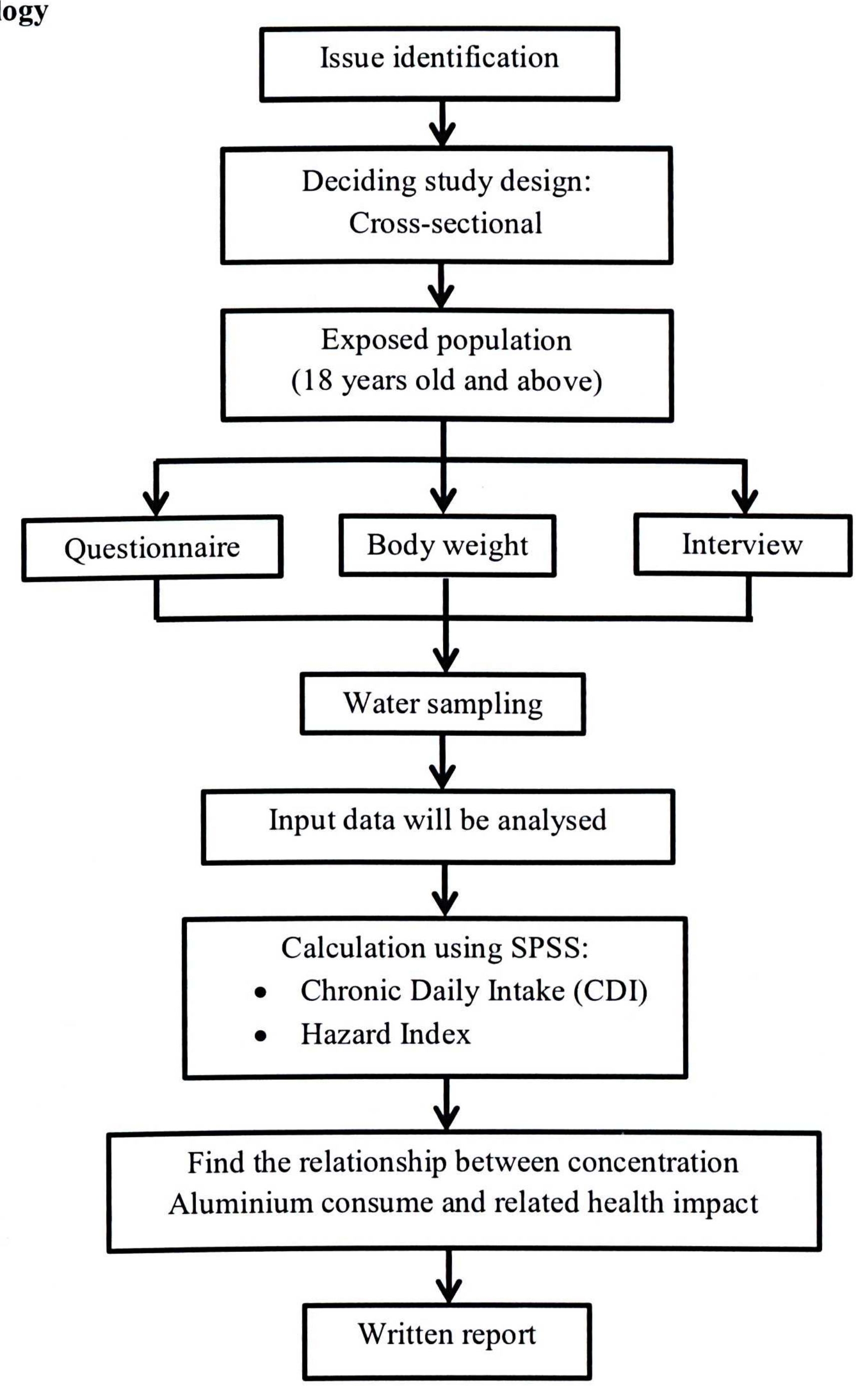

Figure 3.1: Methodology

3.1 Study Design

A cross-sectional survey had been conducted at Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor at one village with 100 respondents. The survey had been carried out by inspection and interview to determine the state of functioning and utilization of rural water supplies. On the other hand, Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor was selected as it is using groundwater system without any filtration since there was no maintenance available at the pump house located at the study area. Thus it was not free from impurities, especially aluminium.

Water sample of drinking water had been taken from the respondent's house who was directly consumed water from the groundwater source. The HDPE plastic bottle had been used to store the water samples to be analysed. Inductively coupled plasma mass spectrometry (ICPMS) had been used to analyse aluminium level in the drinking water sample taken. For data collection, an interview had been conducted and questionnaire had been distributed to the respondents.

3.2 Study Sampling

3.2.1 Water Sample

Water sample had been taken at the house of Orang Asli, the source of water supply after directly supplied via groundwater.

3.2.2 Body Weight

Each respondent among 18 years old and above was weighed in order to calculate Chronic Daily Intake (CDI) which required body weight of the respondents.

3.3 Study Population

Orang Asli are not a homogeneous people but they are officially classified into three main ethno-linguistic groups namely, the Senoi, ProtoMalays or Aboriginal Malays and the Negritos, each consisting of several dialectic sub-groups (Khor et al., 2008). The population selected at Perkampungan Orang Asli Batu 28 Jenderam Hilir Selangor, at the age 18 years old and above, both male and female.

3.4 Study Location

Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor that depended on groundwater source which has no water treatment processes for water supply daily.

3.5 Sampling

3.5.1 Study Sample

The study was conducted on respondent who met the inclusion criteria only.

3.5.2 Sample Size

The sample size was calculated using formula (Equation 1) by Kirkwood and Sterne (2009).

$$N = \frac{P(1-P)}{e^2}$$ (Kirkwood and Sterne, 2009)

(Equation 1)

Where;

N = sample size

P = Expected revalence of dementia disease

e = Probability error (standard value for e is 0.05)

Where P was expected prevalence or proportion which was 0.5 if have no idea or clues, whereas e^2 was 0.05.

$$N = \frac{0.5(1-0.5)}{0.05^2}$$

$$N = 100$$

The sample minimum sample size that was needed for this study is 100 respondents at Perkampungan Orang Asli Batu 28 Jenderam Hilir Selangor. To recover the loss of respondents (Olsen, (-)) the minimum sample size will be rounded up to 20%:

20% of 100 = 20

100 + 20 = 120

Therefore, the total sample size of the population is 120 respondents.

3.5.3 Sampling Method

For this study, simple random sampling which is including in probability sampling has been used as a sampling method.

According to William and Trochim (2002), a probability sample is one which each element of the population has a known non-zero probability of selection; some of the elements of population will be selected and probabilities of selection are known. Probability sampling which are:

- Simple random sampling
- Systematic random sampling
- Stratified random sampling

Random number generator or a random number table will be used when subjects in the population are sampled by a random process, so that each person remaining in the population has the same possibility of being chosen for the sample (Frerichs, 2008). There are few reasons to choose probability sampling which are to make statistical inference, to gain a presentational sample, to minimize bias, to select units using probabilistic method and to meet the criteria needed for probability sampling.

3.5.3.1 Simple random sampling steps

1. Define the population

- From the whole population at Perkampungan Orang Asli Batu 28 Jenderam Hilir, those who consumed water directly from groundwater source daily, who were 18 years old and above; both male and female had been selected. Those who were not in the criteria had been excluded.

↓

2. Sample size had been chosen

↓

3. Population had been listed

- 120 people was selected from the whole population as the approval from JAKOA has been obtained as to view the list needed.

↓

4. Numbers to the units had been assigned

↓

5. Random numbers will be found

- List of random numbers was needed before selecting 120 respondents from total of the whole population.
- Random numbers could be found using random number tables or a computer program.

↓

6. Sample was selected

Figure 3.2: Steps on simple random sampling

3.5.4 Sampling Unit

Sampling unit for this study was resident in Perkampungan Orang Asli Batu 28, Jenderam Hilir, Selangor who had met the inclusive criteria which are:

I. Both male and female who were 18 years old and above which were classified as an adult.

II. The respondents had been live at Perkampungan Orang Asli Batu 28 Jenderam Hilir for more than 5 years.

III. The respondents who consumed daily the water supply directly from groundwater source to the house as drinking water.

Exclusion criteria:

I. Respondents who had water filtered system in their houses.

II. Respondents who consumed water other than were supplied by groundwater.

3.6 Study Instrumentation and Data Collection

3.6.1 Questionnaire

A set of questionnaire comprising of four sections had been distributed to each respondent. Part A of the questionnaire contain questions regarding the personal information, Part B contain questions related to the information about water supply which including daily intake of drinking water. Part C contained questions about the information of criteria of the surrounding and environment whereas Part D related to the health status of the respondents.

3.6.2 Body Weight

The body weights of the respondents had been measured using a Seca Weight scale. The readings was taken three times and then averaged. The unit was in kilogram (kg).

3.6.3 Drinking Water Daily Intake

The sterile HDPE plastic bottles to store the water sample of drinking water had been used. HDPE bottles were used as they were chemical resistance, low cost and did not broken easily when fall. The water was allowed to run for 2 to 3 minutes before fill the water sample inside the plastic bottle to the top. The respondents needed to recall back the amount of drinking water they consumed daily. This information was needed to calculate Chronic Daily Intake (CDI).

3.6.4 Water Sampling

3.6.4.1 Water Analysis

3.6.4.1.1 Equipment

Inductively coupled plasma mass spectrometry (ICP-MS) had been used to analyze content of aluminium level in drinking water. Referring to EPA Method 200.8 (USEPA Method 200.8, 1994), ICP-MS instrument was based on collision and reaction cell technologies. Method 200.8 was designed to generate accurate data for regulatory compliance monitoring of drinking waters and natural water sources for inorganic contaminants under the Federal Regulation 40 CFR parts 141 & 143 (Henry & Wills, 1994). Since aluminium fall under National Secondary Drinking Water Regulations, the lowest value that could be read by ICP-MS is until 0.000048 mg/L.

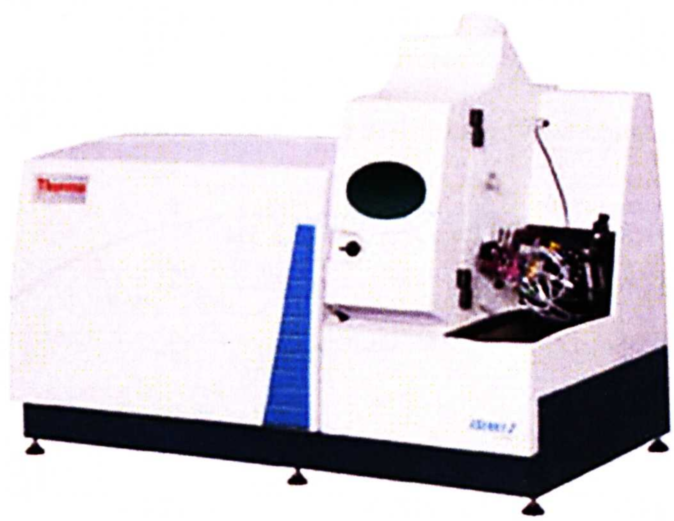

Figure 3.3: Inductively coupled plasma mass spectrometry (ICP-MS)

3.7 Risk Assessment (Calculation)

To determine the exposure of aluminium level in drinking water, Chronic Daily Intake should be calculated first by using this equation:

$$CDI = \frac{C \times DI}{BW} \text{ (USEPA, 1989)}$$

(Equation 2)

Where;

CDI = Chronic Daily Intake (mg/kg/day)

C = Concentration of Al in water sample (mg/L)

DI = Average of rate Daily Intake of water (L/day)

BW = Body weight (kg)

Then Hazard Index was used to conclude the significant different exposure and overall potential of health effects posed by aluminium in drinking water using this equation:

$$HI = \frac{CDI}{RfD} \text{ (USEPA, 2000)}$$

(Equation 3)

Where;

HI = Hazard Index

CDI = Chronic Daily Intake (mg/kg/day)

RfD = Reference Dose (mg/kg/day)

If the HI value is greater than 1 (HI>1), it shows that there is significant risk level of aluminium content in drinking water with dementia disease. The higher the value of HI, the greater the possibility of health impact of aluminium in drinking water to human health. RfD value that will be used in the equation is 1.0 mg/kg/day (USEPA, 2000)

3.8 Ethical Consideration

Ethical issues pertaining to this study was presented and subsequently approved by JKEUPM.

I. The information about the whole activities during the research had been informed to the respondents.

II. The respondents had been given some explanation about health risk assessments, the purpose of the assessment, the steps involved and the respondent's right in this study.

III. The permission of the resident in this study had been obtained and an approval letter had been given to the resident's representative.

IV. An approval letter had been given to the respondents in order to obtain their permission to involve in this study.

3.9 Study Limitation

I. This study was involved the respondents to recall back their consumption of water intake per daily. The information given might not be 100% valid. This might cause recall bias.

II. The data collected in this cross-sectional study did not involve comparison with the non-exposed population. Thus, the result might not be strong enough to relate the health impact of aluminium to the Orang Asli population in Batu 28 Jenderam Hilir.

III. The weather was one of the contributing factors to the content of aluminium in water source as if the acid rain occur, aluminium level will be higher than the normal

Chapter 4

RESULT AND DISCUSSION

4.1 Descriptive Analysis

4.1.1 Socio-demographic Data of Respondents

Data collection was conducted on January – February 2016, at Kampung Orang Asli Batu 28, Jenderam Hilir, Selangor. Those respondents had fulfilled the inclusive and exclusive criteria mentioned in methodology parts.

The study was conducted on 100 respondents and the response rate was 100%. Referring to Table 4.1, it showed that data on socio-demographic was included gender, age, occupational background, monthly income and education background of the respondents involved.

In the study, there was 51% of male (51 respondents) and 49% of female (49 respondents). For the age, most of the respondents (39%) n=39 were at the age of 21-30 years old. Followed by respondents age at 31-30 years old (30%) n=30, 51-60 years old (18%) n=18, 41-50 years old (12%) n=12 and the least respondent involved was at the age of 61-70 years old (1%) n=1. For occupational background, most of the respondents were self-employed (65%) n=65. Others were government employment (3%) n=3, private employment (1%) n=1 and not working respondents (31%) n=31. Other than that, monthly income for the respondents was started from those who gained less than RM600 (21%) n=21. Then followed by those who gained RM600-1000 (29%) n=29, RM1001-RM1500 (20%), RM15001-RM2000 (28%) n=28 and for the respondents who had no income (1%) n=1. After that, educational background for the respondents also included. There were 29 of the respondents (29%) who did not attend school, 29 of the respondents who only attended primary school (29%), 41 of the respondents (41%) who had attended secondary school and only 1 of the respondents (1%) who had attended for university.

Table 4.2 showed the weight measurement that had been taken into account for all of 100 respondents involved. From the table, it showed that the mean of the weight of the respondents was 58.08±9.067. The body weight measurement was taken to calculate the Chronic Daily Intake in the exposure assessment part.

Table 4.1: Socio-demographic of Respondents

Variables	N = 100	Percentage (%)
Gender		
Male	51	51.0
Female	49	49.0
Age		
21-30	39	39.0
31-40	30	30.0
41-50	12	12.0
51-60	18	18.0
61-70	1	1.0
Occupational Background		
Government employment	3	3.0
Private employment	1	1.0
Self– employed	65	65.0
Not working	31	31.0
Monthly Income		
<RM 600	21	21.0
RM 601-1000	29	29.0
RM 1001 - 1500	20	20.0
RM 1501 - 2000	28	28.0
No income	2	2.0
Education Background		
Not attend school	29	29.0
Primary school	29	29.0
Secondary school	41	41.0
University	1	1.0

Table 4.2: Weight Measurement of Respondents

Variable	Mean	Standard of deviation	Median	IQR	95% CI	
					Lower	Upper
Weight (kg)	58.08	9.067	59.00	14.00	56.28	59.88

4.1.2 Water Intake among Respondents

This research was conducted to study the relationship of drinking water consumed by the respondents and the health risk associated with the content of aluminium in the drinking water's source, which is in groundwater. In this study, water intake of the respondents also had been analyzed.

Table 4.3 had summarized the water intake among respondents in Kampung Orang Asli Batu 28, Jenderam Hilir Selangor. From Table 4.3, it showed that all of the respondents (100%) n=100 were using groundwater as their source of daily drinking water. Not only that, the quantity of the drinking water intake per day was also included. Most of the respondents consumed 5-8 glasses per day (53%) n=53, followed by consumed drinking water more than 8 glasses per day (26%) n=26, 2-4 glasses of drinking water per day (18%) n=18 and only 3 out of 100 respondents (3%) consumed less than 2 glasses per day. For the usage of water at their houses, all of the respondents (100%) used water for cooking, drink and domestic use. Considering the quality of drinking water itself, this study found that only 99 respondents (99%) agreed for the good water quality (satisfy) whereas 1 out of 100 respondents (1%) did not satisfy for the water quality.

Table 4.3: Water Intake among Respondents

Variable	N = 100	Percentage (%)
Water source		
SYABAS	0	0
Groundwater	100	100
Others	0	0
Water quantity intake per day (glass)		
< 2 glass	3	3.0
2 glass - 4 glass	18	18.0
5 glass - 8 glass	53	53.0
>8 glass	26	26.0
Water usage at house		
Cooking, drink and domestic use	100	100
Others usage	0	0
Water quality satisfaction		
Yes	99	99.0
No	1	1.0
Not sure	0	0

4.1.3 Study Area Condition

Referring to Table 4.4, the study area condition at Kampung Orang Asli Batu 28, Jenderam Hilir Selangor had been summarized. At the study location, the criteria that had been observed were whether the houses were nearby the industrial activity or not, water piping type and the years of house was built. Based on the Table 4.4, all of the respondents (100%) mentioned that the houses were not located nearby industrial activity. For the water piping type, it showed that all of the respondents (100%) agreed that the type of water pipe used was PVC. In order to increase the strength of the study, the years of house was built also had been take into account. Thus, the result showed that

51 of the respondents' houses (51%) had been built at Kampung Orang Asli Batu 28, Jenderam Hilir Selangor since the year of 1990-2000. In the year 2006 and above, there were 29 of the houses (29%) was built, 12 of the houses (12%) had been built since year 1990-2000 and 8 houses (8%) was built since year 1980-1990.

Table 4.4: Study Area Condition

Variables	n = 102	Percentage (%)
Nearby industrial activity		
Yes	0	0
No	100	100
Not sure	0	0
Water piping type		
Metal	0	0
MDPE	0	0
PVC	100	100
Not sure	0	0
Years of house was built		
Year 2006 and above	29	29.0
Year 2001-2005	51	51.0
Year 1990-2000	12	12.0
Year 1980-1990	8	8.0

4.2 Aluminium Concentration and pH level in Drinking Water

There were two parameters of drinking water samples that had been analyzed; aluminium concentration and pH level. The mean of aluminium concentration was 0.136±0.041, whereas for pH level the mean obtained was 4.163±0.411. The results had been summarized in Table 4.5.

Based on the study that had been conducted, aluminium concentration in the study location did not exceed the standard (0.2 mg/L) whereas pH level in drinking water was found to be at very low level (acidic).

Table 4.5: Aluminium Concentration and pH level in Drinking Water

Variable	Mean	Standard of deviation	Median	IQR	95% CI	
					Lower	Upper
Aluminium concentration	0.136	0.041	0.147	0.065	0.046	0.19
pH level	4.163	0.411	4.01	0.13	3.82	5.84

N = 100

4.3 Comparison Aluminium Concentration and pH level with National Standard for Drinking Water Quality

Referring to the National Standard for Drinking Water Quality Malaysia, Engineering Service Division, Ministry of Health standardized the acceptable limit for aluminium concentration in drinking water must not exceed 0.2 mg/L. Besides, according to United State Environmental Protection Agency (EPA), aluminium fall under secondary contaminant as aluminium did not consider to present risk to human health at the secondary maximum contaminat level. Thus, based on the mean value obtained (Table 4.6), it showed that the mean for aluminium concentration was 0.136±0.041 and it did not exceed the standard provided.

Table 4.6: Comparison Aluminium Concentration with National Standard for Drinking Water Quality

Variable	Mean±SD
Aluminium concentration (mg/L)	0.136±0.041

In order to know whether the mean of the aluminium concentration is significant or not, One Sample T-test had been conducted (Table 4.7). Therefore, the result showed $p<0.05$ ($p=0.001$). Hence, it showed that there was a significant difference between aluminium concentrations in drinking water samples with the National Standard for Drinking Water Quality. Consequently, the hypothesis for significant difference between aluminium concentrations in drinking water samples with the standard was accepted.

Table 4.7: One sample T-test

Variable	p	Test value = 0.2 95% of Confidence Interval	
		Upper	Lower
Aluminium	0.001	-0.056	-0.072

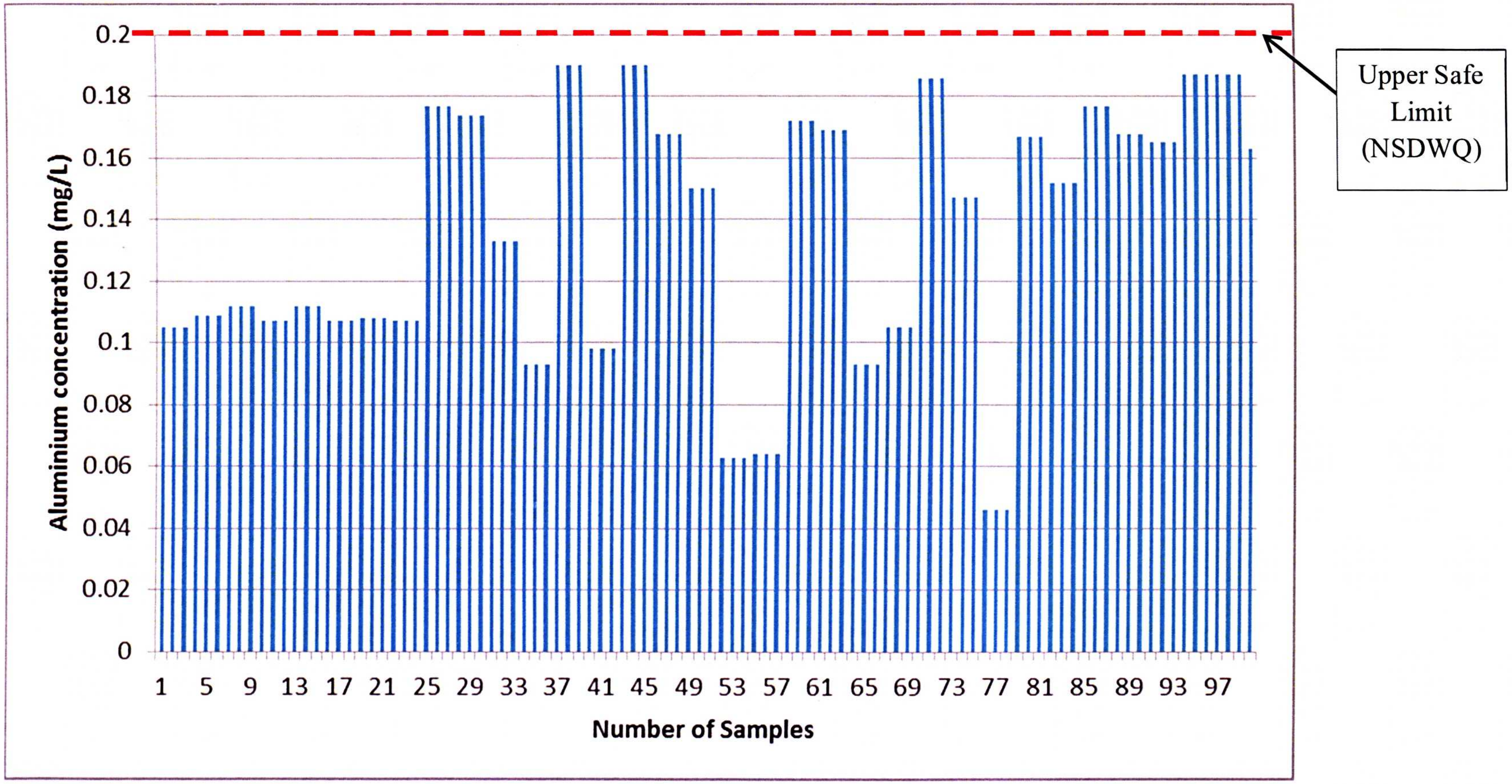

Figure 4.1: Aluminium concentration in drinking water samples

Engineering Service Division, Ministry of Health had standardized National Standard for Drinking Water Quality, thus the standard pH value for drinking water was within the range of 6.5 to 9. Based on the result summarized in Table 4.8, it showed that the mean was not meet the standard given as the mean obtained was 4.163±0.411.

Subsequently, the pH value obtained from the drinking water samples was not safe to be consumed as it was fall under acidic condition.

Table 4.8: Comparison of pH level with National Standard of Drinking Water Quality

Variable	Mean±SD
pH level	4.163±0.411

Generally for groundwater system, a normal water pH level should be within 6 to 8.5. Water pH<7 considered acidic whereas pH>7 considered basic. There were two possibilities which contributed to low pH level in drinking water. One of the factors was from natural occurrence which caused by bedrock and surrounding soils. The other factor was acid rain. According to American Groundwater Trust, rain is one of the sources of groundwater which had pH values near to 5.6 if it was free from any pollutants. However, since there was no industrial activities nearby the study location, acid rain could be caused by the emission from car exhaust. Thus, the pH level could be as low as 4. Once acid rain on the ground, the groundwater would mix with the acidic precipitation which infiltrates downwards and affect the groundwater pH.

The composition of the rocks and sediments that surround the travel pathway of the recharge water infiltrating to the groundwater would affect the pH of the groundwater. The duration of the existing groundwater that was in contact with a particular rock also would vary the groundwater chemistry. The pH of the groundwater tend to be stabilize (buffer) by the chemical composition of the bedrock. The effect of the rock chemistry on the composition and pH of the groundwater would be larger if the contact time was longer. Groundwater would usually neutralized from acidic condition when the groundwater passing through the carbonate-rich rocks (eg: limestone and marbles) thus the pH value would be greater than 7. However, if there was only a few carbonate rocks (eg: sandstones, metamorphic granitic schists and gneisses and volcanic rocks) in the aquifer of the groundwater, the pH level of the groundwater would tend to remain acidic.

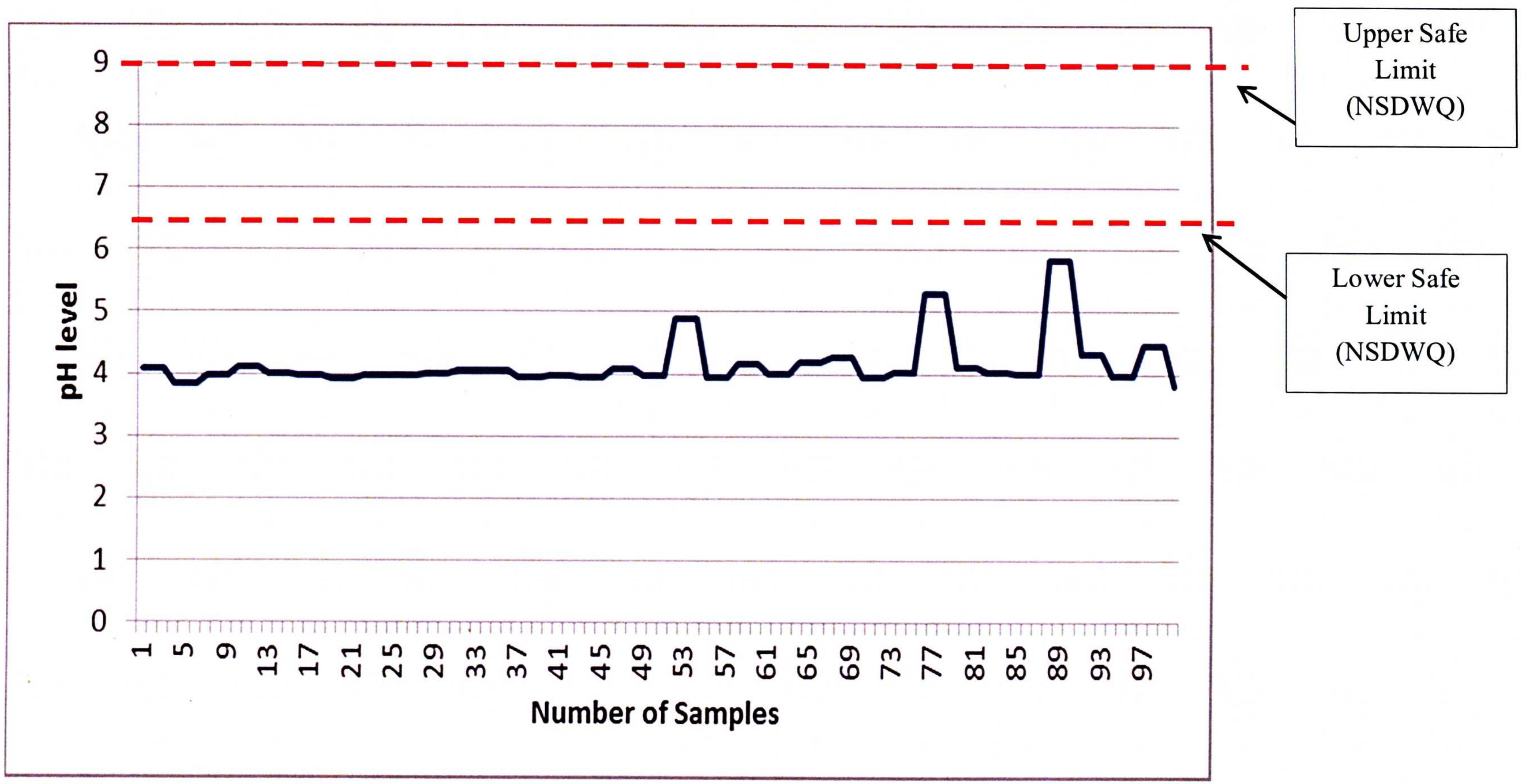

Figure 4.2: pH level in drinking water samples

4.4 Relationship between Aluminium Concentration and pH level

After the normality test had been conducted, it showed that both aluminium and pH level were not normally distributed. Thus, Spearman correlation had been used to obtain the result summarized in Table 4.9.

A Spearman's correlation was run to determine the relationship between aluminium concentration and pH level in drinking water samples from groundwater's source. There was a strong, inverse correlation between aluminium concentration and pH level ($r = -0.218$, $n = 100$, $p < 0.05$)

Table 4.9: Relationship between Aluminium Concentration and pH level (Spearman)

Variable	Correlation coefficient, r	Correlation determination, r^2	p
Al concentration vs pH level	-0.218	0.0475	0.03

Significant at p<0.05

Since $r^2 = 0.0475$, it showed there was 4.7% of the variation in aluminium concentration was explained by pH level.

Several metals were said to be found in groundwater that played important roles in the body provided their level remained within the specified range recommended by World Health Organization (WHO,2004). According to Macioszczyk and Dobrzy ´ nski (2002), aluminium concentration in groundwater that results in low concentration were connected with the transformations of aluminosilicates in the active water exchange zone, where a large amount of aluminium did not move in the structures of secondary minerals, and only small parts of the elements could get to the water. The process of releasing aluminium from mineral as a result of hydrolysis and dissolution, the reactions of cation exchange, the transfer of retained aluminium from pore water to groundwater in the soluble form, and the reactions of aluminium with the other components of the solution had influenced the aluminium activation in the groundwater. Based on Rosborg et al., (2005), the loss of essential elements and increase the concentrations of potentially toxic elements in drinking water might be led by acid precipitation. Strong concentration of Al had being discharged at low pH level which was less than 4 (Bertills et al., 1995).

In this study, aluminium and pH level had been measured in drinking water from groundwater source. Since there was no treatment and maintenance available at the pump house for the groundwater before it being pumped out to the community's houses, from the result that had been obtained, it showed that the range of pH level was within 3.82 - 5.84 which does not meet the standard given for drinking water. Besides, the result for aluminium concentration showed the range from 0.046 to 0.19 which then showed the correlation between aluminium concentration and pH level in drinking water. The lower the pH value, the higher the concentration of aluminium. Thus, the result obtained supported the study conducted by Bertills et al. (1995).

4.5 Exposure Assessment

4.5.1 Daily Intake Rate of Water

From the descriptive analysis (Table 4.11), it showed that the mean of volume of water consumed, in liter per day, by respondents in Kampung Orang Asli Batu 28, Jenderam Hilir Selangor was 3.02±0.752 L/day. Besides, the maximum volume of water intake in a day was 0.19 L/day, whereas the minimum volume was 0.046 L/day.

Thus, it indicated that the respondents (N=100) only consume water from groundwater source in the range of 0.19 – 0.046 L/day. A part from that, the volume of daily water intake was taken to calculate the Chronic Daily Intake (CDI) which then the value would be related to the Hazard Index for health risk that the respondents would face.

Table 4.10: Daily Intake Rate of Water

Variable	Mean	Standard of deviation	Minimum	Maximum
Volume water consumed (L/day)	3.02	0.752	0.046	0.19

N=100

4.5.2 Chronic Daily Intake

Chronic Daily Intake of all of the respondents (N=100) had been calculated to determine the health risk of aluminium exposure among respondents in the study area. By using the formula stated in methodology parts, CDI had been obtained from the calculation.

Descriptive test had been used (Table 4.12) to measure the mean (0.004±0.002), minimum value (0.00) and maximum value (0.01) of CDI.

Table 4.11: Chronic Daily Intake (CDI)

Variable	Mean±SD	Minimum	Maximum
CDI (mg/kg/day)	0.004±0.002	0.00	0.01

To calculate CDI, there were 3 factors that need to be considered which were aluminium concentration in drinking water, respondent's drinking water daily intake and body weight of the respondents. From the calculation (Table 4.12), it showed the range of CDI of the respondents was within 0.00 to 0.01.

4.6 Health Risk Assessment Information (Hazard Index)

Hazard Index (HI) was calculated in order to determine the health risk associated with the exposure to aluminium in drinking water consumed. To calculate the HI, the value of CDI obtained had been divided with the Reference Dose (RfD) recommended by USEPA (2000), 1.0 mg/kg/day.

From the calculation, all of the respondents had HI<1 and none of them had HI>1. The mean for HI was 0.004±0.002) and the range was within 0.00 to 0.01. Table 4.13 had summarized all the results obtained.

The HI mean's value was less as it was related with the low CDI value. Therefore, since HI value is less than 1 for all of the respondents, it indicated that the respondents from the study location were not at a risk of being affected by exposed to aluminium in drinking water.

Table 4.12: Health Risk Assessment Information (Hazard Index)

Variable	Frequency	%	Mean±SD	Minimum	Maximum
HI			**0.004±0.002**	**0.00**	**0.01**
>1	0	0			
<1	100	100			

Based on Table 4.14, the health status of respondents in Kampung Orang Asli Batu 28, Jenderam Hilir Selangor had been collected and summarized. In this study, the outcome for smoking behavior among the respondents had been obtained. It showed that 26 out of 100 respondents (26%) smoked and 74 of the respondents (74%) did not smoke. Smoking behavior had been taking into account as smoking is one of the factors that will increase the risk of getting Alzheimer's disease.

For alcohol consumption, only 1 of the respondents (1%) took alcohol and the rest of the respondents (99%) did not take alcohol. Since alcohol consumption could also contribute to the risk of having Alzheimer's disease, therefore it was crucial to be included in the data collection.

Other than that, the problem in serious body vibration also had been analyzed. There were 4 respondents (4%) were having serious body problem, 95 of them (95%) did not experience serious body vibration and only 1 of them (1%) did not sure whether he had the problem or not.

Furthermore, 100 of the respondents also had been asked about experiencing slow body movement problem. The result was 6 of them did have the problem (6%) and 94 of them (94%) did not suffer from slow body movement.

Next, problem related to the memories, which was the ability to memorize things also had been included. 11 respondents (11%) were suffering from forgetfulness symptom, 87 of the respondents (87%) did not have the problem in memorizing and 2 of them (2%) did not sure whether they have the related problem or not.

For problem in writing and speaking, 7 of them (7%) were suffered from the symptoms and 93 out of 100 (97%) did not have any problem in writing and speaking.

Since Alzheimer's Diseases can also be inherited, therefore, family history of Alzheimer's Diseases were included and 6 of the respondents (6%) were from family who had Alzheimer's Diseases, 93 of them (93%) were not having a family with Alzheimer's Diseases and 1 of them (1%) did not sure whether he had the family with the disease or not.

Table 4.13: Respondent's Health Status

Variables	Frequency	Percentage (%)	Cumulative
Smoking			
Yes	26	26.0	26.0
No	74	74.0	74.0
Alcohol Consumption			
Yes	1	1.0	1.0
No	99	99.0	99.0
Serious Body Vibration			
Yes	4	4.0	4.0
No	95	95.0	95.0
Not sure	1	1.0	1.0
Slow body movement			
Yes	6	6.0	6.0
No	94	94.0	94.0
Forgetful			
Yes	11	11.0	11.0
No	87	87.0	87.0
Not sure	2	2.0	2.0
Problem in speaking and writing			
Yes	7	7.0	7.0
No	93	93.0	93.0
Family History in Alzheimer's Disease			
Yes	6	6.0	6.0
No	93	93.0	93.0
Not sure	1	1.0	1.0

Chapter 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results that had been obtained, it showed that the Al intake in drinking water by the respondents in Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor was below the standard level (0.2 mg/L) since the result obtained was between 0.041 - 0.136 mg/L, therefore the possibility to have Alzheimer's Diseases was low. From the study that had been conducted by Rondeau et al. (2008), increasing risk of dementia and Alzheimer's disease was associated with the high level of aluminium in drinking water (>0.1mg/l). Furthermore, for the second hypothesis, there was a significant difference between standard aluminium level from National Standard for Drinking Water Quality and measured aluminium level in drinking water, thus the hypothesis was accepted. The next hypothesis was HI<1. In this study, it showed that the HI obtained for aluminium exposure is less than 1, therefore the hypothesis was accepted. HI value is less than 1 for all of the respondents and it indicated that the respondents from the study location were not at a risk of being affected by exposed to consumption of aluminium in drinking water. It showed that the risk was negligible. For the last hypothesis, there was a significant correlation between aluminium concentration and pH, thus the hypothesis was accepted.

In conclusion, aluminium concentration in drinking water of study location was found to be in the range of 0.041 - 0.136 mg/L, which was not exceeded the standard level of aluminium concentration in drinking water by Engineering Service Division, Ministry of Health in National Standard for Drinking Water Quality. However, the pH level of the drinking water was found to be below the Lower Safe Limit and Upper Safe Limit, which it found to be less than 5, and considered as acidic. Nevertheless, the HI for all of the respondents was found to be less than 1, thus it showed that there was no risk related to the nervous system such as Alzheimer's Diseases.

5.2 Recommendations

The study was conducted at Batu 28, Jenderam Hilir Selangor which only 100 of the respondents and 50 houses could be involved. For the next study, it is suggested that the researcher shall conduct the study at the resident area which consists a lot of houses and the sample size could be broaden in order to get the actual amount of aluminium residue in the drinking water of the community. Other than that, the improvement can be made by taking the water samples at the source of water itself, rather than taking in the houses of the respondents. This will help the researcher to know the real situation of the water's condition to compare with the water that has been pumped out and transported to all of the houses.

Not only that, according to JAKOA, since the maintenance is not available for this time being, therefore, they should officially induct someone or an organization to do the maintenance in the pump house for the treatment of groundwater before it being transported to the houses.

This study was only focusing on the ingestion of drinking water and how it can be related to the aluminium consumption. However, there was no judgment involved in environmental exposure to aluminium, medical products, food intake, and occupational factors and there was no biological sample being in order to know the actual amount of aluminium being accumulated in the body system. Thus, the study shall be improved by taking into account the sample of biological and surrounding factors.

Although the result for HI is less than 1, however, the pH value for drinking water was fall under acidic condition. Thus, control measures and some actions must be taken in order to neutralize the pH of the drinking water. In addition, the evaluation of the groundwater in the tube well also shall be conducted in order to know the potential of the drinking water to contain leached metals such as copper, lead, iron, cadmium, and zinc from the well pump and plumbing system. Neutralizing solution using soda ash could be one of the ways to adjust the pH level of drinking water.

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APPENDIX A

ETHICAL FORM

JKEUPM Ref No. : FPSK(EXP15-OSH)U038

a) Members of the JKEUPM who reviewed the documents:
   Prof Dr Johnson Stanslas

b) Date of approval: 2/3/2016

Endorsed at JKEUPM Meeting on **4/4/2016**, attended by:

NAME	DESIGNATION	GENDER	TICK IF PRESENT
Prof. Dato' Dr. Abdul Jalil Nordin	Professor of Radiology& Dean, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr Zamberi Sekawi	Professor of Medical Microbiology & Deputy Dean (Research and Internationalization, Faculty of Medicine and Health Sciences	Male	√
Prof. Dato' Dr. Lye Munn Sann	Professor of Medical Statistics, Department of Community Health, Faculty of Medicine and Health Sciences	Male	
Prof. Dr. Tengku Aizan Abd Hamid	Professor Gerontology, Institute of Gerontology	Female	
Prof. Dr. Lekhraj Rampal	Professor of Medical Statistics, Department of Community Health, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr. Lim Thiam Aun	Professor of Anesthesiologist, Department of Surgery, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr. Patimah Ismail	Professor of Biomedicine, Department of Biomedical Sciences, Faculty of Medicine and Health Sciences	Female	√
Prof. Dr. Johnson Stanslas	Professor of Pharmacology, Department of Medicine, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr. Sherina Mohd.Sidik	Professor of Medicine, Department of Psychiatry, Faculty of Medicine and Health Sciences	Female	
Prof Dr. M. Iqbal Saripan	Professor of Biomedical Engineering, Department of Computer and Communication Systems, Faculty of Engineering	Male	
Assoc. Prof. Dr. Mansor Abu Talib	Associate Professor of Guidance and Counseling, Department of Human Development and Family Studies, Faculty of Human Ecology	Male	
Assoc. Prof. Dr. Hejar Abd.Rahman	Associate Professor of Public Health / Head Of Unit, Department of Community Health, Faculty of Medicine and Health Sciences	Female	√
Assoc. Prof. Dr. Normala Ibrahim	Associate Professor of Psychiatry, Department of Psychiatry, Faculty of Medicine and Health Sciences	Female	√

Assoc Prof Dr Sharmala Paramasivam	Associate Professor of English Language, Department of English, Faculty of Modern Languages and Communication	Female	
Assoc Prof Dr Arshad Abdul Samad	Associate Prof of Teaching English as a Second Language(TESL), Department Language and Humanities Education, Faculty of Educational Studies	Male	√
Assoc Prof Dr Muhamamd Najib Mohamad Alwi (Independent Member)	Associate Professor of Psychiatry and Psychiatric Consultant, Cyberjaya University College of Medical Sciences (CUCMS)	Male	√
Dr. Salmiah Md. Said	Lecturer of Epidemiology, Medical Statistics, Department of Community Health, Faculty of Medicine and Health Sciences	Female	
Assoc. Prof. Dr. Noritah Omar (Lay Person)	Associate. Professor of English Language, Department of English Language, Faculty of Modern Languages and Communication	Female	√
Dr. Rojanah Kahar (Lay Person)	Lecturer of Human Development and Family Studies, Faculty of Human Ecology	Female	
Tan Sri Dato' Napsiah Omar (Independent Member)	Chairman, Women's Institute of Management	Female	
En John Posko Anthony (Lay Person)	Headmaster of Sekolah Jenis Kebangsaan (Tamil) Kajang	Male	√

BORANG B1: PENERANGAN DAN PERSETUJUAN RESPONDEN

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

1.TAJUK KAJIAN

Mengkaji air minuman di Perkampungan Orang Asli Batu 28, Jenderam Hilir Selangor.

2. PENGENALAN

Air minuman yang selamat adalah air minuman yang bersih daripada sebarang benda asing yang membahayakan kesihatan tubuh badan. Air minuman yang diperoleh secara terus daripada sumber air (sungai, gunung dan sebagainya) tanpa sebarang proses rawatan boleh menyebabkan air tersebut berbahaya kepada kesihatan sekiranya ia mengandungi benda asing yang, khususnya tahap aluminium yang melebihi kadar yang ditetapkan. Kesan kepada kesihatan,khususnya untuk kajian ini, ialah kesan terhadap sistem saraf yang boleh mengakibatkan penyakit *Alzheimer*. Sekiranya hasil kajian ini mendapati kadar aluminium dalam sampel air minuman yang telah diambil melebihi kadar yang telah ditetapkan, langkah pencegahan dan pengawalan hendaklah diambil.

3. APAKAH YANG PERLU ANDA LAKUKAN?

- Mengambil sampel air minuman di setiap rumah yang hanya mendapatkan air secara terus dari GFS.

- Soal selidik mengenai maklumat peribadi, maklumat penggunaan air, maklumat persekitaran tempat tinggal dan maklumat kesihatan.

- Mengambil berat badan responden.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

- Penduduk yang di bawah umur 18 belas tahun

- Penduduk yang menggunakan sistem penapisan air di rumah

9. PERSETUJUAN

Saya…………………………………………… No Kad Pengenalan. ……………………………
beralamat…………………………………………………………………………………………………
………………………..dengan ini bersetuju untuk mengambil bahagian secara sukarela dalam penyelidikan yang tersebut di atas *(kajian klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti saya akan dirahsiakan.

Saya* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

I setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

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

Tarikh :……………………………………..

Tandatangan …….………………………… (*Saksi*)

Nama :……………………………………..

No. K/P: ……………………………………..

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

Tarikh …….…………………………

Tandatangan …….………………………… (*Penyelidik*)

APPENDIX B

QUESTIONNAIRE

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

Arahan: Sila jawab semua soalan dan tandakan (/) pada ruang yang disediakan.

<u>Bahagian A: Maklumat responden</u>

1. No tel : ☐☐☐☐☐☐☐☐☐☐

2. Tarikh lahir : ☐☐ hr ☐☐ bln ☐☐☐☐ thn

3. Umur : ☐☐ tahun

4. Jantina : ☐ Lelaki ☐ Perempuan

5. Pekerjaan : ....

6. Pendapatan sebulan : RM ....

7. Taraf pendidikan :

   ☐ Tidak bersekolah
   ☐ Sekolah rendah
   ☐ Sekolah menengah
   ☐ Universiti
   ☐ Lain-lain

8. Berat : ....kg

9. Tinggi : ....cm

Bahagian B: Maklumat penggunaan air

1. Apakah punca air di rumah?

☐ Syarikat Bekalan Air Selangor Sdn. Bhd. (SYABAS)

☐ Air bawah tanah (Groundwater)

☐ *Gravity Feed Water System (GFS)*

☐ Lain-lain, sila nyatakan ....

2. Berapa gelas air yang anda minum setiap hari?

.... gelas (200 ml)

3. Penggunaan air dari dapur:

☐ Memasak

☐ Minum

☐ Kegunaan domestik

☐ Lain-lain, sila nyatakan ....

4. Adakah anda berpuas hati dengan kualiti air yang digunakan?

☐ Ya ☐ Tidak ☐ Tidak pasti

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

☐ Ya ☐ Tidak

Jika ya, sila nyatakan jenama yang digunakan: ....

Bahagian C: Maklumat persekitaran tempat tinggal

6. Adakah terdapat kawasan perindustrian berdekatan dengan tempat tinggal anda?

☐ Ya ☐ Tidak ☐ Tidak pasti

7. Apakah jenis pempaipan air di rumah?

☐ Logam

☐ PVC

☐ Tidak pasti

8. Bilakah rumah ini dibina?

☐ Tahun 2001 – 2005

☐ Tahun 1990an – 2000

☐ Tahun 1980an – 1990an

Bahagian D: Maklumat kesihatan

9. Adakah anda merokok?

☐ Ya ☐ Tidak

10. Adakah anda mengambil minuman beralkohol?

☐ Ya ☐ Tidak

Jika ya, sila nyatakan berapa botol sehari? ……………………………………botol

11. Adakah anda mengalami kegetaran badan yang serius?

☐ Ya ☐ Tidak ☐ Tidak pasti

12. Adakah anda mempunyai masalah pergerakan yang lambat (mengambil masa untuk melakukan sesuatu tugasan mudah)?

☐ Ya ☐ Tidak ☐ Tidak pasti

13. Adakah anda sering kali bersifat pelupa?

☐ Ya ☐ Tidak ☐ Tidak pasti

14. Adakah anda mempunyai masalah baru dengan perkataan apabila bercakap atau menulis?

☐ Ya ☐ Tidak ☐ Tidak pasti

15. Adakah keluarga anda mempunyai sejarah penyakit Alzheimer?

☐ Ya ☐ Tidak ☐ Tidak pasti

TERIMA KASIH ATAS KERJASAMA ANDA

-TAMAT-

APPENDIX C

DATA COLLECTIONS PHOTOS

HDPE bottles that had been washed with nitric acid, labeled and filled with water samples.

Analyzing water samples on site using pH meter

Groundwater storage tank located at study location

Taking water samples directly from water tank at respondents' houses

Water tank for groundwater storage at respondents' houses

Tube well that had been sealed and closed

Discussion with teammates at study location

Interview session with one of the respondents at study location