



UNIVERSITI PUTRA MALAYSIA

***HEALTH RISK ASSESSMENT AND ALUMINIUM (AL) CONCENTRATION
IN GRAVITY FEED SYSTEM (GFS) WATER: A CROSS- SECTIONAL
STUDY IN AN ORANG ASLI VILLAGES IN ULU KUANG GOMBAK
SELANGOR***

NUR NASHEIHA RIDZUAN

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STUDY IN AN ORANG ASLI VILLAGES IN ULU KUANG GOMBAK
SELANGOR.**

BY

NUR NASHEIHA RIDZUAN

**Thesis submitted in fulfillment of the requirement for the degree of Bachelor
Science (Environmental and Occupational Health) from the Faculty of Medicine
and Health Sciences, Universiti Putra Malaysia**

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In the name of Allah, the Most Compassionate, the Most Merciful

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ABSTRACT

HEALTH RISK ASSESSMENT AND ALUMINUM (AL) CONCENTRATION IN GRAVITY FEED SYSTEM (GFS) WATER: A CROSS- SECTIONAL STUDY IN AN ORANG ASLI VILLAGES IN ULU KUANG GOMBAK SELANGOR.

NUR NASHEIHA RIDZUAN

Introduction: Gravity Feed System (GFS) was sustainable water supply that has no treatment and commonly installed in Orang Asli village. Since the water supply was directly consumed, there was a potential health effect of Aluminium (Al) among Orang Asli. **Aim:** To determine socio-demographic, Al concentration in GFS water supply and health risk of it among population of Orang Asli at Ulu Kuang, Gombak Selangor. **Methodology:** A cross sectional study involved water sampling (N=50) and questionnaire (N=100) distribution at Orang Asli houses. The equipment used include, High Density Polyethylene (HDPE) plastic bottles, a weighing scale, and a pH meter. Water sample analysis was done by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). **Results:** From socio-demographic results showed that the Orang Asli in this area are having low income, and low educational level. For Al concentration in GFS water supply at Kampung Orang Asli Ulu Kuang range from (0.03mg/L) to (0.07 mg/L). Besides, the pH values of water samples were in the range of (6.4) to (7.1). One sample t-test analysis that have been used to compare Al concentration with national standard, showed significant different with p- value less than 0.05 ($p= 0.001$) and t- value at (-112.517). Spearman correlation analysis found that there is no significant different between pH level and Al concentration, with p-value of the test more than 0.05 ($p= 0.744$). Lastly for calculation of Hazard Index (HI), 100 % of respondent have HI less than 1 ($HI < 1$) with mean \pm SD (0.0023 \pm 0.0018). **Conclusion:** As a conclusion, there was aluminium concentration found in the water sample, however because of lower concentration and calculated HI was < 1 , respondents in this study area were considered safe from having health risk associated with Al exposure due to the consumption of GFS water supply.

Keywords: Gravity Feed Water (GFS), Aluminium (Al), pH, Hazard Index (HI), Orang Asli

ABSTRAK

PENILAIAN RISIKO KESIHATAN DAN KEPEKATAN ALUMINIUM (AL) DALAM SISTEM AIR GRAVITY (GFS): KAJIAN KERATAN RENTAS DI PERKAMPUNGAN ORANG ASLI ULU KUANG GOMBAK, SELANGOR.

NUR NASHEIHA RIDZUAN

Pengenalan: Sistem air graviti merupakan bekalan air mapan yang tidak memerlukan rawatan air dan kebiasaannya menjadi bekalan air utama di perkampungan Orang Asli. Oleh kerana bekalan air ini digunakan secara langsung, Aluminium dilihat berpotensi memberi kesan terhadap kesihatan Orang Asli yang menggunakan bekalan air tersebut. **Tujuan:** Untuk menegakan pasti sosio demografi, kepekatan Al dalam air GFS dan risikonya terhadap kesihatan dalam kalangan Orang Asli di Ulu Kuang, Gombak, Selangor. **Metodologi:** Sebuah kajian keratan rentas yang melibatkan persampelan air (N=50) dan soal selidik (N=100) dalam yang diedarkan di rumah-rumah Orang Asli. Alatan yang digunakan termasuklah botol plastik HDPE, penimbang berat, dan alat pengukur pH. Analisa sampel air dijalankan menggunakan “Inductively Coupled Plasma Mass Spectrometry”(ICP-MS). **Keputusan:** Kepekatan Al dalam bekalan air GFS di Kampung Orang Asli Ulu Kuang adalah dari (0.03mg/l) hingga (0.07 mg/l). Selain itu, nilai pH bagi sampel air adalah dalam lingkungan (6.4) ke (7.1). Analisa “One sample t-test” (uji t satu sampel) digunakan untuk membandingkan kepekatan aluminium dengan standard/piawaiian kebangsaan dan hasil analisis menunjukkan perbezaan yang signifikan dengan nilai p kurang dari 0.05 ($p= 0.001$) dan nilai t (-112.517). Analisis korelasi Spearman menunjukkan bahawa tidak terdapat perbezaan signifikan diantara nilai pH dan kepekatan aluminium, dimana nilai p adalah melebihi 0.05 ($p= 0.744$). Akhir sekali, kiraan bagi Index Hazad (HI) menunjukkan 100% responden mempunyai Index hazad kurang dari 1 ($HI<1$) dengan purata \pm sisihan piawai (0.0023 ± 0.0018). **Kesimpulan:** Sebagai kesimpulan, terdapat kandungan aluminium dalam sampel air yang diambil, walaubagaimanapun kandungan aluminium didalamnya adalah rendah dan kiraan Index Hazad (HI) adalah kurang daripada 1, maka responden di kawasan kajian adalah dikira selamat daripada mengalami sebarang risiko kesihatan berkaitan dengan pendedahan aluminium melalui penggunaan air yang dibekalkan dari sumber GFS .

Katakunci: Sistem air gravity (GFS), Aluminium (Al), pH, Index Hazad (HI), Orang Asli

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LIST OF ABBREVIATIONS

AD	Alzheimer's disease
ADFM	Agency of Dementia Foundation Malaysia
Al	Aluminium
ATSDR	Agency for Toxic Substances and Disease Registry
CDI	Chronic Daily Intake
GFS	Gravity Feed System
HI	Hazard Index
HRA	Health Risk Assessment
mg/L	Milligram per Litre
NSDWQ	National Standard of Drinking Water Quality
RfD	Reference Dose
USEPA	U.S Environmental Protection Agency
USGS	U.S Geological Survey
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

United Nations (UN) General Assembly clearly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights (UN, 2010). Committee on Economic, Social and Cultural Rights adopted General Comment No.15 on the right to water; they defined the right to water as the right of everyone to sufficient, safe, acceptable and physically accessible and affordable water for personal and domestic uses (UN, 2002)

Water is a gift by God so that human and other living things can benefit from it. The distribution of water priorities can be divided into three; the first of these is the right of humans to drink or slake their thirst, second is the right of cattle and household animals and lastly is the right of irrigation (Wickström, 2010). Water is created and sent by God so that men can drink it or grow agricultural products and God also created seas and rivers so that they could be used by men for transportation (Haddad, 2001). The Arabic word ma', water, is mentioned 63 times in the Quran (Amery, 2001). There is other words frequently mention in Quran that related to the semantics of water and hydrology, such as rivers, sea, fountains, springs, rain, hail, clouds and winds (Abdel Haleem, 1989).

Malaysia receives an average rainfall of 3000 mm per annum and this is translated into 566 billion cubic metres of surface water flowing in more than 150 river systems (Chan, 2004). In Peninsular Malaysia alone there are more than 100 major river systems which serve as major surface water sources to the country, this include urban and as well as rural surface water supply.

Ministry of Health Malaysia had come out with a programmed called Environmental Cleanliness Program with the objectives to make sure rural water supply project in Malaysia are supplying a safe and wholesome water, to supply water in adequate quantities and to make water readily and conveniently available to the users in order to encourage a household hygiene. Types of water supply systems that are suitable and implemented in the rural area are gravity feed piped water supply system, pumped piped- water supply system, hydraulic – ram piped water supply system, well- water supply system and rain water supply system (MOH, 1984).

Gravity feed piped water supply system (GFS) is one of the water supply which the water sources are from a small upland river, stream or spring, impounded within a protected catchment (WaterAid, 2013). GFS is also been used as water supply in Orang Asli villages (JAKOA, 2011). The Orang Asli mostly lives in reserved land and these lands are their traditional hunting, farming and fishing grounds. The rights of Orang Asli is been protected by Malaysian government (Edwin and Eng, 2012). In the other hands, 'Jabatan Kemajuan Orang Asli' (JAKOA) had organized the drinking water monitoring in all Orang Asli villages to make sure the water supply does not risk their health (JAKOA, 2011).

Department of Environment established a national monitoring network in 1978 to monitor river quality and detect changes in water quality as a result of development (Aini et al., 2007). The water quality monitoring done by Ministry of Health Malaysia in Peninsular Malaysia showed violation of water quality standard for several physical and chemical parameters such as pH, turbidity, residual chlorine, aluminium, arsenic and lead (MOH, 2003). A study by Calderon in year 2000 has identified a number of chemical contaminants in drinking water and one of those contaminants is aluminium (Calderon, 2000).

Aluminium is a silvery-white metal with many valuable properties. It is light with density of 2.70 g/cm^3 (Shakhashiri, 2008). Aluminium is the third most abundant element in the earth's crust, after oxygen and silicon and it is the most abundant metal (Shakhashiri, 2008). Aluminium occurs naturally in soil, water, and air (ATSDR, 2008). It can occur in the environment as silicates, oxides, and hydroxides, combined with other elements, such as sodium and fluoride, and as complexes with organic matter (WHO, 1998).

Dissolved aluminium concentrations in waters with near-neutral pH values usually range from 0.001 to 0.05 mg/L but rise to 0.5-1 mg/L in more acidic waters or water rich in organic matter (WHO, 2001). Aluminium can be selectively leached from rock and soil to enter any water source (WQA, 2013). Most aluminium containing compounds do not dissolve to a large extent in water unless the water is acidic or very alkaline (ATSDR, 2008). In addition aluminium can only change its form but cannot be destroyed in the environment. Aluminium will only react by became attached or separated from a particles (ATSDR, 2008).

Water is one of the source for aluminium to enter human body as it is being consume with accounting 5% of the total daily intake for the average adult (Health Canada, 2003). Health risks associated with exposure of aluminium in drinking water can be acute or chronic. For acute toxicity, there is little indication that aluminium is acutely toxic by oral exposure, despite its widespread occurrence in foods, drinking-water, and many antacid preparations (WHO, 1997a).

A chronic toxicity of aluminium in drinking water is associated with severe diseases of the nervous system such as Parkinson's dementia, amyotrophic lateral sclerosis and Alzheimer's disease (Health Canada, 2012). It has been established that aluminium is not essential to human metabolism at any concentration and in others compelling evidence suggest that it is a major neurotoxin and disrupter of neurological function (Exley and House, 2011).

1.2 Problem Statement

Aluminium is found to enter environmental media naturally through the weathering of rocks and minerals (Lantz and MacKenzie, 1979). There is high possibility of people to be exposed to aluminium via drinking water with areas naturally high in aluminium concentration (ATSDR, 1999).

Especially in GFS water because these water supply technologies do not have any treatment (WaterAid, 2013). Previous study conducted locally, found there's high concentration of aluminium in one of Orang Asli's Village, in Lembah Pangsun (Nuraina, 2015) Even though Gravity Feed System (GFS) has been practiced in this country for more a decade there is still lack of specific study on this system (Wan et al, 2005) especially on aluminium concentration in natural water supply by Gravity Feed System (GFS) and its health risk in Malaysia.

Many studies have shown that the prevalence of chronic diseases is disturbingly high among indigenous peoples worldwide (Hayati et al., 2007). In term of health, Orang Asli has showed the lower health status compared to the general population. Knowledge is another factor that can affect the health status among Orang Asli, This factor make them less awareness toward exposure to any kind of disease (Hayati et al., 2007).

1.3 Study Justification

Water sources from Gravity feed water supply system (GFS) for research

Gravity-feed pipe-water supply system was the main source of water supply in study area which was at Kampung Orang Asli Ulu Kuang, Gombak, Selangor (JAKOA, 2011). The water that is being supplied by GFS were not treated with any purification elements, which means the raw water from its sources were just directly distributed to all houses using polyvinyl chloride (PVC) pipeline. Thus, this study was carried out to determine aluminium concentration in gravity feed system water supply at location mention above.

Aluminium

The concentration of aluminium in natural waters can vary significantly depending on various physicochemical and mineralogical factors. Dissolved aluminium concentrations in waters with near-neutral pH values usually range from 0.001 to 0.05 mg/litre but rise to 0.5–1 mg/litre in more acidic waters or water rich in organic matter but in extreme acidity of waters affected by acid mine drainage, dissolved aluminium concentrations of up to 90 mg/litre have been measured (Pinheiro, 2001).

The most sensitive target of aluminium toxicity is the nervous system. Impaired performance on neuro behavioural tests of motor function, sensory function, and cognitive function have been observed in animals. Neurobehavioral

alterations have been observed following exposure of adult or weanling animals and in animals exposed during gestation and/or lactation (ATSDR, 2011). In other study, looking at elderly populations exposed to Al³⁺ in drinking water (100 µg/L), also reported a link between exposure and the prevalence of AD (Rondeau et al., 2000).

Orang Asli as target population

The main reason to select Orang Asli as the target population is because to protect the health of vulnerable group of indigenous people is a part of human right, which they live in rural area where limited basic necessities supply were difficult to reach. This condition makes them to use the natural resources as their daily supply for food drink and more. Besides, due to their lifestyle and their behaviour towards health, there is high possibility for them to be exposed with diseases. In addition, many studies have shown that the prevalence of chronic diseases is disturbingly high among indigenous peoples worldwide (Hayati et al., 2007). In term of health, Orang Asli has showed the lower health status compared to the general population. Knowledge is another factor that can affect the health status among Orang Asli, This factor make them less awareness toward exposure to any kind of disease (Hayati et al., 2007).

1.4 Conceptual Framework

Aluminium occurs ubiquitously in natural waters as a result of the weathering of aluminium containing rocks and minerals (ATSDR, 2008a). Aluminium is the main variable in this study that which it has been investigated in rural water supply in Malaysia. By focus on the rural water supply projects in Malaysia that constructed under the Environmental Cleanliness Program, among types of systems that are suitable and implemented in the rural area are Gravity Feed Piped Water supply System, pumped piped- water supply system, hydraulic – ram piped water supply system, well- water supply system and rain water supply system. Mostly, our country is practicing the Gravity Feed Piped Water supply System (MOH, 1984). Water is one of the sources for aluminium to enter human body especially through oral ingestion (Health Canada, 2003). Increased oral aluminium absorption has been suggested in Neurological disease such as Alzheimer's disease (Krewski et al., 2007)

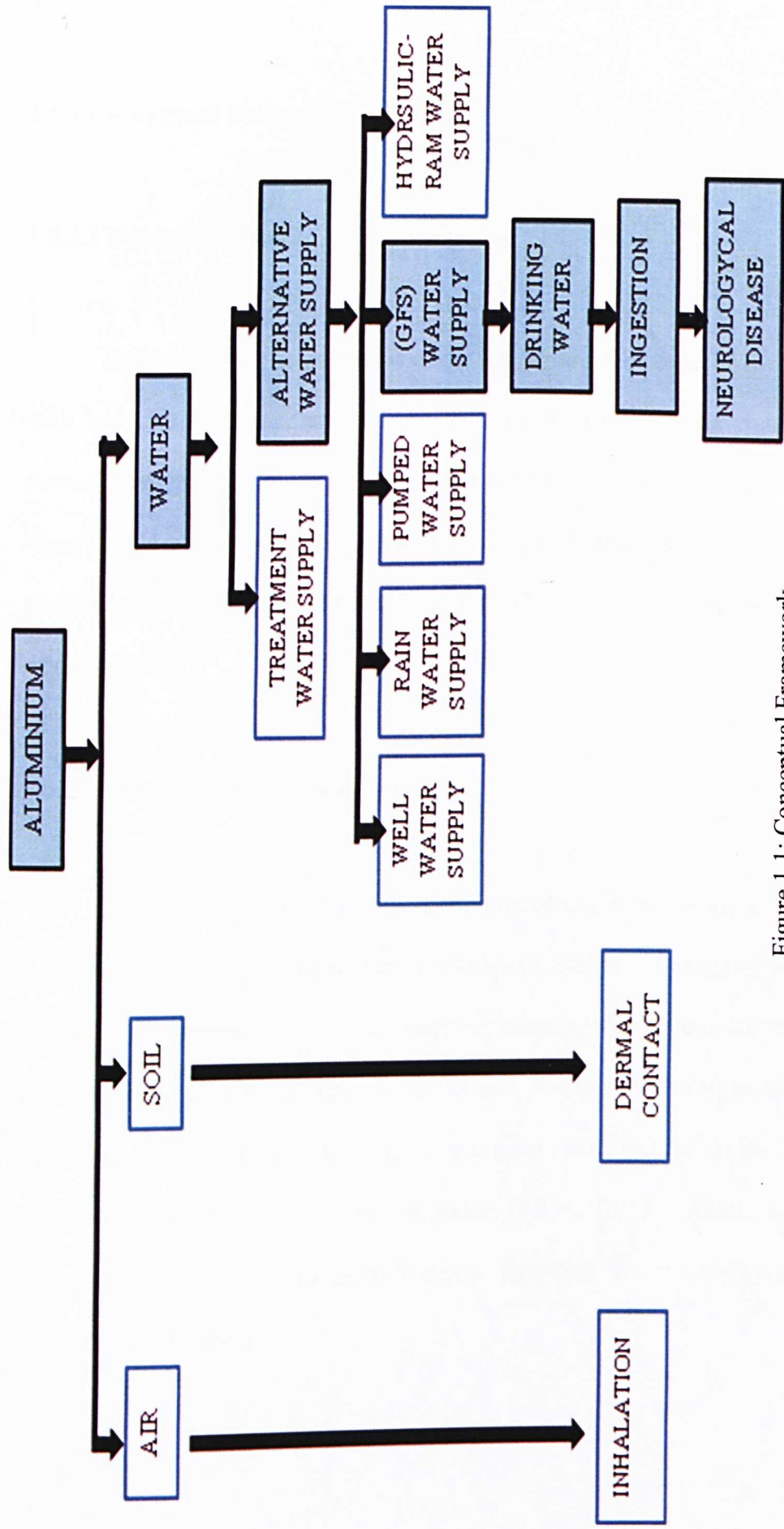


Figure 1.1: Conceptual Framework

1.5 Definition

1.5.1 Conceptual Definition

1.5.1.1 Drinking Water

Drinking water or potable water is water pure enough to be consumed or used with low risk of immediate or long term harm. The drinking water quality is a powerful environmental determinant of health (WHO, 2010). In this study drinking water would be the water that sources from gravity feed system that being directly distributed to each houses in the village and being used by the villagers as their daily drinking water.

1.5.1.2 Aluminium concentration

Aluminium is regulated in public drinking water with a recommended Secondary Maximum Contaminant Level (SMCL). SMCL's are used when the taste, odour, or appearance of water may be adversely affected. In this case, the Environmental Protection Agency (EPA) and World Health Organisations (WHO) agree that aluminium above 0.1 mg/l may impact colour but recognize that level may not be appropriate for all water supplies (WQA, 2013). Aluminium allowable concentration levels according to National Drinking Water Quality Standard was 0.2mg/l (MOH, 2009)

1.5.1.3 Health Risk Assessment

Health risk assessment is the process of quantifying the probability of a harmful effect to individuals or populations from certain human activities. The risk assessment process is typically described as consisting of five basic steps (OEHHA, 2001):

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

1.5.2 Operational Definition

1.5.2.1 Drinking Water

There were two methods to gain information on water consumption and detection of aluminium in drinking water at the study location. Firstly, through questionnaires the respondents were asked on how many litre of water they consume daily and secondly, water samples were taken from respective houses for analysis. The drinking water was collected directly from each of respondent's house using 250ml high density polyethylene (HDPE) bottles (MOH, 2004). Water sample were then checked for its pH level before nitric acid being added as preservation.

1.5.2.2 Aluminium Concentration.

The water samples that have been preserved with nitric acid were then analysed in laboratory by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This equipment helps to identify the aluminium concentration (US EPA, 1997) in the water samples.

1.5.2.3 Health Risk Assessment

Chronic daily intake

Chronic daily intake equation was used to calculate the daily exposure for ingestion route (US EPA, 1989).

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

Calculation of Hazard index (HI)

The hazard index (HI) was calculated to estimate non-carcinogenic risk (US EPA, 1989)

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

1.6 Objective

1.6.1 General Objective

To determine the socio-demographic information, concentration of aluminium (Al) in gravity feed water system (GFS) daily consumption and its relation with health risk among respondents at Kampung Orang Asli Ulu Kuang Gombak Selangor.

1.6.2 Specific Objective

1. To determine socio-demographic information of residents at Kampung Orang Asli Ulu Kuang, Gombak.
2. To determine aluminium concentration and pH levels in gravity feed system (GFS) water
3. To compare aluminium concentration in gravity feed system (GFS) water with national standard
4. To determine the relationship between aluminium levels with pH of water samples from gravity feed system (GFS)
5. To determine Hazard Index (HI) of respondents

1.7 Hypothesis

1. There is a significant difference between standard of aluminium and measured aluminium concentration in gravity feed system
2. The Hazard Index of respondent is less than one ($HI < 1$)
3. There is a relationship between pH and aluminium concentration

CHAPTER 2

LITERITURE REVIEW

2.1 Aluminium Characteristic

Aluminium is the most abundant metal and the third most abundant element in the earth's crust, after oxygen and silicon, constitutes about 8% by weight of the earth's solid surface (Shakhashiri, 2008). Aluminium is a silvery white in appearance and light in weight (ATSDR, 2008). It is never found as free metal in nature but 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 (WHO, 2003). Instead, over 270 different minerals is found to combined with aluminium such as bauxite which is the chief ore of aluminium, a mixture of hydrated aluminium oxide ($\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$) and hydrated iron oxide ($\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$) (Shakhashiri, 2008).

Aluminium occurs naturally in soil, air and water. A high level of aluminium in environment can be caused by the mining and processing of aluminium ores or the production of aluminium metal, alloys and compound (ATSDR, 2008). It is also found that aluminium enters environmental media naturally through the weathering of rocks and minerals (ATSDR, 2008a).

Other than that, aluminium release in the form of air emission, waste water effluents, and solid waste primarily associated with the industrial process. Due to the fact aluminium is prominent as a major constituent of Earth's crust, natural weathering processes far exceed the contribution of releases to air, water and land associated with human activities (Lantz and MacKenzie, 1979).

2.2 Aluminium Reaction In Natural Water

According to Scotland & Northern Ireland Forum for Environmental Research report, aluminium exists in natural waters in the form of dissolved and particulate forms. Dissolved species may be categorized as complexes with free aluminium ions (Al^{3+}), inorganic ions (e.g. hydroxide) and complexes with naturally occurring organic substances (including humic and fulvic acids). Particulate forms comprise colloidal precipitates, divided aluminosilicate minerals and suspended particles. At the pH value of most natural waters, the proportion of dissolved aluminium that exists as free ions is small (SNIFFER, 2007).

Depending on several factors such as physicochemical factors and mineralogical factors, the concentration of aluminium in natural waters can vary significantly. In waters with near-neutral pH values, dissolved aluminium concentration is usually in the range of 0.001-0.05 mg/L but it can rise to 0.5-1 mg/L in more acidic waters or waters rich in organic matter. At the extreme acidity of waters affected by acid mine drainage, dissolved aluminium concentrations of up to 90 mg/L have been measured (WHO, 1997).

Dissolved aluminium concentration in water is very with pH and the humic-derived acid content of the water (Brusewitz, 1984). Aluminium is only sparingly soluble in water between pH 6 and 8. Because 95% of naturally-occurring water having pH between 6 and 9 and since high aluminium concentrations occurs in surface water bodies only when the pH is <5, the aluminium concentration in most natural water is extremely low (Filipek et al., 1987).

2.3 Aluminium and Reaction to Human Body

Aluminium has been found throughout the body (Exley et al., 1996). The exposure may come from various sources such as in the air, soil water or even in consumer product. The three route of entry of aluminium was through inhalation ingestion and dermal contact (ATSDR, 2008). Water is one of the source for aluminium to enter human body as it is being consume with accounting 5% of the total daily intake for the average adult (Health Canada, 2003).

Gastrointestinal tract are the most common absorption of Aluminium oxide in human body. The rate of absorption is approximately 0.22% (Priest et al., 1998) and once in the blood, approximately 90% of the metal is bound to transferrin (Harris et al., 2003). Aluminium oxide can pass the blood-brain barrier by receptor-mediated endocytosis of the Fe carrier protein and in rats approximately 0.005% of the metal complexes enter the brain (Yokel et al., 2001).

Concentration of aluminium in tissue increases with age. It is greater in lung, in bone and soft tissue (Krewski et al 2007). Aluminium also leaves our body, most aluminium in food, water and medicines leaves body quickly in the faeces. Much of the small amount of aluminium that does enter the bloodstream will quickly leave your body in the urine (ATSDR, 2008).

2.4 Aluminium Health Effect

Aluminium had been related with several health effects. Some people who have kidney disease store a lot of aluminium in their bodies. The kidney disease causes less aluminium to be removed from the body in the urine. Sometimes, these people developed bone or brain diseases that doctors think were caused by the excess aluminium (ATSDR, 2008).

Lots of experiment has been conduct to identify the aluminium reaction in body. A study that uses mice as experiment shows a significant elevation of brain aluminium when given a single administration of oral aluminium hydroxide (Cutrufo et al., 1984). mice consuming $\sim 20 \mu\text{g Al/day}$ as aluminium hydroxide gel in their drinking water for 105 days were reported to have 30, 60 and 340% increases in kidney, liver and brain aluminium concentrations, respectively (Sahin et al., 1994). Next, consumption by mice of drinking water containing 400 mg Al/L (as aluminium lactate) for 6 months increased aluminium in brain and other tissues (Anghileri et al., 1994). In other study, brain aluminium was significantly increased in rats that given 90 daily oral doses of 30 or 100 mg/kg of aluminium chloride (Bilkei-Gorzó, 1993).

The meta-analysis of epidemiological studies suggests that chronic aluminium exposure is associated with increased risk of Alzheimer's disease (AD) (Wang et al., 2015). Some studies have reported that the aluminium concentration in the bulk brain samples, neurofibrillary tangles (NFT) and plaques was higher in AD subjects than controls. Other study showed that Al, in cooperation with Abeta peptides, may play an important role in the pathogenesis of AD (Sakae et al., 2009). In the mature, and especially the aging brain, these mechanisms can lead to progressive neurodegeneration, as seen with AD, PD and ALS (Russell, 2012).

2.5 Gravity Feed System as Water Supply

Malaysia receives an average rainfall of 3000 mm per annum and this is translated into 566 billion cubic meters of surface water flowing in more than 150 river systems. In Malaysia, more than 2,500 small community rural water supply schemes are support by upland watersheds (Wan et al., 2005). Water supply project in Malaysia have the objective of supplying safe and wholesome water to the villages, they also wanted to supply an adequate quantities of water and to make readily and conveniently available to the users in order to encourage house hold hygiene (MOH, 1984). Gravity- feed piped water supply system (GFS) are among the types of systems that implemented in the rural areas.

GFS is a system that channeled water from natural surface water sources located on a high level position. This system starts from where water is collected by means of dams and piped into homes through the main source of water pipes and distribution pipes and the system does not use any conventional methods of

treatment. GFS locations were selected based on preliminary research and studies to determine the sanitary water supply in accordance with the approved standard. GFS project is based on the following criteria (Engineering Services Department, MOH):

- I. The location is far from pollution and no reserve development for a period of five years
- II. No plantation / farm is run close to water sources
- III. Capacity is sufficient water in the area to be supplied

In building this water supply system three parts of GFS are very important first is dam at source, reservoir storage tank and pipeline for distribution of the water. (WaterAid, 2013)

2.6 Orang Asli

According to the Jabatan Kemajuan Orang Asli (Department of Orang Asli Development) or JAKOA, “Orang Asli” people are actually heterogeneous, which are comprised of at least 18 distinct cultural-linguistic groups broadly classified into the Negritos, Senoi and Proto-Malays. The Negrito group includes the Kensiu, Kintak, Lanoh, Bateq, Jahai and the Mendriq. The Senoi group includes the Semai, Temiar, Semoq Beri, Jahut, Che Wong and the Mah Meri. The Pro-Malay group includes the Temuan, Semelai, Jakun, Kanaq, Kuala and the Seletar (JAKOA, 2015)

The Asian Development Bank’s define “Orang Asli” as population groups that present in a given area, most often before modern states or territories were created and before modern borders were defined. Their maintenance of cultural, social identities, economic, and political institutions were separate from mainstream or dominant societies and cultures. (Asian Development Bank, 1998)

Besides, established study has shown that indigenous people commonly experience various kinds of “displacement” and marginalization, which eventually result decrement of their health and welfare. The displacement includes several factors such as geographical factor, economic, socio and political factors (Alderete, 1999)

A Malaysian non-governmental organization called the Center for Orang Asli Concerns (COAC) which has been documenting the marginalization and poor socio-economic status of Orang Asli, stated that Orang Asli continue to suffer from high poverty rates and tend to be poorly-educated. There is also the phenomenon of loss of traditional land (because such land is not legally titled with permanent tenure) to non-Orang Asli individuals and outside entities. This affects the ability of Orang Asli to have continued access to forest resources, a vital part of their traditional way of life.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter discussion will be focusing on mechanism to conduct the research. It is comprise of study location, study design, sampling, data collection method and instrumentation, risk assessment, quality control, ethics committee approval and data analysis.

3.2 Study Location

Kampung Orang Asli Ulu Kuang is located in Gombak district in Selangor. This study location was purposively selected following the specific criteria needed for this study. Most of residential areas of Orang Asli in Gombak, particularly, this study location are fully supply with GFS water for drinking and other purposes. This village comprises about 300 villagers so it is very easy to find respondents for this study.

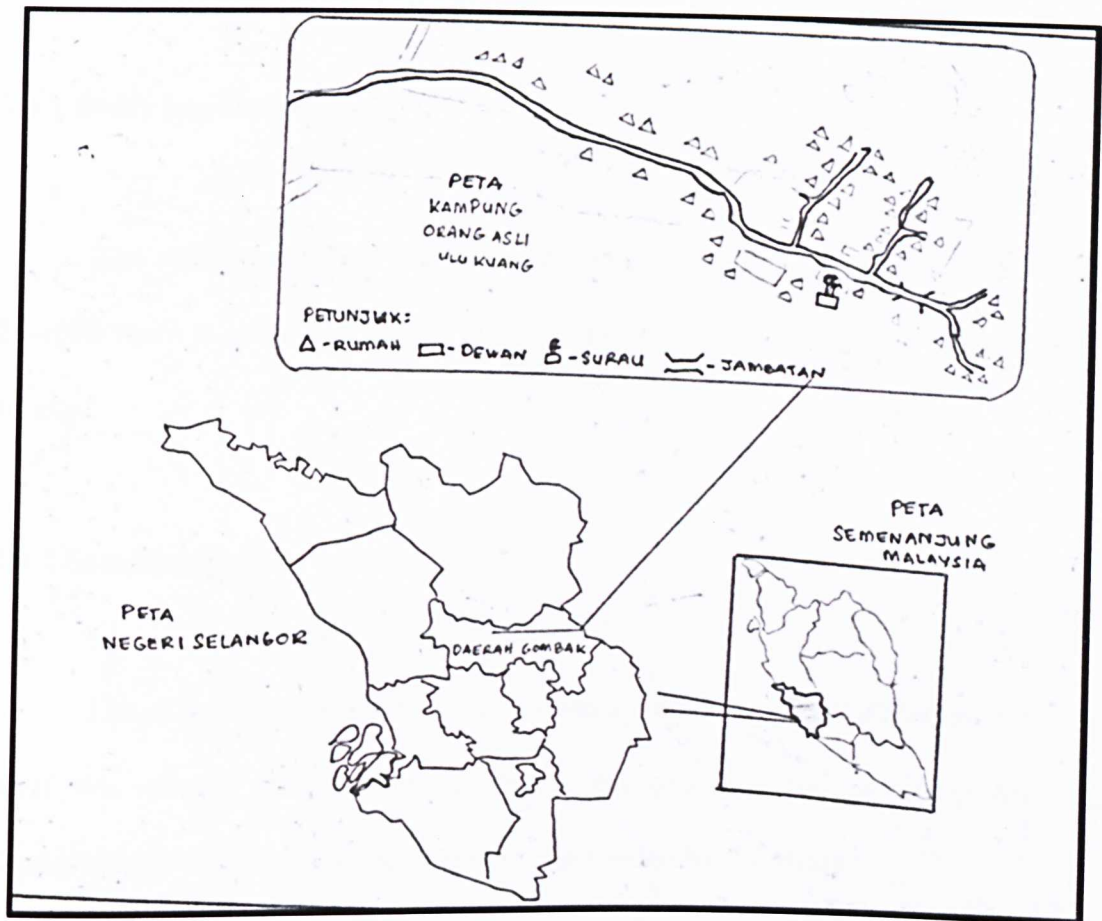


Figure 2.1: Maps for study location

3.3 Study Design

The study design for this study is a cross-sectional study with the aim to determine the aluminium level in Gravity Feed System (GFS) water used by Orang Asli villages in Ulu Kuang, Gombak.

3.4 Sampling

3.4.1 Study population

The study population was villagers from Kampung Orang Asli Ulu Kuang, Gombak there is about 300 people in this villages who totally depend on GFS water supply.

3.4.2 Sampling frame

List of information on the villagers was obtained from JAKOA Gombak. The study was selected among male and female villagers in Kampung Orang Asli Ulu Kuang and they had met the inclusion criteria needed by the study.

3.4.3 Sampling unit

The sampling unit for this study is an Orang Asli living in Ulu Kuang Gombak, Selangor who fulfilled the inclusive criteria.

Inclusion criteria:

1. Aged 18 years old and above which is considered as an adult.
2. The respondent is a lifelong or at least 6 month duration of staying at Kampung Orang Asli Ulu Kuang, Gombak
3. The respondent uses GFS water as his/her main source of water supply for his/her daily usage.

Exclusion criteria:

1. Respondents who use water filtered systems.
2. Respondents who used other than GFS as their main water supply for their daily needs.

3.4.4 Sampling method

The study location was chosen by using Purposive sampling. Next, Simple random sampling method was used to select respondent based on the list name obtained by Jabatan Kemajuan Orang Asli (JAKOA) where villagers who fulfil the inclusion criteria were selected.

3.4.5 Study sample

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

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

Equation 1

Where,

N= sample size

P=Prevalence or proportion

e=Probability error or mean (0.05)

on the formula equation, P is the expected proportion with 0.7 when there are 70% of prevalence of water samples that exceeding the AI acceptable limit under acceptable limit in NSDWQ (Qaiyyum et al., 2011) . * P= 0.7, e= 0.05

$$N = \frac{P(1 - P)}{e^2}$$
$$N = \frac{0.7(1 - 0.7)}{(0.05 \times 0.05)}$$
$$N = 84$$

Equation 2

Based from Equation 2, the minimum sample size needed for this study is 84 people, and for minimum sample size the number will be rounded up to 20 % to recover the loss of respondent throughout the study.

$$20 \% \text{ of } 100 = 20$$
$$20 + 84 = 104$$

Equation 3

Thus, the total sample population will be 104 people from villagers of Kampung Orang Asli Ulu Kuang Gombak Selangor.

3.5 Data Collection

3.5.1 Questionnaires

A set of questionnaire comprising of three sections were administered to each respondent. Part A of the questionnaire contain questions regarding the socio-demographic information, Part B contain questions related to duration of residence. Part C contained questions about the information of daily intake of drinking water. The questionnaire was adopted from the previous study (Nuraina Nadia, 2015) that was also conducted the same study design but at different study location which was at Kampung Orang Asli Kuala Pangsun, Hulu Langat. During the data collection, the respondents were interviewed face to face with the researcher at their respective houses.

3.5.2 Water Sampling

Drinking water samples were collected at the respondents' houses. Two replicates of water samples were taken from each respondent's house. The water sample was then preserved with nitric acid

3.6 Instrumentations

3.6.1 Water Sampling equipment

HDPE bottles (250 ml)

A 250 millilitre (mL) high density polyethylene (HDPE) bottles was used to collect samples of GFS water.

MILWAUKEE MW100 Standard Portable pH Meter (0.1 resolution)

On- site pH measurement was taken using this instrument to check pH level of water samples. To make sure the pH meter are detected the exact pH value, before being used this instrument was calibrate by using their standard solution.



Figure 3.1: MW100 Portable pH Meter

3.6.2 Water Analysis Equipment

Inductively Coupled Plasma Mass Spectrometry

For the determination of Al concentration in GFS water samples, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) methods are being used as its applicable with the detection level less than 0.2mg/L by refer to the method 200.8. (US EPA, 1997)

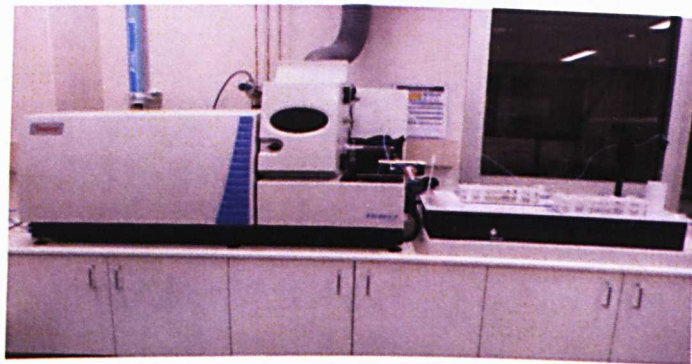


Figure 3.2: Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

3.6.3 Anthropometry measurement equipment

Weighing scale

In determining the chronic daily intake, body weight measurement was taken using a Weighing Scale. In order to take the weight of the respondent, the weighing scale was placed on a flat surface, respondents were asked to get on the weighing scale and measurement was recorded.



Figure 3.3: SECA weighing scale

3.6.4 Health Risk Assessment

The following equation was used to calculate the daily exposure for ingestion route (US EPA, 1999; Chrostowski, 1994).

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

Equation 4

Where,

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

C = Aluminium concentration in water (mg/L),

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

BW = Body weight (kg).

Then to conclude the significant different exposure and overall potential for non-carcinogenic health effects posed by nitrate in drinking water, the Hazard Index (HI) is calculated using the following equation:

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

Equation 5

Where,

HI = Hazard Index,

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

RfD = Reference dose (mg/kg/day)

HI value more than 1 (HI>1) will show a significant risk level, the higher the value, the greater the likelihood of adverse non-carcinogenic health impacts. RfD value that used in this study was 1.0 mg/kg/day (USEPA, 2000).

3.6 Statistical Analysis

3.8.1 To determine the socio-demography of the resident at Kampung Orang Asli Ulu Kuang Gombak.

Statistical Analysis:

Descriptive Analysis

(Mean and standard deviation (SD), Median and interquartile range (IQR):
categorical data-Frequency and percentage (%))

3.8.2 To determine aluminium level in gravity feed system (GFS) water

Statistical Analysis:

Descriptive Analysis

(Mean and standard deviation (SD), Median and interquartile range (IQR):
categorical data-Frequency and percentage (%))

3.8.3 To compare aluminium level in gravity feed system (GFS) water with national standard

Statistical Analysis:

Parametric : One sample t-test

Non-Parametric : Wilcoxon Sign Rank Test.

3.8.4 To determine the relationship between aluminium level with pH of water sample from Gravity feed system (GFS)

Statistical Analysis:

Parametric : Pearson Correlation Test

Non-Parametric : Spearman Rho's Test

3.8.5 To determine the Hazard Index (HI) which is equal to Chronic Daily Intake (CDI) (mg/kg/day) over Reference dose (RfD) (mg/kg/day)

Statistical Analysis:

Descriptive Analysis

(Mean and standard deviation (SD), Median and interquartile range (IQR):

categorical data-Frequency and percentage (%))

3.9 Quality Control

Samples of water were taken using concurrent replicates. Concurrent replicates are two or more samples of environmental water that are collected simultaneously or at approximately the same time. Concurrent replicates provide basic Quality Control data for surface-water sampling and incorporate (USGS, 2006).

The analysis of water samples using ICP-MS followed the standard operating procedures (SOPs) as given by the manufacturer. Other instruments such as pH meter and weighing scale were calibrated before being used and operated based on the SOPs of the respective equipment as well.

Pre-testing of questionnaires was conducted on 10% of sample size before data collection to ensure that every question asked in questionnaires could be understood and easily answered by respondents. Pre-testing was conducted on 10 Orang Asli in Kg Sungai Lalang Baru, Hulu Langat, Selangor.

3.10 Ethical consideration

Ethical issues pertaining to this study is presented and approved by Ethics Committee, Faculty of Medicine and Health Science, Universiti Putra Malaysia.

1. The respondents are given some explanation about the whole of the study activities involved.
2. The respondents are given some explanation about the health risk assessment that are held in term of the purpose of the assessment, the procedure taken, and also respondents' right in this study.
3. Approval letter are given to the village representative to obtain the consent of the resident involved in this study.
4. Approval letter is given to the respondents to get their consent to be participant in this study.

3.11 Study Limitation

1. The information given from respondents could not be determined to be 100 % valid in term of this limitation we assumed the answer and the information given met validity purposes. Recall bias may contribute to this study.
2. The data collected in this cross-sectional study does not involve comparison with the non-exposed population. Thus, the result may not be strong enough to relate the health impact of Al to the Orang Asli population in Ulu Kuang, Gombak
3. The weather is one of the contributing factors to the content of Al in water source as if the acid rain occur, Al level will be higher than the normal
4. There is no biological sample taken to prove the aluminium concentration in respondents body, only chronic daily intake (CDI) of respondent was calculated using their weight and assumptions of their daily intake of water.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Respondent Socio-Demographic.

Result

From questionnaires that distributed to the resident of Kampung Orang Asli Ulu Kuang, there were 100 respondents that take part in this study. Based on the table 4.1.1, number of female respondents is significantly higher compare to male with value of 54% female and 46% male respondents. For the age of respondents in this study, there were 25% of respondent age in the rage of 18-25 years old, 54% was in range of age between 26-50 years old and about 21% respondent was age between 51-80 years old.

Questionnaires also include question on respondent's occupational status. Referring to table 4.1.1, result obtain was 47% of respondents are not working, and only 1% of respondent has work as government servant. 25% work in private agency and another 27% were self-employed. Result obtain for respondent's income is 47% do not have income, 3% get the income less than RM 300. 18% of respondents had income in the range of RM 301-RM 500, 22% with income of RM 501-RM1000. Only 10% of them had income between RM 1,001 –RM 2,000.

Education level of respondent been categorized as primary school education for who was taking standard 1 until standard 6, secondary school education for level of PMR, SPM. For STPM, Diploma, Degree/ Master or PhD was under category of University level. Others are for any education such as kinder garden, or school for adult. From the result obtain, 57% of respondents had education until primary school only. 21% of respondents had education until secondary school. 12% of respondent is in other categories which all are taking education until kinder garden and another 10% of respondent had no education at all.

In the first section of the questionnaires, respondent was asked on period of staying in their village, results were stated in table 4.1.2. From the table we can summarize that the mean and standard deviation was 25.45 ± 16.64 . The minimum period of staying in the villages by respondent was two years, whereas the maximum period of staying in the villages by respondent was 70 years.

Anthropometric measurement also being taken during interviewing respondent, measurement of their weight was taken. Table 4.1.3 showed that minimum weight recorded was 34 kg and maximum weight was 96 kg with mean and standard deviation of 62.0 ± 12.8

Table 4.1.1: Socio-demographic information of respondents

Variable	Frequency	Percentage %
Gender		
Male	46	46.0
Female	54	54.0
Age		
18- 25 years old	25	25.0
26- 50 years old	54	54.0
51- 80 years old	21	21.0
Occupation		
Government servant	1	1.0
Private- employment	25	25.0
Self- employment	27	27.0
Not working	47	47.0
Income / month		
<RM 300	3	3.0
RM 301-500	18	18.0
RM 501-1000	22	22.0
RM 1001- 2000	10	10.0
>RM 2001	0	00.0
No income	47	47.0
Education level		
No education	10	10.0
Primary school	57	57.0
Secondary school	21	21.0
University/ college	0	0.0
Others	12	12.0

N=100

Table 4.1.2: Period of staying in the village

Variable	Minimum (years)	Maximum (years)	Mean ± S.D
Period of staying	2	70	25.45±16.64

N=100

Table 4.1.3: Anthropometric measurement of respondent

Variable	Minimum	Maximum	Mean ± S.D
Weight (kg)	34.0	96.0	62.0±12.8
N=100			

Discussion

The study was done in an Orang Asli Villages in Ulu Kuang Gombak Selangor. There are 100 respondents consisting of 54 female and another 46 more male respondents with age range from 18 to 74 years old. From the socio-demographic results it is clearly showed that the Orang Asli in this area are having low living standard.

From the occupational background most of them were self-employment and there is high numbers of respondents that is unemployed, and result with monthly income that not more than RM 1000 and most does not have any income. Orang Asli was also determined of having low education level. As a result, they were classified as the vulnerable group live in poverty, which in other sense they also classified as group that has low immunization and lower education level (Masron et al, 2014).

Duration of staying at current location was asked in the questionnaires, result showed minimum period of staying in the villages is two years and the maximum period of staying was 70 years. This information was important as it showed how long actually the respondent were being exposed to aluminium in their drinking water that they consume daily. Long period of exposure might lead to chronic toxicity of aluminium in drinking water with severe diseases of the nervous system such as Parkinson's dementia, amyotrophic lateral sclerosis and Alzheimer's disease (Health Canada, 2012).

The anthropometric measurement which is weight of respondent is taken using weighing scale. A minimum of 37 kg and maximum of 96 kg weigh of responded have been record. This information is useful as it is involve in calculation of Chronic Daily Intake (CDI) of aluminium in respondent.

4.2 Respondent Usage of water.

For second section of the questionnaires, topic was focusing on information of water usage among respondent. Referring to table 4.2, 100% of respondent received water from Gravity feed system GFS as their main water source and 100% of respondents used the water for daily routine such as cooking, drinking and other domestic used.

For quality of water sources that they receive, 97% of respondent agree that the GFS water that they used are in good quality while another 3% said water that they receive is not in good condition.

This part also asked respondent on how many litter they consume water every day. One of the most important used of water from gravity feed system that respondent receive at their house was as drinking water. Results obtain from this study showed the daily intake of water by respondent per day. 65% of respondent drink water in the range of 1.6 litres – 3.0 litres per/day, followed by 17% respondents drink water in range of 0.6 litres – 1.5litres/day. 13% of respondent drink water in more than 3.0 litres per day and lastly only 5% of respondent drink water less than 0.5litres/day

Table 4.2: Water Usage of Respondent at Kampung Orang Asli Ulu Kuang, Gombak.

Variable	Number	Percentage (%)
Water source		
Syarikat Bekalan Air Selangor (SYABAS)	-	-
Gravity Feed System (GFS)	100	100.0
Others	-	-
Water usage		
Cooking, drinking, and domestic used	100	100.0
satisfaction		
Yes	97	97.0
No	3	3.0
Water intake per day		
<0.5 litre	5	5.0
0.6 - 1.5 litre	17	17.0
1.6 -3.0 litre	65	65.0
>3.1 litre	13	13.0
N=100		

Discussion

Based on the water usage information among respondents, it is showed that 100% of respondents are receiving water for daily routine which is drinking, cooking, and for domestic used from Gravity Feed System (GFS) water emanating from Sungai Ulu Kuang. From the result, it was also showed that most of the respondents are satisfy with the quality of the GFS water as there is no disturbance of water supply and condition of water such as odour, colour or turbidity is fine.

In this section there is also question asked on water intake per day for each respondents. This was asked in the purpose to know how many litres of water are being consumed by respondents every day and it is one of parameter to be used in calculating the CDI.

4.3 Respondent Environment Condition

Result

Table 4.3 showed the information gain from respondent on environment of the resident. From the result, 100% of respondent agree that there is industry nearby their resident. For water piping information results obtain was 100% of respondent said that their house were using Polyvinyl Chloride (PVC) pipe as main piping system.

Table 4.3: Industry and type of water piping information

Resident environment	Number	Percentage %
Industry nearby		
Yes	100	100.0
No		
Water piping type		
Metal	-	-
MDPE	-	-
PVC	100	100.0
N=100		

Discussion

In the environmental condition data, clearly showed that 100 % of respondents agree that there is a nearby industrial activity. From the visit during data collection, it was observed that there was a mining project nearby the villages. Other than that they were also ask on their piping system and 100 % of the respondent answered PVC as their main piping system. This question is to make sure that there were no other sources that can contribute to aluminium contamination in their water supply.

4.4 Water Sample Analysis

In this study, water sample collected from 50 houses was analysed. There are two types of parameters that being focused, first parameter was aluminium concentration and second parameter was pH level. The result was summarized in table 4.4.

Mean of aluminium concentration obtain in this analysis was 0.04 with standard deviation of 0.01. Minimum value of Aluminium concentration in water sample was 0.03mg/L and the maximum value of aluminium concentration was 0.07 mg/L. Next for pH level obtains in the analysis was 5.3 as the minimum value of pH and 7.1 as maximum value of pH, Mean for pH level was at 6.8 with standard deviation of 0.15

Table 4.4: Aluminium concentration and pH level of water samples

Variable	Mean±S.D	Minimum value	Maximum value
Al concentration (mg/l)	0.04± 0.01	0.03	0.07
pH level	6.8± 0.15	5.3	7.1

N=50

4.5 Comparison of Aluminium concentration with National drinking water quality standard (NDWQS)

Aluminium concentrations obtain from GFS water in Kampung Orang Asli Ulu Kuang was compared with the National Drinking Water Quality Standard (NDWQS). One sample t-test was performed to compare between aluminium levels with standard value. Result obtain from the analysis was significant different between aluminium concentration with the standard value where p- value of the test is less than 0.05 ($p= 0.001$), thus the mean Aluminium levels in the GFS water is not 0.2mg/L. We are at 95% confident that the mean Aluminium level in GFS water was between 0.045 and 0.050 mg/L. Figure 4.1 showed the comparison between aluminium concentrations in GFS water with the NDWQS

Table 4.5: Comparison of Aluminium concentration with NDWQS

Variable	t	p	Test value = 0.2 mg/L	
			95% of Confidence Interval (CI)	
			Lower	Upper
Aluminium concentration (mg/L)	-112.517	0.001	-0.1323	-0.1190

N =50 , Significant at $p < 0.05$

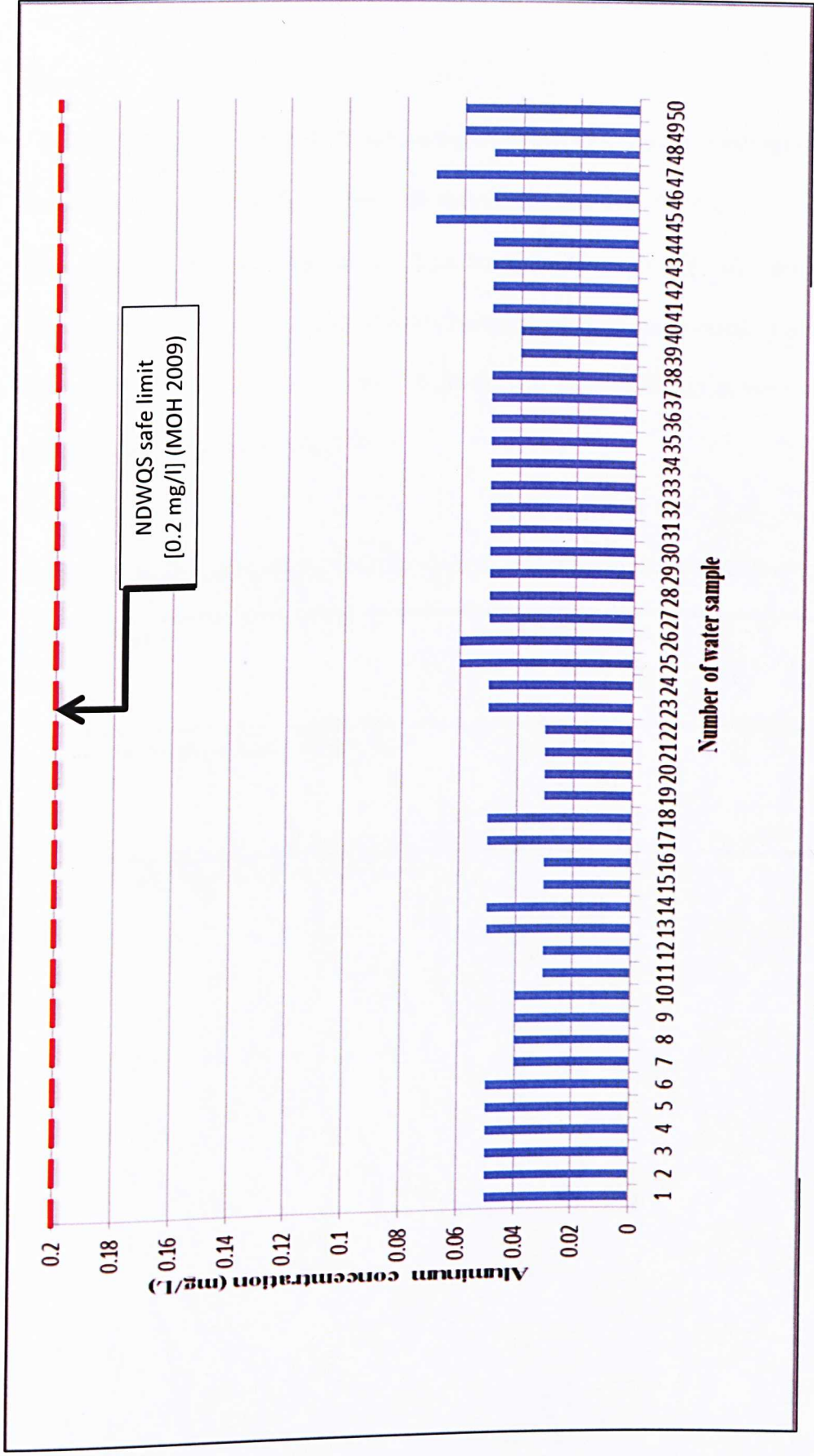


Figure 4.1: Aluminium concentrations in water samples

4.6 Relationship between aluminium concentration and pH level

Result

Table 4.6 showed the relationship between aluminium concentration and pH level of water sample. Normality test was performed and the result showed that the data were not normally distributed, thus non-parametric test (spearman correlation) was performed to get the relationship between aluminium concentrations with pH level. Referring to results in table 4.6, there was no significant correlation between pH and aluminium concentration.

Table 4.6: Relationship between Aluminium concentrations with pH level

Variable	Correlation coefficient, r	p value
Aluminium concentration vs pH level	-0.047	0.744
N=50, Significant at $p < 0.05$		

Discussion

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method was applied in this study to analysed aluminium concentration in water sample. Aluminium concentration in ground water, surface and drinking water can be determined by using ICP- MS which function in detection reading as lowest as 0.2 part per billion (ppb) (USEPA., 1994). Results of aluminium concentration were recorded. According to Malaysian Drinking Water Quality Standard (MDWQS), Maximum Acceptable Value for aluminium in drinking water was 0.2 mg/L (MOH. 2009). From the data obtain in this study, aluminium concentration that been analysed in the GFS water sample was not exceeding the NDWQS. Minimum concentration of aluminium detected in this location was 0.03mg/L and the maximum concentration of aluminium detected was 0.07 mg/L.

Even though this level was not exceeding the standard there was possibility that aluminium concentration can be increase. It have been stated that aluminium was abundant and wisely distributed element and will be found naturally in most rocks, soils, water, air and foods (ATSDR., 2008). The soil-water interaction may influence aluminium mobility and subsequent transport within the environment (ASTDR, 1992).

For pH value of the samples measurement was directly (on-site) using MW100 Standard Portable pH meter. Results showed that only two samples had pH below the standard and the rest of water sample was not exceeding Malaysian Drinking Water Quality Standard (MDWQS). This standard stated that maximum acceptable value for pH was in the range of 6.5 to 9.0. 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).

These studies also make a comparison between aluminium concentrations with pH levels. The results showed that there was no correlation between pH levels with the concentration of aluminium in water sample. However there was a study that stated relation between this two parameter. Lower pH level (acidic) will contribute to the higher aluminium concentration in drinking water (Srinivasan et al, 1999).

4.7 Exposure Assessment

4.7.1 Daily intake of water (DI)

Results

Result from descriptive analysis showed that the mean of volume of water consumed by respondents was 2.5900 with standard deviation of 1.00599 L/day. Minimum volume of water consume by respondent is 0.5 L/day while the maximum volume of water consume by respondent is 4.5 L/day.

Table 4.7.1: water intake per day

Variable	Minimum value	Maximum value	Mean \pm S.D
Volume of water consume(L)	0.5	4.5	2.5900 \pm 1.00599
N=100			

4.7.2 Chronic Daily Intake (CDI)

Result

In order to determine exposure aluminium in GFS water, chronic daily intake (CDI) is first calculated using the following equation which is the concentration (C) of aluminium in water times with daily intake of water (DI) then divided with body weight of respondent. By using descriptive analysis, the mean of CDI obtain was 0.0023 with standard deviation of 0.00184. The maximum value was 0.02 while the minimum value recorded was 0.00.

Table 4.7.2: Chronic Daily Intake (CDI)

Variable	Minimum	Maximum	Mean ± S.D
CDI (mg/kg/day)	0.001	0.02	0.0023 ± 0.00184

N=100

Discussion

As shown in chapter 3, Chronic Daily Intake (CDI) was calculated for each respondents using the actual daily intake rate of water (L/day) multiple with aluminium concentration in water consumed (mg/L) then divided by body weight of each respondents (kg) (US EPA, 1999; Chrostowski, 1994). CDI of the respondents was calculated to determine the aluminium exposure in drinking water through oral ingestion. Factors of exposure are including the dose (how much), the duration (how long) and how the ways contact with the exposure (ATSDR, 2008).

From the results, the mean CDI of respondent was 0.0021 with standard deviation of 0.00090. When compare with previous study conducted at Kampung Orang Asli Kuala Pangsun by Aina (2015) the mean CDI recorded was 0.728 mg/kg/day there is huge differences between the mean CDI. This result was showed that GFS water in Kampung Orang Asli Ulu Kuang, Gombak has lower tendency to have high HI result compared to this previous study. The reason of these CDI difference was because aluminium concentration at Kampung Orang Asli Ulu Kuang, Gombak were lower compared to study at Kampung Orang Asli Kuala Pangsun.

4.8 Hazard Index

Result

Hazard Index was determined by dividing Chronic Daily Intake (CDI) with reference dose (RfD). The RfD recommended for aluminium exposure was 1.0 mg/kg/day (ATSDR 2008). Table 4.8 shows result obtained in this study. It was found that all respondent have a Hazard Index (HI) of less than 1 with mean of 0.0023 and standard deviation 0.0018 range of HI calculated was from 0.001 to 0.02. Thus there is no health risk of aluminium exposure to respondent at Kampung Orang Asli Ulu Kuang, Gombak.

Table 4.8: Hazard Index (HI) of respondent

Variable	frequency	Percentage %	Max	Min	Mean \pm S.D
HI			0.02	0.001	0.0023 \pm
HI<1	100	100.0			0.0018
HI>1	0	0			

N=100

Discussion

Hazard Index (HI) was Result showed that there was no health risk exposure among respondent in Kampung Orang Asli Ulu Kuang, Gombak 100 % of respondent in this study had hazard index lower than 1. If HI value was less than 1 (HI<1), it indicates an unlikely potential for adverse health effects, while if the HI value was greater than 1 (HI>1), the total concentration (or dose) of mixture components exceeds the level considered to be acceptable. Thus, it indicates a concern for adverse health effects or need for further study (USEPA 2007).

Previous study showed that risk of aluminium was found, there was relationship between aluminium concentration in drinking water and the cognitive function in Alzheimer's Disease (AD) (Campbell et al, 2004). a study by Rondeau et al. (2000) has found that aluminium level of more than 0.1 mg/L was associated with an elevated risk of dementia and Alzheimer's disease.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main objective of this study which to determine socio-demographic, Aluminium (Al) concentration in Gravity Feed System (GFS) water and health risk among population of Orang Asli at Ulu Kuang, Gombak Selangor has been achieved. This study found that most of respondent live in poverty and have low education level. Aluminium concentration in GFS water in this study location was lower than maximum limit stated by national standard and there is no relation between pH levels with aluminium concentration.

As a conclusion, there was aluminium concentration found in the water sample, however because of lower concentration and calculated HI was <1 , respondents in this study area were considered safe from having health risk associated with aluminium exposure due to the consumption of GFS water supply.

5.2 Recommendation

Based on the result, it indicates that GFS water was safe consumed by the residences in this study area. However, some of action needs to be taken to make sure there is no risk of aluminium exposure among the villagers in of Kampung Orang Asli Ulu Kuang Gombak as consideration to ensure quality and safety of the drinking water sources. There is some of improvement that should be highlighted.

According to sources from the district health office Gombak, they had done a water monitoring in the location but the monitoring was only twice a year. It is recommended that monitoring of water parameters in the GFS water especially in rural area such as in Orang Asli villages should be enhanced through regular monitoring at least once a month, because by regular monitoring we will be able to detect any violation in water parameters, thus fast action can be taken before any health problems occurs.

Other than that, government can take action by providing a complete facilities for GFS as Malaysian GFS water was not having any treatment process. Opportunities to improvise the GFS facilities may give huge impact on health and sanitation of rural population including Orang Asli.

For future study, it is suggest that researcher to take a biological sample (urine sample for test) as it will give an accurate reading for level of aluminium in human body.

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APPENDIX 1

EVIDENCE OF APPROVAL ETHIC BY MEDICAL RESEARCH ETHICS COMMITTEE

APPENDIX 2

CONSENT FORM (MALAY VERSION)

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini

9. PERSETUJUAN

Saya..... No. Kad. Pengenal.
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)

Tandatangan
(Saksi)

Tarikh :.....

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 3

QUESTIONNAIRE (MALAY VERSION)

Bahagian B: Maklumat penggunaan air paip

10. Apakah sumber air minum di rumah?

- Syarikat Bekalan Air Selangor (SYABAS) Air dari *Gravity Fed System* (GFS)
 Lain-lain, sila nyatakan

11. Berapa kuantiti air yang anda minum setiap hari?

500 mL : _____ botol 1.5 L : _____ botol 5 L : _____ botol Gelas : _____

12. Penggunaan air dari dapur:

- Memasak Minum Kegunaan domestik Lain-lain :

13. Adakah anda berpuas hati dengan kualiti sumber air yang digunakan?

- Ya Tidak Tidak pasti

Bahagian C: Maklumat persekitaran tempat tinggal

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

- Ya Tidak Tidak pasti

15. Apakah jenis pempaipan air di rumah?

- Logam polyethylene) MDPE (Medium - density
 PVC (polyvinyl chloride) Tidak pasti

TERIMA KASIH ATAS KERJASAMA ANDA

-TAMAT-

APPENDIX 4

PHOTOS OF DATA COLLECTION

**DATA COLLECTION OF PHOTO AT KAMPUNG ORANG ASLI ULU
KUANG, GOMBAK SELANGOR.**



Interview with respondents and collect data by using questionnaire.



Weight of respondents was measured



Water samples was collected from the main source of drinking water of each respondents's houses.



pH level measurement was taken by using MW100 Portable pH meter, and water sample was preserve before being analysed



Aluminium concentration was analysed using ICP-MS