UNIVERSITI PUTRA MALAYSIA

HEALTH RLSK ASSESSMENT ON ALUMINIUM (AL) IN GRAVITY FEED SYSTEM (GFS) WATER USED BY ORANG ASLI VILLAGERS IN KAMPUNG KUALA PANGSUN, SELANGOR

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BY

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Thesis submitted in fulfilment 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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ABSTRACT

HEALTH RISK ASSESSMENT ON ALUMINIUM (AL) IN GRAVITY FEED SYSTEM (GFS) WATER USED BY ORANG ASLI VILLAGERS IN KAMPUNG KUALA PANGSUN, SELANGOR.

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Introduction: Gravity feed system (GFS) distributes water from rivers or springs using gravity to houses without any chemical treatment. In Malaysia, GFS has been used as a rural water supply for more than a decade. Aluminium (Al) is naturally present in water through the weathering of rocks and leaching of soil. High prevalence of Al in drinking water was reported in Selangor which was 90% due to agriculture activities. There was very limited study has been done on GFS water supply. Hence, it is needed to provide a baseline data for public management specifically to enhance the quality of GFS water supply. **Objective:** To determine Al concentration in GFS water and health effects of Al intake among Orang Asli Villagers in Kampung Kuala Pangsun, Hulu Langat, Selangor. **Methodology:** A cross-sectional study was conducted at Kampung Kuala Pangsun by using purposive sampling and ninety-two of Orang Asli Villagers were selected as sample population. Respondents were interviewed using minor modified Baseline, Descriptive and Time Activity Questionnaires. The health risk was calculated using equation based on the given information. Three replicates of GFS water samples were taken from each respondent's house using a 200 mL high-density polyethylene (HDPE) bottle, pH was measured in-situ using pH meter while Al concentration was analyzed using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). **Results and Discussion:** Mean Al concentration was 0.079 mg/L with a range of 0.02 mg/L to 0.23 mg/L. There were four (7.3%) out of forty six samples which had Al concentration that exceeded the National Standard for Drinking Water Quality of Malaysia (0.2 mg/L) due to usage of pesticide near to catchment area. pH levels ranged from 3.6 to 7.4 with a mean of 7.07. There was a significant association between pH and Al concentration in water samples studied ($p < 0.01$). Hazard quotient (HQ) for all respondents were found to be less than 1. **Conclusion:** The water supply received by the respondents is safe to be consumed as the health risk from aluminium is negligible.

Keywords: Aluminium (Al), pH, Gravity Feed System (GFS) Water, Hazard Quotient (HQ)

ABSTRAK

PENILAIAN RISIKO KESIHATAN TERHADAP ALUMINIUM (AL) DI DALAM SISTEM GRAVITI FEED (GFS) YANG DIGUNAKAN OLEH ORANG ASLI DI KAMPUNG KUALA PANGSUN, SELANGOR.

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Pengenalan: Sistem graviti feed (GFS) mengagihkan air dari sungai atau mata air menggunakan kuasa graviti ke kawasan perumahan tanpa apa-apa rawatan kimia. Di Malaysia, GFS telah digunakan sebagai bekalan air di kawasan pedalaman lebih dari sedekad. Aluminium (Al) wujud secara semulajadi dalam air melalui proses luluhawa batuan dan larutan dalam tanah. Kadar kelaziman Al dalam air minuman di Selangor dilaporkan tinggi iaitu sebanyak 90% disebabkan aktiviti pertanian. Kajian berkaitan sistem bekalan air GFS adalah sangat terhad untuk didapati. Jadi, adalah menjadi keperluan untuk menyediakan data asas untuk pengurusan awam khususnya untuk meningkatkan kualiti bekalan air GFS. **Objektif:** Untuk menentukan kadar Al dalam GFS dan kesan kesihatan berkaitan pengambilan Al dalam kalangan penduduk Orang Asli di Kampung Kuala Pangsun, Selangor. **Metodologi:** Satu kajian keratan rentas telah dijalankan di Kampung Kuala Pangsun berdasarkan kriteria pemilihan dan sebanyak sembilan puluh dua orang penduduk kampung Orang Asli telah dipilih sebagai sampel populasi. Responden telah ditemubual menggunakan survei *Baseline, Descriptive and Time Activity* yang telah mengalami sedikit pengubahsuaian. Risiko kesihatan telah dikira dengan menggunakan persamaan berdasarkan maklumat yang diberikan. Tiga replikasi sampel air GFS telah diambil dari rumah setiap responden dengan menggunakan botol 200 mL berkepadatan tinggi polyethylene (HDPE), pH diukur in-situ menggunakan meter pH manakala, kadar Al dianalisis menggunakan Pasangan Plasma Induktif-Mass spektrometri (ICP-MS). **Keputusan dan Perbincangan:** Kadar min Al adalah 0.079 mg/L.dengan julat dari 0.02 mg/L sehingga 0.23 mg/L. Terdapat empat (7.3%) daripada empat puluh enam sampel dengan kadar Al yang melebihi Standard Kebangsaan bagi Kualiti Air Minuman (0.2 mg/L) disebabkan penggunaan racun perosak berdekatan kawasan takungan air. Kadar pH dalam julat 3.6 hingga 7.4 dengan kadar min 7.07. Terdapat signifikan kaitan antara pH dan kadar Al dalam sampel air yang dikaji ($p < 0.01$). Nilai indeks bahaya (HQ) untuk kesemua responden didapati kurang dari 1. **Kesimpulan:** Bekalan air yang diterima oleh penduduk adalah selamat untuk diminum berdasarkan nilai risiko kesihatan Al.

Kata kunci: Aluminium (Al), pH, Sistem Graviti Feed (GFS), Nilai Indeks Bahaya (HQ)

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LIST OF ABBREVIATIONS

AD	Alzheimer's Disease
ADD	Average Daily Dose
Al	Aluminium
ATSDR	Agency for Toxic Substances and Disease Registry
Ca	Calcium
Fe	Iron
GFS	Gravity Feed System
HQ	Hazard Quotient
K	Potassium
Mg	Magnesium
MRL	Minimal Risk Level
NSDWQ	National Standard for Drinking Water Quality
P	Phosphorus
ppt	Parts per trillion
RfD	Reference Dose
Si	Silicon
USEPA	United State Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Earth is known as the 'blue planet' because about 71% of the earth's surface is covered with water (Mullen, 2012). According to U.S.Geological Survey (2016), 97% of the water on the earth is ocean water consist of salt and other minerals and humans unable to drink this water. It is a difficult and expensive process to remove this salt. About 2% of the water on earth is glacier ice at the North and South Poles. It can be melted but it is great distance from where people live to be usable. Only less than 1% of all the freshwater on earth surface water,which is all the lakes,river and streams on Earth that we can actually use for a variety of everyday things such as drinking, transportation, heating and cooling, industry and many other purposes (American Water Works Association, 2002).

Malaysia has a lot of water resources since it is located within the equatorial zone. An estimated annual water resource in Malaysia about 900 billion cubic metres with very high average of rainfall about 3,000 mm annually (Weng, 2004). About 99% of water supply comes from rivers and streams which serve as utmost surface water sources to the country including urban and rural area. Only 1% of the water required supply by groundwater due to its restricted availability (Teik, 1985).

Gravity Feed System (GFS) is water supplies that use gravity force to distribute water from river or spring direct into houses without any chemical treatment (Pendek, 2016). Majority of rural people use GFS (78.1%) as compare to another alternative rural water supply such as pump/hydraulic-ramp pipe system, rain and well system (Kiyu & Hardin, 1992).

In the Earth's crust, aluminium (Al) is the most abundant metallic element about 8.3% by mass and the third most abundant of all elements cover about 8% of the Earth's surface. It is available in all natural water sources (after oxygen and silicon make up 47% and 28%, respectively) (Dzulfakar et al., 2011). Natural processes contribute the most of Al in the environmental media which is through the weathering of rocks peculiarly igneous rocks as aluminosilicate minerals (Keith & Ingerman, 2009), metamorphic and sedimentary rock (Butcher, 1988). However, most of this Al in the form of acid-insoluble form (Hunter Water, 2011).

By present alongside waste water, Al gets into surface waters which is from plants that produce Al and its salts or making use of it in their production (Bezak-Mazur,Widłak & Ciupa, 2001). In soils, Al concentration ranging from about 0.07% by weight (0.7 g/kg) to over 10% by weight (100 g/kg) (Keith & Ingerman, 2009). Acidic soil water reacts with rock-forming minerals to let-off ions and make up new minerals such as sodium,potassium and calcium Al silicates or clays (Hays, 1996). But the clays are the most typical of all the sedimentary Al-bearing minerals that natural waters come into contact with (Butcher, 1988).

The presence of Al in the environment depends on its combination of chemistry and the characteristics of the local environment, especially pH. In surface water and groundwater,dissolved Al concentrations differ with pH and the humic acid content of the water. The concentration of Al in natural water is high that occur only when the pH is <5. Or else,the Al concentration in most surface water are very low (Keith & Ingerman, 2009). Base on National Standard for Drinking Water Quality (NSDWQ), Al concentration in drinking water must not exceed the maximum acceptable value 0.2 mg/L and the pH acceptable value ranged from 5.5 to 9.0 for raw water and 6.5 to 9.0 for drinking water (Engineering Services Division, Ministry of Health Malaysia, 2010).

1.2 Problem statement

In Malaysia, GFS has been used as a rural water supply for more than a decade. But,there was still very limited study have been carried out in this area (Sulaiman et al., 1997). In Kg. Kuala Pangsun, there were two water supply system being provided which were GFS and treated water, Puncak Niaga. But,majority of villagers used GFS water supply as their main water source for daily activities such as drinking,bathing and domestic activities such as gardening due to it's availability and it is provided with no cost.

The drawback of using GFS as water supply itself are this system was unable to treat water contaminated with oil, chemicals such as Al, Fe, Si, Ca, K, Mg, Na and P,heavy metals,dissolve salts or strong acids/bases. Additional steps may be required to solve these problems such as portable cation exchange,distillation and reverse osmosis (Water Quality Association, 2013). If not, Al still presence in drinking water (Marusek, 2007).

Al commonly known as an innocent element (Edward, 2012) may be present naturally in water through the weathering of rocks and leaching of soil. High prevalence of Al in drinking water were reported in Selangor which was 90% (Nadia,2015) due to agriculture activities. There is interest throughout the world over the levels of Al found in drinking water sources (raw water) and treated drinking water (Srinivasan,Viraraghavan & Subramanian, 1999).

1.3 Study justification

This study was carried out to determine the concentration of Al in GFS water and measure the health status of individual that exposed.The data that obtained from the study can serve as data for public management specifically to enhance the quality of GFS water supply, since there was very limited study being carry out in Malaysia on GFS. It also help the policy makers in policy development for 100 percent safe water supply in rural area as safe drinking water was an vital need for human wellbeing, health, development and necessity.

1.4 Definition

1.4.1 Conceptual Definition

a)Aluminium

Al is a metal that naturally occur in the earth's crust. It is a soft,gray,shiny metal that is mined in its pure form. Metallic Al is used as a structural material in the construction,automotive and aircraft industries,as well as in cookware,soft drink cans and Al foil. Acidic precipitation moves Al from natural sources and direct man-made releases Al compounds related with industrial processes to air (Krewski et al., 2007).

b)Health risk assessment (HRA)

Health risk assessment (HRA) is the process to foresee the nature and probability of harmful health effects in humans that exposed to chemicals in contaminated environment, now or in the future. It involve four steps which are hazard identification,dose response assessment,exposure assessment and risk characterization (United States Environmental Protection Agency, 2015).

1.4.2 Operational Definition

a) Aluminium exposure

The concentration of Al in water was determined using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) in the unit of μg/L. It is a robust method that uses an inductively coupled plasma as an ion source and a mass spectrometer as an ion analyzer. It can detect the presence of >75 elements in a single scan and can attain detection limits down to parts per trillion (ppt) levels for many elements (Keith et al., 1999). For Al,the detection limits generally in the 0.1-10 ppt (ResearchGate, 2001).

b) Health risk assessment (HRA)

Average Daily Dose (ADD) predict the exposure of every respondent to Al through ingestion as the exposure routes. Thus, HQ was calculated to know the risk of exposure. Exposures below of 1.0 or 1.0 are unlikely to result in harmful health effects (United States Environmental Protection Agency, 2016).

1.5 Conceptual Framework

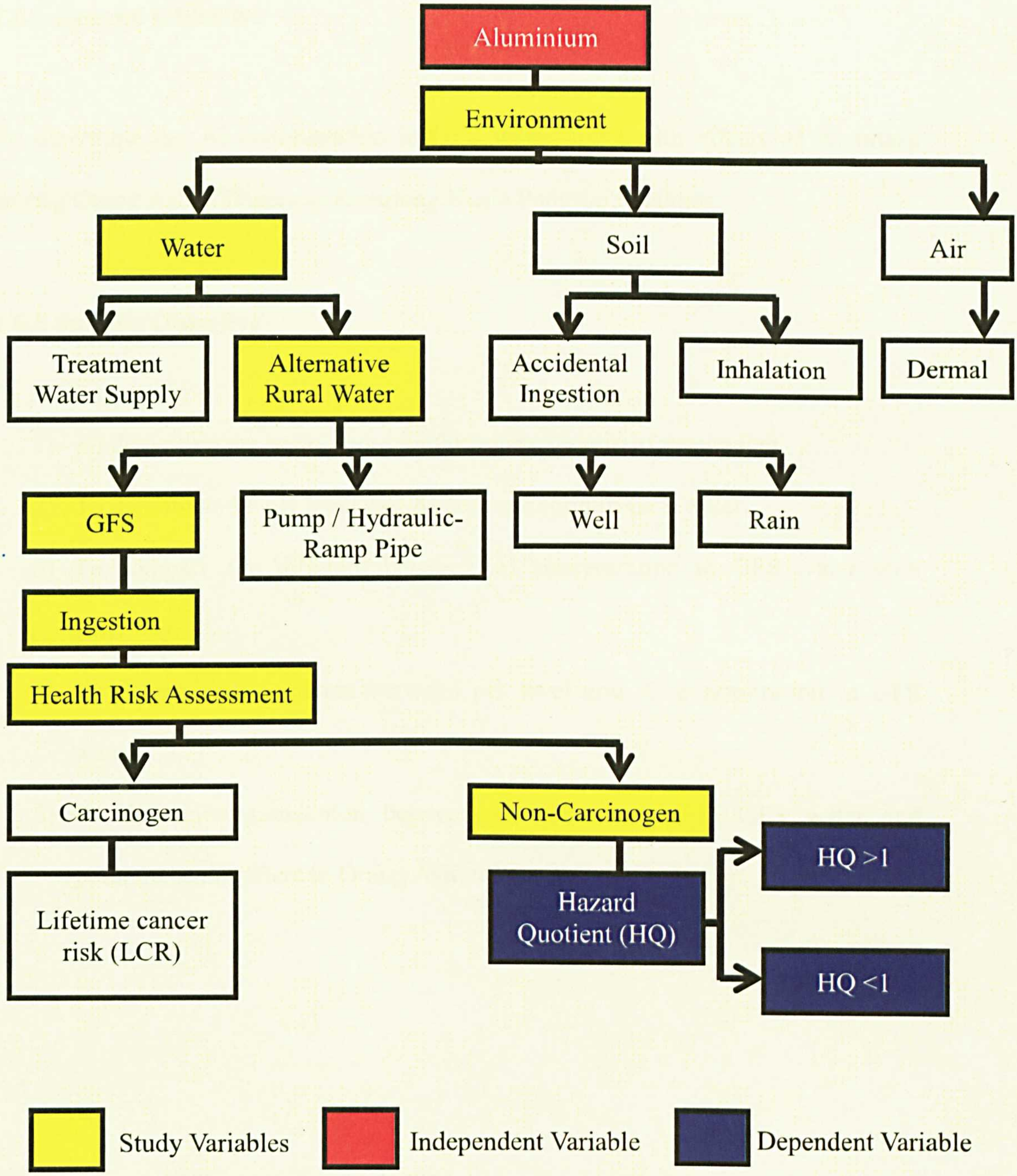


Figure 1.1: Conceptual framework

1.6 Objectives of Study

1.6.1 General Objective

To determine the Al concentration in GFS water and health effects of Al intake among Orang Asli Villagers in Kampung Kuala Pangsun,Selangor.

1.6.2 Specific Objective

1) To determine the socio-demographic characteristic of respondent.
2) To determine the pH level and Al concentration in GFS water.
3) To compare the different between Al concentration in GFS water with NSDWQ.
4) To determine association between pH level and Al concentration in GFS water.
5) To determine association between Al concentration in GFS water and possible health effect to Orang Asli villagers.

1.7 Hypothesis

1) There was a significant difference between Al concentration in GFS water with NSDWQ.
2) There was a significant association between pH level and Al concentration in GFS water.
3) There was a significant association between Al concentration GFS water and possible health effect of Orang Asli villagers.

CHAPTER 2

LITERATURE REVIEW

2.1 Al

Al in the earth's crust constitute about 8.8% by weight (88 g/kg) (Agency for Toxic Substances and Disease Registry, 2008b). Al never occurs as a metal in nature but it is found only in the form of its compounds, such as alumina because of its strong affinity to oxygen (Spirit of Health, 1996). Al compounds in the most part are insoluble in water except under strongly acidic or alkaline conditions.

Al metal usually use to make beverage cans, pots and pans, airplanes, siding and roofing, and foil. While in form of powder, it is often used in explosives and fireworks. Al products give benefits for our health in term of safe blockade to bacteria and pollution when Al is being use in food and beverage packaging. Besides that, Al are widely use in consumer products such as antacids,astringents,buffered aspirin,food additives,antiperspirants and cosmetics. Al compounds such as alums (aluminum sulfate) helps purify drinking water in water-treatment (Agency for Toxic Substances and Disease Registry, 2008a) and boost immune response in vaccines and medicines such as in tetanus, diphtheria, pertussis and poliomyelitis vaccines for child vaccination (Lindblad, 2004).

Al as Secondary Maximum Contaminant Levels (SMCLs) or National Secondary Drinking Water Regulations (NSDWRs) is contaminants that may have cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste,odor or color) in drinking water (Water Quality Association, 2013).

2.2 Sources of Aluminium in the Environment

2.2.1 Natural Sources

Important natural sources of Al are bauxite, cryolite, alum, corundum and the kaolin minerals. Some acid soils contain enough Al to damage certain plants (Merck, 1989). Al is also present naturally in foods like spinach, potatoes and even tea (Shore, 2013). Al accumulate more than 100 µg Al/g in certain plants such as tea leaves. But, this Al is often non-soluble and become less concern for human health as the body does not as readily absorb it (Greger & Sutherland, 1997).

2.2.2 Antrophogenic Sources

2.2.2.1 Alum Water Treatment

Al salts such as aluminium sulphate (alum) or polyaluminium chloride are used in drinking water treatment to intensify the removal of particulate, colloidal and dissolved substances through coagulation processes (Srinivasan,Viraraghavan & Subramanian, 1999).

Figure 2.1 : Alum used in water treatment
(Focus Technology Co, 2016)

2.2.2.2 Effluent discharge

Industrial emission from paper mills,Al manufacturing,canneries,tanneries,textile mills and metal cleaning plants have high level of Al. According to one study conducted at Roanoke River,Virginia,sewage treatment plants were the most significant man-made contributors of Al to the river followed by landfill site and railroad yard (Butcher, 1988).

2.2.2.3 Mining

Al can be found naturally in the form of bauxite, an ore containing Al oxide, or alumina (Alcoa, 2016). Bauxite exist primarily in tropical and sub-tropical areas, like Africa, the West Indies, South America and Australia (Australian Aluminium Council Ltd, 2013).

Figure 2.2 : Bauxite or Al Hydrates,anelementary ore of Al
(Harder, 2015)

2.2.2.4 Acid Rain

Acid rain is a removal of acidic material from the atmosphere. Acids cause nutrients from the soil to seep and being carried deeper into the ground or into streams. It divest essential elements such as calcium, potassium, magnesium and trace metals from plants. There are metals sticked to clay particles which produced by weathering of rocks. It undergoes ion exchange process in which the H+ anion of the acid replaces the metal ions in the clay. More acidic solutions from the soil dissolve Al and the Al enter into streams and lakes by runoff and groundwater. If the pH is more than 5, Al in soils and rock is very insoluble (Stewart, 2008).

2.3 Exposure to Al

2.3.1 Routes of Exposure

Oral is the main route of Al exposure to the most people (Keith & Ingerman, 2009). It is about 90% of our daily intake of Al mainly comes from food. But this Al usually found bind to other substances in the food and the blood stream cannot absorbed it. While,Al in water can be absorbed by humans as this Al is in an unbound form after water treatment (Peterson, 2011). Even so, the amount of Al absorbed from drinking water is usually very small which is only 0.4 to 1% (Hunter Water, 2011).

Next is through **inhalation**. In occupational settings, exposure to Al (dust, bulk powder) has been decreasing over the last 10 years. But, inhalation exposure to Al nanomaterials in occupational settings is raising (Krewski, 2014).

Lastly, a small amount of Al is contributed through **dermal** contact that exist in some cosmetics, antiperspirants and pharmaceuticals such as antacids and buffered aspirin (Agency for Toxic Substances and Disease Registry, 2008a). Al chloride, Al chlorohydrate and recently, Al zirconium tetrachlorohydrex glycine are the most typical active ingredients in antiperspirants. It may cause irritation in sensitive underarm areas since this Al compounds in antiperspirants form a chemical reaction with sweat and clumping to block sweat glands,result in allergic reactions such as contact dermatitis, acne or itching (Thurman, 2015).

2.3.2 Metabolism of Al

2.3.2.1 Absorption

Al is absorbed from the GI tract as oral phosphate-binding agents (Al hydroxide), parenterally through immunizations, dialysate on patients on dialysis or total parenteral nutrition (TPN) pollution, via the urinary mucosa through bladder irrigation and transdermally in antiperspirants (Bernardo, Barnett & Edwards, 2015).

The primary site of ingested Al absorption is at proximal intestine. Mechanisms of Ca uptake such as Ca channels, Na transport processes and a role for transferrin helps to ponder intestinal Al absorption. But, in animal, Al absorption depend on the calcium and iron status of the animal. Al absorption is increase when uraemia exist as it helps in increasing gut permeability of the paracellular pathway (Yokel & McNamara, 2001).

Lactate, citrate and ascorbate increase GI absorption (Bernardo, Barnett & Edwards, 2015). There is higher levels of urine and serum Al were noticed in patients taking citrate-containing pharmaceuticals simultaneously with Al-containing pharmaceuticals. The existence of citrate may increase the solubility of Al in the gut, making it easy to absorb (Landry, 2016).

2.3.2.2 Retention

Al is stored primarily in the lungs, liver, thyroid, bone and brain. Levels in most tissues do not increase with age, but level of Al in the lungs and brain increases with age (Analytical Research, 2012). In normal humans, the higher concentration in lung means entanglement of airborne Al particles while the higher concentration in bone, liver and spleen may reflect Al desolation. In healthy individuals, the total body burden of Al is 30-50 mg. Approximately 50% of the body burden is in the skeleton,25% in the lungs and 1% in brain (Yokel & McNamara, 2001).

2.3.2.3 Excretion

Absorbed Al is eliminate primarily in the kidney for 95% and to a lesser extent, in the bile (Krewski et al., 2007). Kidney failure is known to overly increase Al toxicity, probably because the small amount of Al that is absorbed from the gut cannot be eliminated (Analytical Research, 2012).

2.4 Biomarkers

The amounts of Al exist in the bodies can be measured in the blood, bones, feces or urine. Urine and blood Al measurements can determine the exposure more than normal amounts of Al, specifically for recent amounts. Bone measurement can also show exposure to high levels of Al, but with the help of bone biopsy.While Al measured in feces is unable to predict absorption (Agency for Toxic Substances and Disease Registry, 2011).

2.5 Effects of pH Level to Solubility of Al

pII is one of crucial factors in determining Al solubility and residual Al. Al is amphoteric in solution and can form both organic and inorganic complexes,forming polymer. Al has a very low solubility in the pII ranges 5 to 8, but at extremely acidic ($pH < 6$) and alkaline ($pH > 8.5$) conditions, it can react and dissolve. At near neutral pH values (7.0 to 7.5), it is insoluble and produce high residual Al causing consumer to complaints (Srinivasan,Viraraghavan & Subramanian, 1999).

Temperature and pH both effect the transportation of Al species base on thermodynamics calculation. At pH 5 and 25 C, Al 3+ is 36%, Al(OH) 2+ is 37%, Al (OH) 2+ is 26% and Al(OH)3 is 1%. Doubling acidity or reducing temperature to 15 C,produce the same increase of Al(OH)3. At the same pH but at 2 C, these species are present at 84%, 13 %,2 % and 0 % respectively, a big change in the proportion of toxic hydroxide species,while at higher temperature, Al(OH)3 was eliminate by flocculation (Howells, 1994).

Al^{3+} move from soil depend on land use. Trees collect acid-forming material from the atmosphere by dry deposition between rain events and by tramping aerosols and droplets in mist and fogs. These substances together with substance produce from the tree canopies are washed on to the soil beneath during rain events. Al dissolved in acidic conditions then mobile from the soil into drainage channels (Howells, 1994).

Al from mine drainage, acid sulphate soil waters, geothermal waters, poorly buffered lakes and streams receiving acid runoff are having low pH about 5.5 and low ionic strength which are toxic to aquatic organisms usually dissolve in the water. At this pH, at least four species comprise in the fraction of "inorganic monomers" which are Al 3+ , Al(OH) 2+ and Al(OH) 4- (Howells, 1994).

2.6 Health Effects

2.6.1 Acute Toxicity

On acute exposure,Al is low toxicity. In humans, oral doses up to 7200 mg/d (100 mg/kg bw per day) can be endure (Government of Canada, 2016). According to World Health Organization (2003), individuals that exposed to unknown but rising levels of Al unintentionally distributed from a water supply using Al sulfate for at least 5 days only experience nausea, vomiting, diarrhoea, mouth ulcers, skin ulcers, skin rashes and arthritic pain. This symptom are mild and in a short period.

2.6.2 Chronic Toxicity

2.6.2.1 Neurological

Nervous system is the most sensitive target of Al toxicity (Clarkson, 1987). Chronic toxicity of Al such as Parkinson's dementia (PD), Amyotrophic Lateral Sclerosis (ALS) and Alzheimer's Disease (AD) (Dzulfakar et al., 2011).

Parkinson's disease is regressive neurological disorder resulting from nerve cells in the brain not producing enough of the chemical dopamine, which coordinates movement (Gina Kemp,Buxton & Porter-Buxton, 2016). According to Parkinson's Australia (2010), not all people with Parkinson's will develop dementia. **Parkinson's dementia (PD)** is an deterioration in thinking and reasoning that eventually affects many people with Parkinson's disease. It is a decrease in thinking and reasoning that establish in someone diagnosed with Parkinson's disease at least a year earlier (Alzheimer's Association, 2016).

Amyotrophic lateral sclerosis (ALS) or Lou Gehrig's disease (National Institute of Neurological Disorder and Stroke, 2016) is a gradual neurodegenerative disease that disturbs nerve cells in the brain and the spinal cord. The initial symptoms of ALS are tripping, dropping things, abnormal fatigue in the arms and/or legs, slurred speech and others (The ALS Association, 2016).

Alzheimer's disease (AD) is a neurological ataxia causes memory loss and cognitive decline due to death of brain cells (Gill, 2016). It is a form of dementia that affects memory, thinking and behavior and become bad over time and can obstruct daily tasks. It often affect people at the age of 65 and older (Alzheimer's Association, 2016).

2.6.2.2 Renal

Intravenous Al exposure from dialysis,total parenteral nutrition,intramuscular exposure from 20 vaccine in the first 6 years of life or regular treatment regimen of allergen extract immunotherapy can contribute to cause absorbed Al (Yokel & McNamara, 2001). The absorbed Al leaved serum immediately and pile up in bones. The consequences of Al accumulation in bone include paucity of bone cells, lack in mineralization and low rate of bone turnover (Cannata-Andia & Fernandez-Martin, 2002).

2.6.2.3 Lung

Al workers were suggested to be susceptible to respiratory diseases and impairment of ventilatory function tests, which results in chronic obstructive pulmonary disease (COPD). Al might causing oxidative and inflammatory stress, resulting to functional disruption of lung epithelium. Chronic lung inflammation appears to be added to the causes of COPD (Elserougy et al., 2015).

2.6.2.4 Skeletal

It is predict to be safe to healthy individuals who consume Al-containing over the counter medications such as antacids and buffered aspirin at endorsed dose base on historical use. But there is some symptom on skeletal effects such as osteomalacia for a long term use in some individuals (Agency for Toxic Substances and Disease Registry, 2011).

2.6.3 Children's Health

Children exposed to Al are expected to have comparable effects to adults. There is little information on whether unborn child that exposed to Al during pregnancy experienced damage. Only small amount of Al present in breast milk being transfer to the infant (Bull, 2010).

2.6.4 Reduce Risk of Exposure to Al

Exposure to Al is impossible to avoid since Al is one of the most abundant metals on earth and being used in variety of products. However, some precaution can be take to decrease the exposure. Instead of using Al, glass cookware can be used for cooking. Hygiene products such as antacids and deodorant with Al hydroxide can be avoided and being change to natural substitutes. Processed and frozen foods need to be avoided as their containers can contain Al. Instead optional for fresh, eat organic fruits and vegetables (Edward 2012) that free from Al exposure.

2.7 Health Risk Assessment (HRA)

The HRA process consist of four basic steps which are hazard identification, dose-response assessment, exposure assessment and risk characterization. First, hazard identification is to identify harmful effects of agents. Dose response examines the relationship between doses and incidences of harmful effects in exposed populations. Exposure assessment estimate the intensity, frequency and duration of human exposures to agent in the environment. Lastly, risk characterization is to measure the incidence of health effects under the various conditions of human exposure (National Academy of Sciences , 2004).

Non-carcinogenic effects are decided by comparing an exposure level (dose) with the toxicity value indicate by HQ value (Ohio Environmental Protection Agency, 2016). If HQ is equal to or less than one, there is no probability of risk that non-cancer health effects will arise. If the HQ exceeds 1, the probability of non-cancer effects rise (Colorado Department of Public Health & Environment Disease Control and Environmental Epidemiology Division, 2007).

2.8 GFS

There are three common types of water supply distribution system which are gravity system, pumped system and combined gravity. To choose suitable water supply distribution system, it depends on the level of source, topography of the area, location and extent of the distribution area, elevation and site conditions (Elojali, 2011).

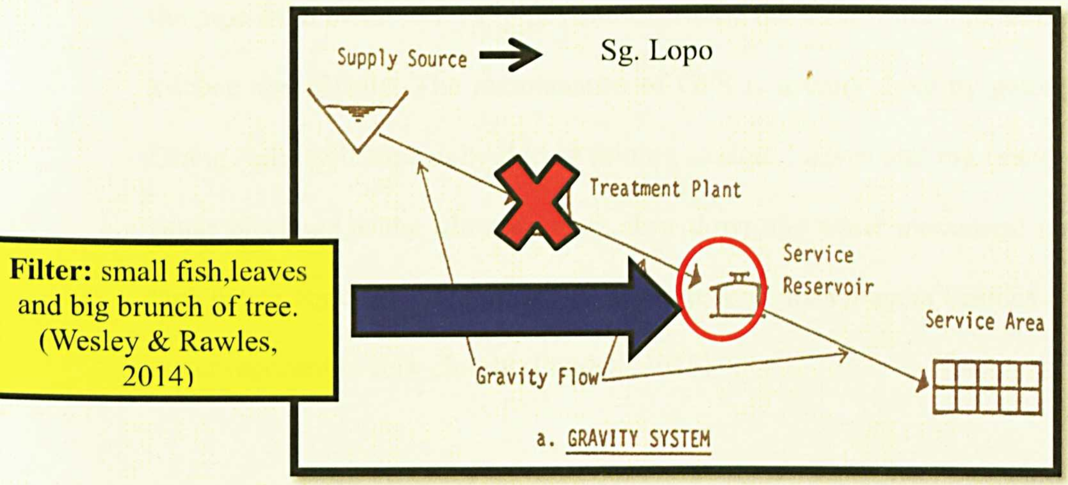


Figure 2.3: How GFS works
(Elojali, 2011)

GFS is the most favored type of water distribution where adequate height of the supply is available (Elojali, 2011). A typical GFS comprise catchment area constructed across a stream and intake point. All activities such as recreational, agricultural and logging are restricted at the catchment area as it will contribute to increase the turbidity of water. The dam or catchment area need regularly observe to make sure that there is no leakage or damage hence allow pesticides from agricultural activities, faeces of domestic animals and infiltration of sullage from kitchen and toilet to contaminate the water (Ministry of Health Malaysia, 2012). Only when the gravity type is not function, the combined gravity and pumped system are used. The pumped system is the least favoured as it involved higher operation cost.

GFS in Kampung Kuala Pangsun was provided by government since 1970 from Sungai Lopo (Lim and Ahmad, 2004) direct into houses using polyvinyl chloride (PVC) pipe. Before this, there are 4 pipes that supply GFS water outside their house that made up from metal pipes. In early year 2000, government change the pipe from metal to PVC pipes and distribute the GFS water into their house,at the kitchen specifically. The maintenance of GFS is usually done by gotong royong of Orang Asli itself especially during raining season. Leaves and big branch of tree can cause blockage to the filtration tank, slow down the water movement into the water tank,hence result in low amount of water receive by villagers besides the colour of water received is very cloudy (Pendek, 2016).

Figure 2.4 : Flowchart on How GFS Work in Kg. Kuala Pangsun

Source of GFS water : Sg. Lopo

Long PVC pipes from catchment area to water tank

Water that filter from leaves and big branch of trees

First water tank

Second water tank

Long PVC pipe into houses

Water supply directly into their kitchen

CHAPTER 3

METHODOLOGY

3.1 Study Location

This study was conducted at the village in state of Selangor in West Coast of Peninsular Malaysia,namely Kampung Kuala Pangsun,Selangor. According to interview done with head villagers or "Tok Batin" , En Andak Pendek (2016), majority of the Temuan Orang Asli was permanent settlers living in this village with total population of 467 people and approximately 149 houses.

Adapted from Radzak (2015)

Figure 3.1: Study location at Kg. Kuala Pangsun, Hulu Langat, Selangor

Kampung Kuala Pangsun was chosen as the study location since Selangor was reported of having high prevalence of Al in drinking water about 90% compare to other countries such as Johor,Pahang and Sabah (Nadia, 2015). Besides that, it was a potential area that can contribute to increase of Al concentration in GFS water due to agriculture activity as their source of income such as fruit plantation for example durian,rambutan and lemongrass plantation near to water catchment, Sungai Lopo (Pendek, 2016). Agriculture can cause increasing of soil acidity (Department of Agriculture and Food, 2015).

According to Lim and Ahmad (2004) , even the Temuan Orang Asli are provided with free basic amenities such as electricity, pipe water (treated water) and pour flush toilet, but they still depend on river as source of water for them. Besides that, the village is just near to laboratory for Al analysis and the villagers are easy to cooperate in term of giving reliable information regarding their water intake and personal information.

3.2 Study Design

A cross sectional study was conducted to estimate the health risk associated with the exposure to Al in GFS water among Orang Asli villagers. A cross-sectional study is an observational study. It determines the exposure and disease of a given population at the same point of time. It measures the prevalence of exposures and/or of diseases in the population and provides evidence for further research into the causes of diseases (Kanchanaraksa, 2008).

3.3 Study Population

The Temuan Orang Asli Villagers in Kg. Kuala Pangsun,Hulu Langat who used GFS water as their main water supply in their daily life.

3.4 Sampling

3.4.1 Sampling Method

The sampling method in this study was purposive sampling method. Respondents were selected based on inclusion and exclusion criteria as they can provide the information needed to answer the researcher judgement. Inclusion criteria for respondents were both male and female are allowable, age 18 and above and used of GFS water as their main source of drinking water. Exclusion criteria for respondents that use tap and filter water at home, dietary intake (example : smoking and alcohol) and have Alzheimer history disease.

3.4.2 Sampling Unit

The sampling unit was Temuan Orang Asli in Kampung Kuala Pangsun,Hulu Langat,who fulfilled the inclusion and exclusion criteria.

3.4.3 Sampling Size

Formula adapted from Kirkwood & Sterne (2003)

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

Where $\hat{p}$ is proportion of Al in GFS water which is 0.7 (Qaiyum et al.,2011), e2 is standard error of mean which is 0.05.

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

$$= \frac{0.7\,(0.3)}{0.0025}$$

= 84 people (minimum sample size)

Therefore,the minimum sample size needed for this study is 84 people. The minimum sample size will be rounded up to 10 % to recover the loss of respondents throughout the study.

Response rate 10 %

10 % x 84 = 8.4

= 8 people

Hence, 84 + 8 = 92 samples.

Thus,the **total sample size** population was **92 people.**

3.5 Study Instrumentation

3.5.1 Questionnaire

The respondents were interviewed face to face at their respective houses using a set of structured questionnaires which comprise of four sections. The first section contain questions regarding respondents' background data such as age, gender, household income and education level. The second section contain questions regarding information on tap water usage. Third section contain questions on living environment and fourth section contain questions on health information. The questionnaire was minor modified from the Baseline, Descriptive and Time-Activity Questionnaires used in the National Human Exposure Assessment Survey (NHEXAS)-Arizona study (Kavcar, Sofuoglo & Sofuoglo, 2009) to make it suitable with local community.

3.5.2 Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

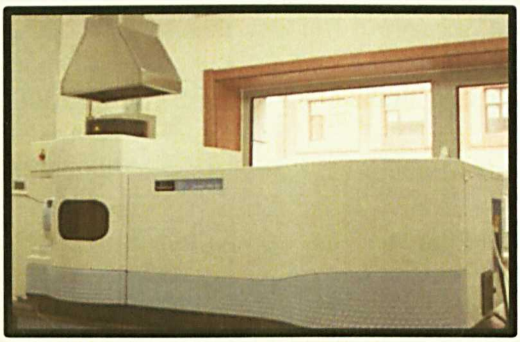


Figure 3.2 : ICPMS Model Elan DRC-e

Al concentration in water samples was measured using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) using EPA Method 200.8. ICPMS was used to analyze the samples because detection limits for most elements equal to or better than those obtained by Graphite Furnace Atomic Absorption Spectroscopy (GFAAS), higher throughput than GFAAS, with a minimum of matrix interferences. ICPMS able to handle both simple and complex matrices due to the high-temperature of the ICP source, good detection capability to ICP-AES with the same sample throughput and the ability to obtain isotopic information (U. S. Geological Survey, 2013).

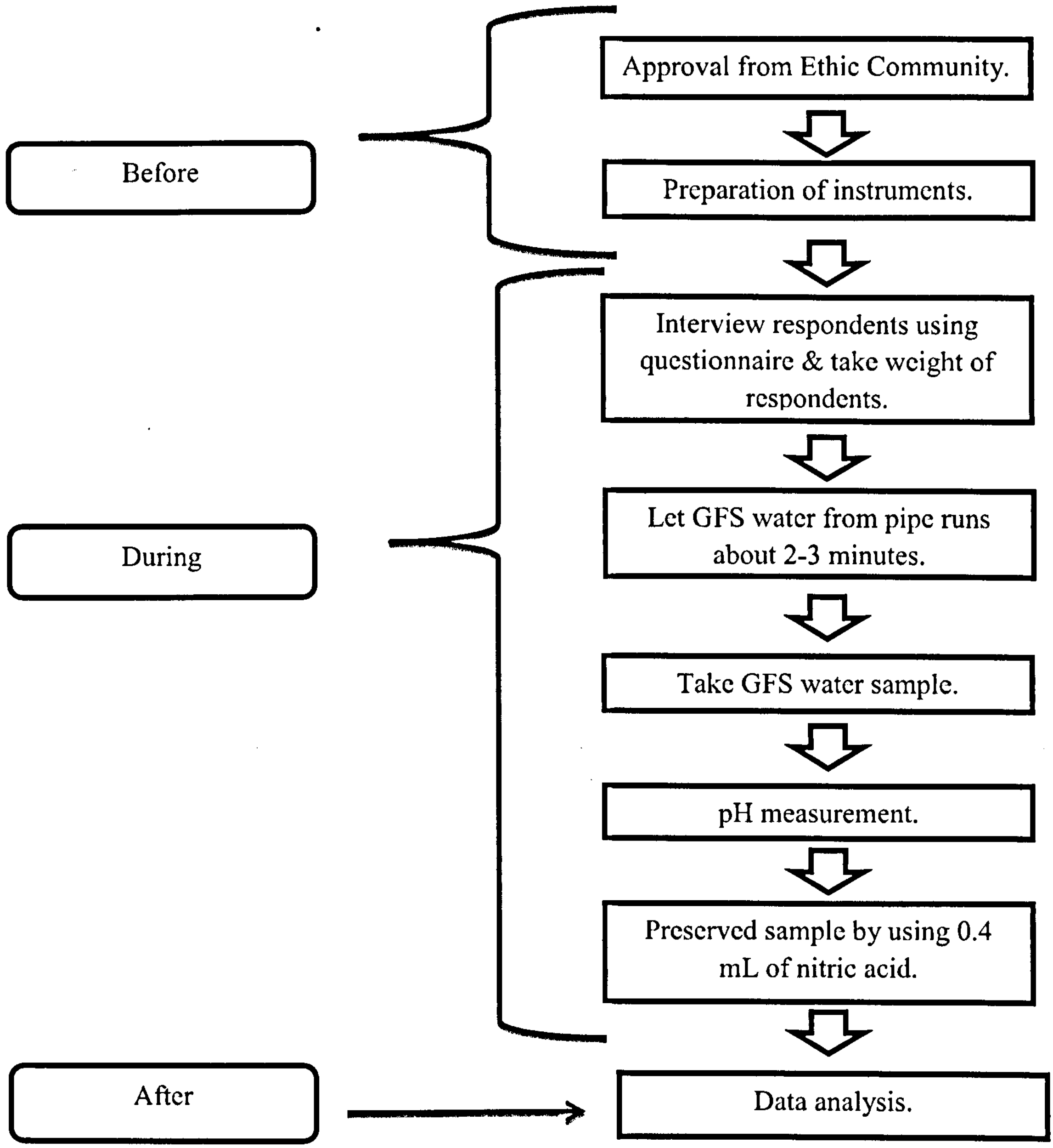
3.5.3 Water Sampling

GFS water samples were collected at the respondents' kitchen tap. There were 46 water sample with three replicates were taken from each respondent's house to obtain the average. Firstly, 200 mL non-acidified high-density polyethylene (HDPE) bottle used for water sample collection were washed thoroughly with 10% of diluted of nitric acid (HNO_3) and several rinsed with distilled water to remove foreign substances and residues of processing chemicals (Loon & Barefoot, 1989).

The tap was turned on and water was left to run for 2-3 minutes (Ministry of Health New Zealand, 2007) to ensure that the system was flush enough before the sample were taken. The samples were took very close to the source of the supply with a gentle stream to avoid turbulence and air bubbles (HACH, 2015). pH measurement was done before preservation of water sample. The pH meter was calibrated by directly placing the electrodes in water sample immediately (Khadse, 2010). Since Al may be lost from solution to the walls of sample containers,0.4 mL of nitric acid (HNO3) were added (Ballance, 1996) before analysis at the laboratory to lengthen the storage time of the samples (6 month). The sample was labelled was seal in plastic bag. The sample bottle was then placed in the room temperature and maintained at that temperature until further analysis (HACH, 2012). Al detection was done using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) (Perkin Elmer, 2013).

Figure 3.3 : Water Sampling

3.5.4 Data Colcction Technique



3.6 Health Risk Assessment (HRA)

As Al was categorize as non-carcinogen (World Health Organization, 2003), hence Non-Carcinogenic Risk formula was used. The Average Daily Dose (ADD) was calculated using the following equation (Oosthuizen, 2014):

$$ADD = (C \times IR \times EF \times ED) / (BW \times AT)$$

Where C is concentration of Al in drinking water (mg/L), IR is water ingestion rate (L/day), EF is exposure frequency (days/year), ED is exposure duration (years), BW is body weight (average value) (kg) and AT is average of exposure duration (ED × 365 days/year).

Next, the HQ was calculated using the following equation (United States Environmental Protection Agency, 2005) so that conclusion on the significant exposure and overall potential for non-carcinogenic health effect posed by Al in drinking water can be made:

$$HQ = ADD / MRL$$

MRL is minimal risk level (mg/kg-day). MRL for Al is 1 mg Al/kg/day (Agency for Toxic Substances and Disease Registry, 2011). According to Illinois Environmental Protection Agency (2015) , if $HQ < 1$, there is unlikely that harmful health effects would occur. If $HQ > 1$,there is significant risk of non- carcinogenic effect.

3.7 Data Analysis

Statistical Package for Social Science (SPSS) version 22.0 with the significant value ($p < 0.05$) was used to analyze data from questionnaire.

Objectives	Data Analysis
1) To **determine the socio-demographic characteristic** of respondent.	Descriptive test : Frequency (N)
2) To **compare the different** between **Al concentration** in GFS water with **NSDWQ.**	**One sample t-test**
3) To determine **association** between **pH level** and **Al concentration** in GFS water.	**Simple Linear Regression**
4) To determine **association** between **Al concentration** in GFS water and related **health effect** to Orang Asli villagers.	**Correlation** Pearson Test

3.8 Quality Control

3.8.1 Pre-testing questionnaire

In order to validate the questionnaire, pilot study was carried out among nine of Orang Asli villagers from Sg. Congkak,Hulu Langat. The pre-testing of minor modified questionnaire was conducted to observe and evaluate their level of knowledge and understanding toward the questionnaire. Cronbach alpha from analysis using SPSS was 0.741. As value near to 1 showing higher reliability.

3.8.2 Calibration

For portable pH meter,the equipment was calibrated with a known standard,pH 4 and pH 7 solution before used.

Figure 3.4 : MW100 Standard Portable pH Meter with 0.1 pH resolution

3.8.3 Standard Operating Procedures (SOP)

For pH measurement, MW100 Standard Portable pH Meter with 0.1 pH resolution was used. This instruments can read the pH instantly by dipping the probe into the water and it can measure the pH from 0.00 to 14.00 with accuracy of ± 0.1.

Figure 3.5 : SECA Body Weight Scale

Body weight of respondents was measured by using SECA Body Weight Scale. The scale were ensured to be at zero mark to get accurate reading. The respondents body weight was measured in kg and reading taken 3 times and then averaged.

3.8.4 Water Quality

All the apparatus and glass wares were soaked in 10% of hydrochloric acid (HCl), rinsed with distilled water and left air dried to prevent any contamination of the samples (Khan et al., 2015).

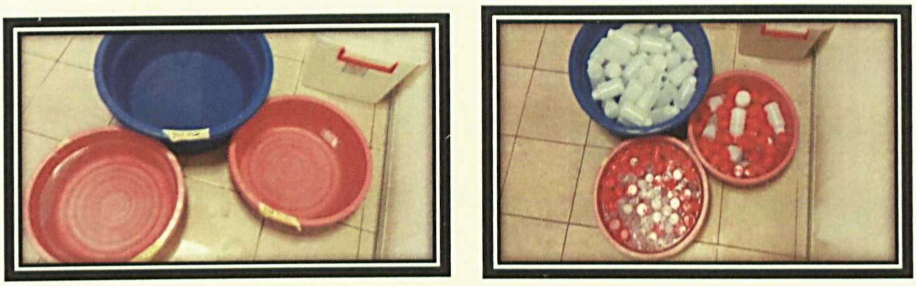


Figure 3.6 : Acid wash of HDPE Bottles

After collection of GFS water sample, 0.4 ml of nitric acid (HNO3) was added to preserve the water samples.

3.8.5 Analytical Data

Calibration Standard (CAL) was prepared using Instrument Calibration Standard 2. Five standard solutions were used to calibrate the instrument response with respect to analyte concentration. Calibration curve was plot using standard solution of 100 ppb, 50 ppb, 20 ppb, 10 ppb and 5.0 ppb with slope value, r^2 = 0.999524. Calibration curve was constructed by plotting the graph of the concentration of Al against intensity.

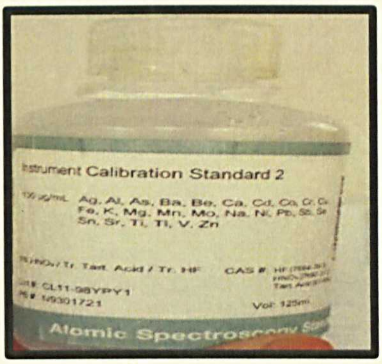


Figure 3.7 : Instrument Calibration Standard 2

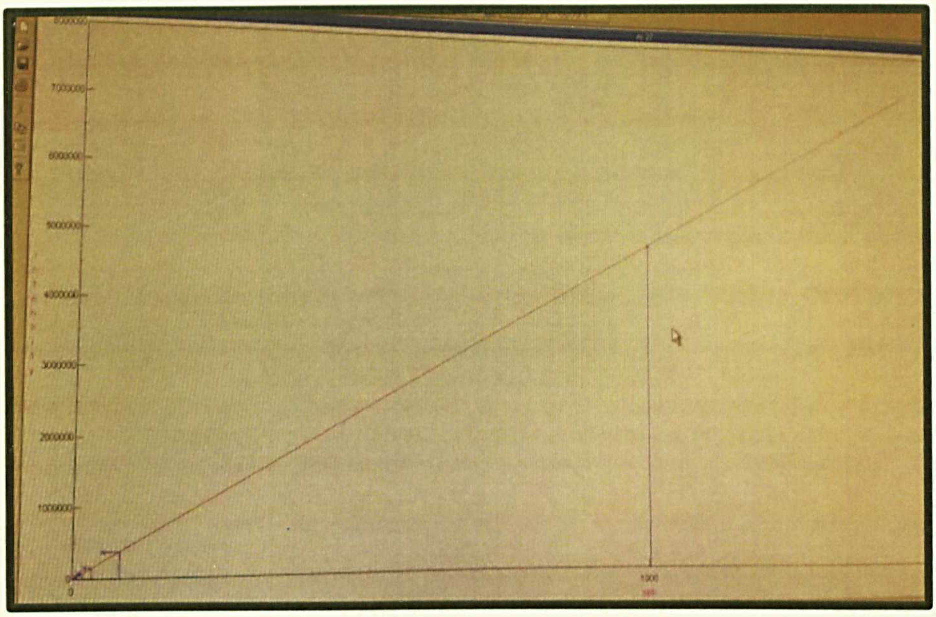
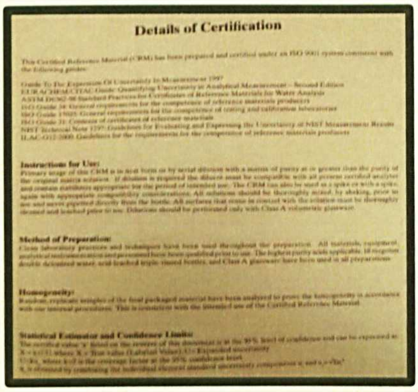


Figure 3.8 : Calibration Curve

For every analysis of ten sample of GFS water, method blank which was 20 ppb of Instrument Calibration Standard 2 as quality control solution were added. If the analytical result still showing 20 ppb,the analysis was proceed. But, if the reading showed other than that, ICPMS need to be calibrated again.

Besides that,smart tune solution was used to check optimization of machine. The optimization values should be considered to check whether the machine was in good condition by looking on value for Mg intensity, In intensity and U intensity. For Mg intensity value should be > 50000, In intensity > 200000 and U intensity > 250000.

To ensure accuracy and precision of method used, Instrument Calibration Standard 2 was analyzed and compare with Certified Reference Material (CRM).



Details of Certification

Instructions for Use:

Method of Preparation:

Homogeneity:

Statistical Estimator and Confidence Limits:

Figure 3.9 : Certified Reference Material (CRM)

3.9 Ethical Consideration

Approvals by Medical Researcher Ethics Committee, Faculty of Medicine and Health Sciences, University Putra Malaysia (UPM) and Jabatan Kemajuan Orang Asli (JAKOA) before project were obtained. Information sheet consent was given to all respondent before data collection commenced. Short briefing before interview session related to the research was carried out. Results obtained will be sending to JAKOA for further references. There were no biological samples taken from the respondents in this study.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Socio Demographic Data of Respondents

4.1.1 Gender

The study used purposive sampling method. Purposive sampling targets a particular group of people that can provide particular information to researcher base on inclusion and exclusion criteria until ninety-two respondents were achieved.

Variables	N = 92	Percentage (%)
Gender		
Male	37	40.2
Female	55	59.8

Table 4.1 : Gender of the respondents

4.1.2 Education Level

Most of Orang Asli Villagers (43.5%) never attend to school.

Variables	N = 92	Percentage (%)
Education Level		
Never went to school	40	43.5
Primary school	26	28.3
Secondary school	20	21.7
University	6	6.5

Table 4.2 :Education level of the respondents

Local communities were responsible for protecting their community's drinking water. By having education,communities were more understanding where the sources of drinking water and finding out about its quality, by sustaining the amount of water that they used such as using hand-held hoses for garden watering and learning ways to avoid water supply from becoming contaminated (United States Environmental Protection Agency, 2016) by checking the water supply periodically if there is source of contamination near to water supply such as usage of pesticide to plant the crops or condition such as cracked around water storage. In agricultural areas in Peninsular Malaysia, the water quality monitoring done by Ministry of Health Malaysia (M. R. Siti Farizwana et al., 2010).

Besides that, education was important since communities can choose their own water supply for their daily life activities from their basic knowledge. People with high education such as secondary school tend to avoid usage of GFS since the water was not safe enough as there was no chemical treatment such as chlorination to kill the pathogenic microorganism (Lenntech, 2016a) being put inside before received by consumer and no water filter provided. In this village, only 7 houses out of 149 houses received water supply from Puncak Niaga for their daily drinking purpose. For other purpose such as watering crops, washing cars, they tend to used GFS water supply. This is maybe due to high awareness on health effect that they may get after consuming untreated water which is GFS. According to Lim and Ahmad (2004), only one river water sample (16.7%) from upstream was polluted with Giardia cysts.

But,since majority of them never went to school, they thought that GFS water supply was safe enough for their daily purpose activities especially for drinking purpose. They just treat the water by boiling method before consumed it. They complained the weird taste of water that already being treated with chlorine and tend to have diarrheal after consumed the mineral water from available shop. Hence, they tend to bring and drunk only GFS water supply if they were going outside to work at the cities.

Benefits to health were not really important in the minds of Orang Asli villagers being provided with GFS water supplies as long as the water was made available closer to households need it (Cairncross & Valdmanis, 2006) and it was free of charge to received water from river.

4.1.3 Monthly Income (RM)

For monthly income,the mean was 2.924 with average of > RM 500.Majority of them, 45 people (48.9 %) were full time housewives, 32 people (34.8 %) were doing village work such as collect and selling fruits and vegetables from farm such as banana leaves and 'ulam-ulam' to middle man that will collect the yield every evening before sold it back to market at the city. There were 5 people (5.4 %) work as cleaner at school, 3 people (3.3 %) work as security and others worked as tehnician,fish farmers,cashier,mechanics and rubber tapper.

Since mostly of them have lower income range from RM 500-RM 900, they were unable to pay to Syarikat Bekalan Air Selangor (SAYABAS) if their house is supplied with treated water which is Puncak Niaga.

Variables	Mean± SD	Minimum	Maximum
Monthly Income (RM)	2.924±2.230	0	> 500

Table 4.3 : Monthly income for the usage of GFS

4.1.4 Age

The mean age of respondents was 1.435 with average age of 28-37 years old by picked them randomly.

Variables	Mean± SD	Minimum	Maximum
Age	1.435 ± 1.225	18	64

Table 4.4 : Age of respondents in Kg. Kuala Pangsun

Children who were exposed to high levels of Al will have identical symptoms like adults including neurological effects and skeletal effects (Agency for Toxic Substances and Disease Registry, 2011). According to Alzheimer's Association (2016), Alzheimer's was not a typical part of aging, but the main risk factor increasing age. Most of people with Alzheimer's were 65 and older. Hence, the limit of age for this study was from 18 to 64 years old.

4.1.5 Body Weight

For body weight of respondents, the mean was 57.169. The maximum and minimum body weight were 36.5 kg and 111.5 kg respectively.

Variables	Mean± SD	Minimum	Maximum
Body weight (kg)	57.169±13.294	36.500	111.500

Table 4.5 : Body weight of respondents

According to National Health and Nutrition Examination Survey, from years 1999 to 2004, females had greater mean percentage body fat than males at all ages. In males, mean percentage body fat ranged from 22.9% at age 16-19 years to 30.9% at age 60-79 years. While, mean percentage body fat in females ranged from 32.0% at age 8-11 years to 42.4% at age 60-79 years (Centers for Disease Control and Prevention, 2016). Chemicals and heavy metals composed our "total toxic burden". This bioaccumulation consist our physiological and psychological health and cause to chronic disease (High Tech Health International, 2011). The range amount of Al in the body of healthy individuals between 30-50 mg (Agency for Toxic Substances and Disease Registry, 2011).

4.2 : Information on tap water usage

4.2.1 Water Supply Received

Based on the questionaires distributed,all respondents, 92 people (100%) respond on having the same water source for their daily drinking purpose which was supplied from river through GFS from Sungai Lopo. Respondent that receive water supply from Puncak Niaga about 7 houses and other source were excluded from this study.

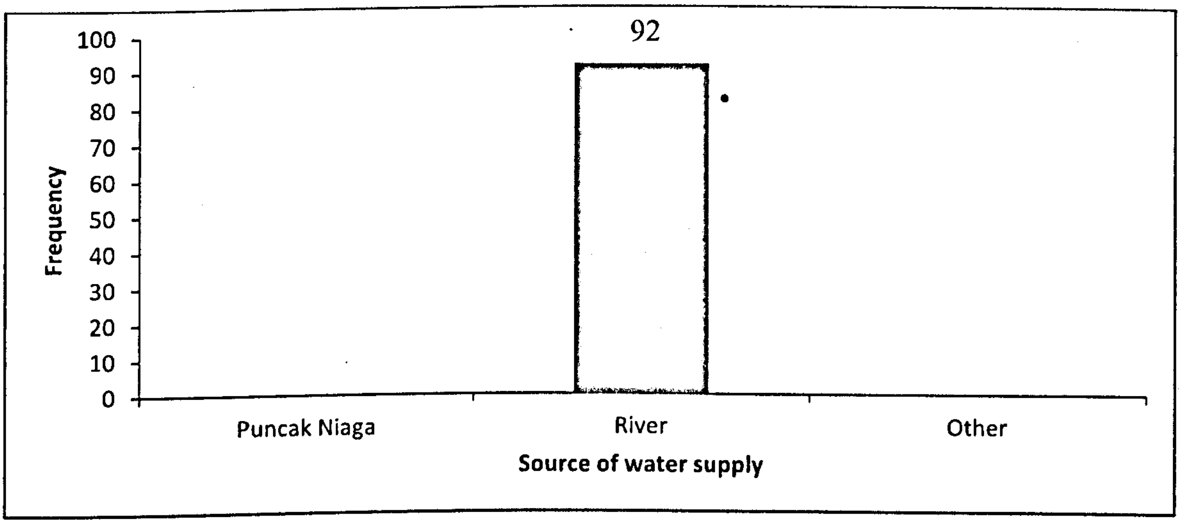


Figure 4.1 : Drinking Water Supply in Kg. Kuala Pangsun

4.2.2 : Satisfaction with quality of water supply

About 86 people (93.5%) satisfied with quality of gravity feed system (GFS) water supply,while 6 people (6.5%) not satisfied with quality of water supply especially during raining season. They complained that the water color was very cloudy and they feel fear to drink, but they have no choice.

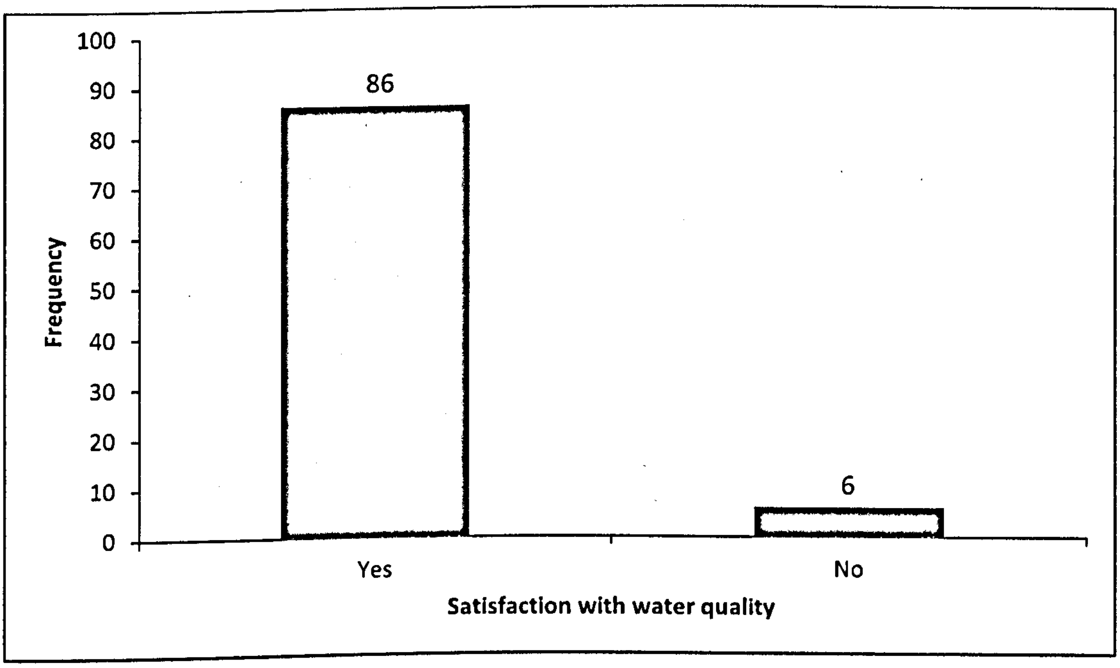


Figure 4.2 : Satisfaction with quality of water supply in Kg. Kuala Pangsun

4.2.3 : Usage of water filter system

All of the respondent,92 people (100 %) did not use water filter system in their house to treat the water. They just used boiling method for the drinking purpose. The respondents that use water filter were excluded from this study. According to Hunter Water (2011), usage of filtration and flocculation can result in decreasing of Al concentration in drinking water by applying the conventional water treatment practices.

Variable	Category	Frequency	Percentage, %
Usage of Water	Yes	0	0
Filter System	No	92	100

Table 4.6 : Usage of water filter system at house

Even using alum as a flocculant in a well operated water filtration plant, Al concentrations in the finished water can reached less than 0.1 mg/L (Hunter Water, 2011).

4.2.4 : Industrial area near to residential area

All of 92 people (100%) agree that there was no industrial area such as factory near to their residential area.

Variable	Category	Frequency	Percentage, %
Industrial area near to their residential area	Yes	0	0
	No	92	100

Table 4.7 : Industrial area near to residential area

Individuals who live near to residential area may be expose to greater amount of Al (Agency for Toxic Substances and Disease Registry, 2008b). Three major sources of pollution potent along the rivers which are industry such as smelting, that process crustal minerals (Agency for Toxic Substances and Disease Registry, 2008b), agriculture and domestic. Rivers serve transportation and have been available place to remove waste (Lenntech, 2016b).

4.2.5 : pH level and Al concentration in GFS water samples

The mean of pH was 7.070 whereas the minimum and maximum pH level were 3.6 (acidic) and 7.4 (alkali) respectively. Mean of Al concentrations in the forty six of GFS water samples analyzed was 0.079 mg/L with range from 0.02 mg/L to 0.23 mg/L.

Variables	Mean ±SD	Minimum	Maximum
pH level	7.070 ± 0.374	3.60	7.40
Al concentration (mg/L)	0.079 ± 0.055	0.02	0.23

N = 46

Table 4.8: pH level and Al concentration in GFS water samples

Most lakes and streams would have a pH level near 6.5 if pollution or acid rain do not exist (Stewart, 2008). While, Al concentration is normally below 0.1 mg/L (Agency for Toxic Substances and Disease Registry, 2008a).

Simple linear regression test was conducted to measure association between pH level and Al concentration in GFS water samples. The following null and alternative hypotheses were used, H0: There was no significant association between pH level and Al concentration in GFS water samples, H1: There was significant association between pH level and Al concentration in GFS water samples.

Variable	B (95 % CI)	P- value
pH level	-0.073 (- 0.112, - 0.034)	0.000

Table 4.9: Results from simple linear regression test between pH level and Al concentration (mg/L) in GFS water samples

Simple Linear Regression ($p < 0.01$)

N = 46

R^2 = 0.244.

Al concentration = 0.593 - 0.073 (pH)

From Table 4.8, it shows that there was a significant association between pH level and Al concentration in GFS water samples. By using simple linear regression, it indicated that only 24.4% of the variation Al concentration can be explained by pH. As pH level decreases, Al concentration increases by 24.4%.

Base on previous study done in Selangor by Nadia (2015), it was found that Al concentration in drinking water ranges from 0.028 mg/L to 0.949 mg/L with mean of 0.456 which was higher than the finding in this study. The mean Al concentration in drinking water from public water supplies in Galicia, Northwest Spain was 0.12 mg/L, which was similar to the mean from Kg. Kuala Pangsun (Rubinos et al., 2005). In addition, the mean Al concentration in this study was lower than the mean value reported in a study from the Moroccan city of Marrakech (0.21 mg/L) (Zaida et al., 2007).

Up to 70 % of Al concentration is depending on existence of other dissolved substances and not so much depending on temperature and the period of exposure of the water (Howells, 1994). Even pH level of GFS water sample decreases, but amount of organic matter in soil is low,hence, Al concentration in GFS water is low.

4.2.6 Comparison of Al concentration in Kg. Kuala Pangsun with NSDWQ

One Sample T-test was run to compare the mean difference of Al concentration in Kg. Kuala Pangsun with NSDWQ. The following null and alternative hypotheses were used; H0: There was no significant difference of Al concentration in Kg. Kuala Pangsun with NSDWQ, H1: There was significant difference of Al concentration in Kg. Kuala Pangsun with NSDWQ.

	Test Value = 0.2 mg/L					
	t	**Df**	**Sig. (2 tailed)**	**Mean Difference**	**95 % Confidence Interval of The Difference**	
					Lower	Upper
Al Concentration (mg/L)	9.700	45	0.000	0.079	0.063	0.096

Table 4.10: Results from One Sample t-test between Al concentration in Kg. Kuala Pangsun with NSDWQ

From Table 4.10, it was found that there was a significant Al concentration in GFS water sample similar with finding done by Dzulfakar et al. (2011) at Sungai Lembing, Pahang. This shows the quality of water received in terms of Al concentration in both study areas met the NSDWQ (0.2 mg/L).

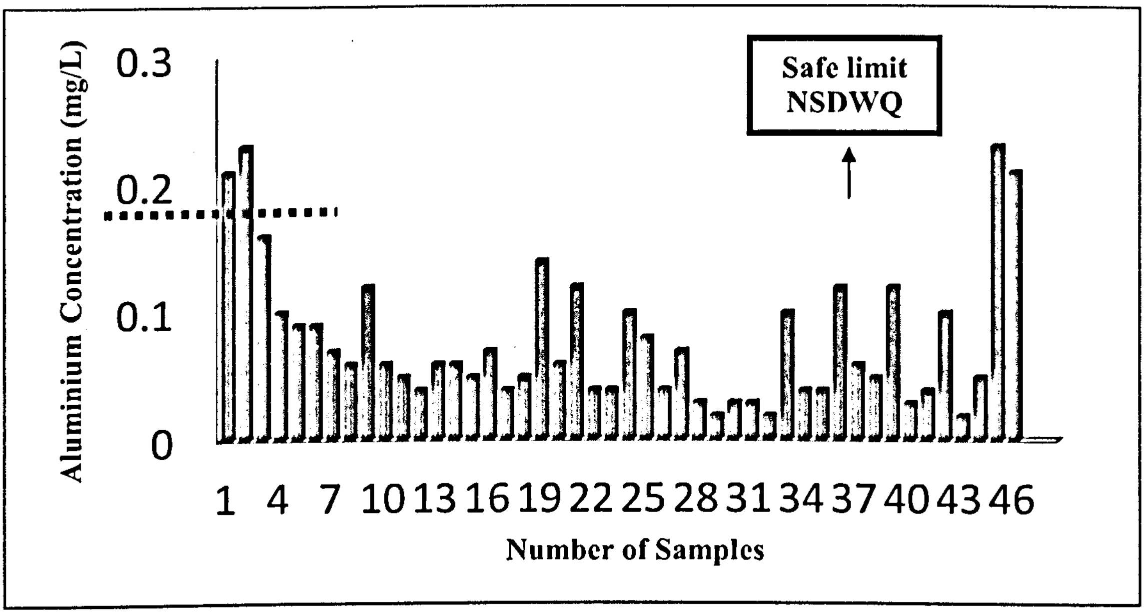


Figure 4.3 : Comparison of Al concentration with NSDWQ

There were only four of GFS samples (7.3%) out of forty six sample with Al concentration that exceeded NSDWQ which was 0.2 mg/L in Kg. Kuala Pangsun while in similar study done by Nadia (2015) in Selangor, there were 90 water samples (90%) violate the national standard.

Agriculture is the biggest consumer of freshwater on a global basis and as a main cause of deterioration of surface and groundwater resources through disintegration and chemical runoff can give a global impact on water quality (Natural Resources Management and Environment Department, 2016).

According to Pendek (2016), besides Orang Asli Villagers who were planting tropical fruit such as rambutan, durian, there was Indonesian people who were planting lemongrass near to storage tank of GFS. In sandier soils or areas that produce large agriculture product, soil acidification was common as there was readily nitrogen/ nitrate leaching (AS Miner Geotechnical, 2013).They also used pesticide to promote their plant growth.

Due to usage of pesticide, pH level of soil decreases, Al turn into soluble form,ion is releases and new material such as sodium, potassium and clays are made (Hays,1996). Al bound to the soil component, especially clay particles and organic matter. Hence, Al concentration in surface water increases (Department of Agriculture and Food, 2015).

4.2.7 Al concentration in GFS water samples and associated health effects

To determine health effects of Orang Asli Villagers in Kg. Kuala Pangsun after exposed to certain level of Al in GFS water, HQ value was used.

Variables	Mean ±SD	Minimum	Maximum
HQ Value	0.000 ± 0.00002	0.000005	0.0001

Table 4.11 : HQ value

The mean of HQ value was 0.000 with minimum and maximum HQ value was 0.000005 and 0.0001.

A Pearson's correlation test was conducted to measure association between Al concentration in GFS water samples and HQ value. The following null and alternative hypotheses were used, H0: There was no significant association between Al concentration in GFS water samples and health effects to Orang Asli Villagers, H1: There was significant association between Al concentration in GFS water samples and health effects to Orang Asli Villagers.

Variable	R	P-value*
Al Concentration (mg/L) –HQ Value	0.635	0.000

Table 4.12 : Results from the parametric Pearson's Correlation test between Al concentration with HQ value

Pearson's Correlation test ($p < 0.01$)

From Table 4.12, Pearson's correlation indicated moderate, positive association between Al concentrations in GFS water samples and health effects to Orang Asli Villagers in term of HQ value, ($r = 0.635$, $p < 0.01$). The p-value was 0.000, which was less than 0.01. Thus, the H0 was rejected. There was significant association between Al concentration in GFS water samples and related health effects of Orang Asli Villagers.

For the HQ in Batu Pahat was 0.00088 (Mukim Parit Lubok) and 0.00101 (Parit Raja) (Qaiyum et al., 2011), meanwhile in Kuala Terengganu was 0.0008. Another study conducted by Dzulfakar et al., (2011) in Kuantan, both HQ for Sungai Lembing and Bukit Ubi were 0.00053 and 0.00058, respectively. In this study, the HQ was 0.00002, which was slightly lower than the HQ of previous studies.

A study by Rondeau et al. (2000), high Al levels in drinking water (≥0.1 mg/l) were related with an increasing risk of dementia and Alzheimer disease (AD). The risk of Al exposure was demonstrated in several studies which found a relationship between Al concentration in drinking water and the cognitive function in Alzheimer's disease (Campbell et al., 2004).

4.3 : Health Information

For respondents' health status,all of respondents, 92 people (100%) were having good health and free from alcohol intake, medicine user, kidney problem and having an Alzheimer history disease. If respondents have one of this characteristic below, they were excluded from this study.

Variable	Category	Frequency	Percentage, %
Smoking	Yes	0	0
	No	92	100
Alcohol intake	Yes	0	0
	No	92	100
Medicine use	Yes	0	0
	No	92	100
Kidney problem	Yes	0	0
	No	92	100
Alzheimer history disease	Yes	0	0
	No	92	100

Table 4.13: Health Information of Orang Asli Villagers in Kg. Kuala Pangsun

In cigarettes, Al is highly concentrated with values ranging from 699 – 1200 mg/g (Bernhard, Rossmann, & Wick, 2005). Al foil was used for the inner liner of cigarette packets as it ability to keep the characteristic aroma distinctive to each blend and brand, within a unique quality of 'feel' and appearance which is light, powerful and easy to re-seal (European Aluminium Foil Association, 2016).

Beer cans was made from Al. Since these beverage was generally highly acidic, even one beer per day can caused Al toxicity in susceptible individuals in a chronic exposure (Analytical Research ,2012).

People that consume Al-containing medicinal preparation such as antacids and buffered aspirin expose to high intake of Al compared to people that expose to Al through food and drinking water. For example, 104-208 mg of Al per tablet/capsule/5 mL dose for frequent antacids compare to daily intakes of Al from food range from 3.4 to 9 mg/day (Agency for Toxic Substances and Disease Registry, 2008b). Some individuals might experience skeletal effects (e.g., osteomalacia) from long-term use (Agency for Toxic Substances and Disease Registry, 2011).

Al toxicity was a systemic disorder in hemodialysis patients and sometimes in nondialysis patients who have severe chronic kidney disease (CKD). It was mainly due to exposure to Al in dialysis fluid and from the ingestion of Al-containing phosphate binders among patients who cannot excrete it. It was now become rare as Al was now eliminated from water used for dialysis and because non Al-containing phosphate binders were generally convenient (Qunibi & Henrich, 2016).

According to Flaten (2001), nine out of 13 published epidemiological studies of Al in drinking water and AD have shown statistically significant positive relations. Occupational exposure to Al dust suggests a prominent part for the olfactory system and lungs in the accumulation of Al in the brain (Exley & Vickers, 2014).

4.4 : Health Risk Assessment (HRA)

ADD was calculated using the following equation (Oosthuizen, 2014):

ADD = (C x IR x EF x ED) / (BW x AT)

ADD = (0.07 mg/L x 0.9 L/ Day x 7 Days/ Year x 24 Years) / (58.5 kg x 8577.5 Days / Year)

= 2x 10^{-5} mg/kg-day

ADD of respondent was 0.00002 mg/kg-day.

HQ was calculated using the equation as below (United States Environmental Protection Agency, 2005):

HQ = ADD / MRL

Where MRL = minimal risk level (mg/kg-day).

MRL for aluminium was 1 mg Al/kg/day.

HQ = (0.000034mg/kg-day) / (1 mg/kg-day)

= 0.000034

HQ for all respondents was 0.000034 which was less than 1.

This study found that the HQ ranged from 0.000005 to 0.0001. The respondents' HQ was less than 1 due to low ADD values. If the HQ was more than 1 it shows a risk of Al exposure to the respondents and if less than 1, it means respondents were not succeptible to a risk of Al exposure.

However, even though the HQ shows an tolerable level of risk but exposure to Al in several studies was associated to several diseases. According to reports by Exley & Esiri (2006) has found that result of very high Al concentration in affected brain region cause a 58-year-old woman with a rapidly dynamic, fatal dementing illness shows sudden b-amyloid deposition of cerebral cortical and leptomeningeal blood vessels, moderate numbers of neurofibrillary tangles and Lewy bodies during autopsy. Besides that, there are several variables that need to be considered, which can affect the HQ value such as the respondents ADD including Al concentration in water, average daily intake of water and body weight. These variables were used to calculate the respondent's ADD, which have the possibility to affect the HQ as different respondents have different value of variables. When comparing ADD of Al intake with Reference Dose (RfD) which is 1 mg/kg/day, ADD for Al intake were far lower than RfD.

In this study, the ADD value was 0.00002 mg/kg-day mg/kg/day. A previous study from Novodvinsk, Northwest Russia found the HQ for adults to be 0.009 (Unguryanu, 2009) while the previous study conducted in two villages in Kuala Terengganu by Aminah (2012) was 0.0057 mg/kg/day. Other study conducted by Qaiyum et al., (2011) in Batu Pahat, the ADD mean value was 0.00619 mg/kg/day which almost the same with the CDI in Kuala Terengganu. This was clearly because the Al concentration in this study was far lower than the previous studies. The lower the Al concentration, the lower the ADD.

CHAPTER 5

CONCLUSION

From the result, it showed that all hypothesis were accepted. The first hypothesis was accepted as there was a negative association between pH level and Al concentration. As pH of soil drop, Al concentration in surface water increases. It was summarized that pH only contribute 24.4% of Al solubility in GFS water. The second hypothesis was also accepted because there was significant different between Al concentration in GFS water sample with National Standard for Drinking Water Quality (NSDWQ). The last hypothesis was accepted as there was no respondent with HQ value more than 1. The water supply received by the respondents is safe to be consumed as the health risk from Al is negligible.

RECOMMENDATIONS FOR

FUTURE RESEARCH

For further research, it is recommended to conduct further assessment of drinking water samples from water source, Sg. Lopo to determine the level of contaminants that contributed to the Al concentration. By doing this, researcher can know the exact reason of increase Al concentration in finished water.

This study only focus on ingestion of Al in drinking water and did not consider the exposure from other sources such as food and medical products, environment and occupational factors. Other than that, there were no biological samples such as urine and blood taken to determine the actual level of Al in the body. This study can be improved by considering the other factors and taking biological samples.

Even though the HQ calculation showed that all respondents had HQ below 1, the analysis showed that four concentration of Al in GFS water samples measured violate the national standard. Thus, remedial actions must be taken to ensure that the Al level is below the set standard. Regular monitoring in water source must be conducted by the authorities to assure community always consume safe water, where do not affect health.

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APPENDICES

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b) Date of approval: 5/1/2016

Endorsed at JKEUPM Meeting on 27/1/2016, attended by:

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Assoc Prof Dr Muhammad 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	
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Tan Sri Dato' Napsiah Omar (Independent Member)	Chairman, Women's Institue of Management	Female	√
En John Posko Anthony (Lay Person)	Headmaster of Sekolah Jenis Kebangsaan (Tamil) Kajang	Male	√

Appendix 1.3 : Conscent Form

JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

BORANG B2: PENERANGAN DAN PERSETUJUAN IBUBAPA/PENJAGA

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

1.TAJUK KAJIAN

Health Risk Assessment On Aluminium (Al) In Gravity Feed System Water Used By Orang Asli Villagers In Kampung Kuala Pangsun,Selangor.

2. PENGENALAN

Kajian ini dijalankan bagi menentukan penilaian risiko kesihatan ke atas jumlah aluminium (Al) dalam sistem graviti feed (GFS) air yang digunakan oleh Orang Asli di Kampung Kuala Pangsun, Selangor. Hal ini kerana hanya sistem GFS sahaja yang digunakan sebagai bekalan air mereka dalam kegunaan kehidupan seharian. GFS menggunakan kuasa graviti untuk mengalirkan air ke rumah-rumah responden.Takungan air bagi GFS biasa diambil dari sungai,mata air dan air yang mengalir.Satu paip yang panjang dari kawasan takungan air disalurkan terus ke penduduk tanpa ada sistem penapisan yang baik.Hanya daun-daun kering dan akar kayu sahaja yang ditapis dari sumber air.Sedangkan aluminium yang terlalu banyak dijumpai dan tidak larut dalam air pada keadaan biasa tidak dapat dibuang.Ini disebabkan oleh sifat GFS sendiri yang terhad dalam merawat air yang tercemar dengan minyak, bahan kimia seperti Al, Fe, Si, Ca, K, Mg, Na dan P, logam berat, garam atau asid kuat atau asas. Langkah-langkah tambahan diperlukan untuk merawat masalah-masalah seperti pertukaran kation mudah alih, penyulingan dan osmosis songsang. Jika tidak, keadaan akan menjadi lebih teruk terutama apabila hujan asid turun dan akan menyebabkan aluminium menjadi larut dalam air. Selain itu, proses semula jadi juga menyebabkan aluminium masuk ke dalam air permukaan bersama sisa air iaitu dari tumbuh-tumbuhan yang menghasilkan aluminium dan garam atau menggunakan ia dalam pengeluaran mereka (Mazur, et al., 2001). Air tanah yang berasid akan bertindak balas dengan batuan mineral lalu melepaskan ion dan membentuk mineral baru seperti natrium, kalium dan kalsium aluminium silikat atau tanah liat. Tetapi tanah liat adalah yang paling biasa dijumpai dalam air semulajadi.

Menurut Rondeau, pendedahan manusia kepada aluminium melalui pendedahan oral (>0.1 mg/l) adalah faktor risiko penyakit Alzheimer (AD) dan demensia. Setakat ini,tiada lagi kajian khusus telah dilakukan untuk mengukur tahap kesihatan Orang Asli yang menggunakan GFS.Jadi, untuk menganggarkan sama ada pendedahan semasa kepada jumlah aluminium (Al) akan menimbulkan risiko kesihatan kepada masyarakat yang dikaji, penilaian risiko kesihatan (HRA) digunakan. Data yang akan terhasil daripada kajian ini boleh dijadikan sebagai bukti untuk pengurusan awam dalam meningkatkan kualiti bekalan air GFS. Ia juga membantu pembuat dasar dalam membangunkan dasar untuk 100 peratus bekalan air bersih di kawasan luar bandar sebagai air minuman yang selamat adalah satu keperluan penting untuk kesejahteraan manusia, kesihatan, pembangunan dan keperluan.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Ibu bapa atau penjaga perlu mengisi borang soal selidik yang mengandungi empat (4) bahagian iaitu Bahagian A tentang maklumat responden, Bahagian B tentang maklumat penggunaan air paip, Bahagian C tentang maklumat persekitaran tempat tinggal dan Bahagian D tentang maklumat kesihatan. Seterusnya, ibu bapa atau penjaga perlu memberi keizinan untuk mengambil berat badan peserta supaya dapat mengira *Average Daily Dose* (ADD) dan akhirnya risiko kesihatan yang bakal dihidapi oleh peserta dalam jangka masa panjang dapat diketahui daripada pengiraan nilai HQ.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Peserta yang menggunakan air paip dan penapis air di rumah,merokok and mengambil minuman alkohol serta mempunyai sejarah penyakit Alzheimer tidak boleh menyertai kajian ini.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANAK/JAGAAN SAYA SEBAGAI PESERTA?

Peserta mendapat pengetahuan baru tentang kesan apabila terdedah kepada aluminium terkumpul dalam Gravity Feed System (GFS) bagi jangka masa panjang,seterusnya mengambil langkah pencegahan bagi mengurangkan risiko kesihatan yang bakal dihidapi.

b) KEPADA PENYELIDIK?

Sebagai salah satu syarat untuk bergraduat,penyelidik perlu menjalankan penyelidikan tahun akhir kursus EOH4999A&B (Projek Ilmiah Tahun Akhir).

6. ADAKAH IA BERISIKO?

Ia tidak akan memberi sebarang risiko kepada psikologikal peserta seperti peserta akan berasa malu,tertekan atau sedih, kecederaan kepada fizikal dan sosial peserta seperti hilang status,privasi atau reputasi.

7. ADAKAH MAKLUMAT DAN IDENTITI ANAK/JAGAAN SAYA KEKAL RAHSIA?

Ya.Maklumat dan identiti peserta kekal rahsia.Ia hanya digunakan untuk kegunaan penyelidikan sahaja.

8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEPANJANG PENYELIDIKAN INI?

Saya akan menghubungi Tok Batin sekiranya saya mempunyai soalan tambahan semasa mengikuti penyelidikan ini.

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

9. PERSETUJUAN

Saya .... No Kad Pengenalan. ....beralamat.. ....dengan ini secara sukarela bersetuju membenarkan *anak/jagaan saya .... menyertai **penyelidikan tersebut di atas *(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 yang tercatat dalam Helaian Penerangan). Saya memahami bahawa *anak/jagaan saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti *anak/jagaan saya akan dirahsiakan.

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

Saya setuju/tidak bersetuju untuk imej/gambar/rakaman video/ rakaman suara berkaitan dengan anak/ jagaan saya digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan ....Tandatangan
....(*Ibubapa/ Penjaga*) ....
(*Saksi*)

Tarikh :..................   Nama :...

No. K/P: ....

Saya mengesahkan bahawa saya telah menerangkan kepada ibubapa/penjaga responden mengenai sifat dan tujuan penyelidikan tersebut di atas.

Tarikh ....Tandatangan ....
(*Penyelidik*)

Appendix 1.4: Questionnaire

Semua maklumat adalah untuk kegunaan kajian sahaja dan maklumat ini akan dianggap sulit.

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

Bahagian A: Maklumat responden

1. Umur : ☐ tahun
2. Jantina : ☐ Lelaki ☐ Perempuan
3. Pendapatan sebulan : > RM 500 ( )
   RM 400 – RM 499 ( )
   RM 300 – RM 399 ( )
   RM 200 – RM 299 ( )
   RM 100 – RM 199 ( )
4. Taraf pendidikan :
   ☐ Tidak bersekolah
   ☐ Sekolah rendah
   ☐ Sekolah menengah
   ☐ Universiti
   ☐ Lain-lain
5. Berat : ....kg

Bahagian B: Maklumatpenggunaan air paip

1. Apakah punca air paip di rumah?
   ☐ Puncak Niaga
   ☐ Sungai
   ☐ Lain-lain, sila nyatakan ....

2. Berapa gelas air yang anda minum setiap hari?

....

3. Berapa kerap anda minum air dari rumah?Adakah setiap hari?

☐ Ya ☐ Tidak

Jika tidak,berapa kerap anda minum dalam seminggu?

----

4. Penggunaan air dari dapur:

☐ Memasak

☐ Minum

☐ Kegunaan domestik

☐ Lain-lain, sila nyatakan ....

5. Adakah anda berpuas hati dengan kualiti air paip yang digunakan?

☐ Ya ☐ Tidak

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

☐ Ya ☐ Tidak

Bahagian C: Maklumat persekitaran tempat tinggal

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

☐ Ya ☐ Tidak

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 mengambil ubat-ubatan?

☐ Ya ☐ Tidak

12. Adakah anda menghidap penyakit kegagalan buah pinggang?

☐ Ya ☐ Tidak

13. Adakah keluarga anda mempunyai sejarah penyakit Alzheimer?

☐ Ya ☐ Tidak

TERIMA KASIH ATAS KERJASAMA ANDA

-TAMAT-