



UNIVERSITI PUTRA MALAYSIA

***TOTAL ALUMINIUM (AL) IN GRAVITY FEED SYSTEM (GFS) WATER
AND HEALTH RISK ASSESSMENT AMONG THE ORANG ASLI FROM
KAMPUNG SUNGAI LALANG BARU, HULU LANGAT, SELANGOR***

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ABSTRACT

TOTAL ALUMINIUM (AL) IN GRAVITY FEED SYSTEM (GFS) WATER AND HEALTH RISK ASSESSMENT AMONG THE ORANG ASLI FROM KAMPUNG SUNGAI LALANG BARU, HULU LANGAT, SELANGOR

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Introduction: Gravity Feed Water System (GFS) in Malaysia is one of the water supply from a small upland river, impounded within a protected catchment and it is an example of a sustainable water supply technology requiring no treatment for rural area. Aluminium (Al) may present in the GFS water since aluminium can naturally present and released in rocks and soil. As consequence, those consumers whom consuming drinking water high in aluminium content tend to have risks of developing neurodegenerative diseases especially Alzheimer's Disease. **Objectives:** The aims of this study were to determine and compare the aluminium concentration and pH level in GFS water samples with National Standard for Drinking Water Quality (NSDWQ). Besides that, this study also aimed to determine the health risk assessment related to aluminium in drinking water among respondents. **Methodology:** A cross-sectional study was performed at Kampung Sungai Lalang Baru, Hulu Langat among 102 respondents. The data collection was conducted by using a set of questionnaire and collected water samples from each of respondent's houses by using 250ml HDPE bottle. Then, the samples was analyzed by using Inductively Coupled Plasma Mass Spectrometry to measure aluminium concentration. The pH of water sample also was measured using pH meter. **Results:** There was significant inverse correlation relationship between aluminium concentration with water pH level ($r = -0.268$, $p = 0.007$). A significant difference was found when aluminium concentration were lower than acceptable limit according to NSDWQ (0.2 mg/L) when $p < 0.01$. The minimum and maximum of aluminium concentration were 0.1 mg/L and 0.15 mg/L respectively. Lastly, there was no health risk of aluminium exposure among respondents when the Hazard Index (HI) was less than 1 ($HI < 1$). **Conclusion:** This study found mean aluminium 0.07mg/L below the acceptable limit according to NSDWQ (0.2mg/L). The calculated Hazard Index that did not exceed 1. Thus, the respondents at study area are considered safe from having chronic health risk related to the aluminium exposure towards nervous system (Alzheimer's Disease) during the period of study conduct.

Keywords: Aluminium, Orang Asli, GFS, water pH level, drinking water, National Standard for Drinking Water Quality, Hazard Index, Alzheimer's Disease.

ABSTRAK

JUMLAH ALUMINIUM (AL) DALAM AIR “GRAVITY FEED SYSTEM” (GFS) DAN PENILAIAN RISIKO KESIHATAN ANTARA ORANG ASLI DARI KAMPUNG SUNGAI LALANG BARU, HULU LANGAT , SELANGOR

NORASLIZA BINTI NGADINA

Pengenalan: “Gravity Feed Water System” (GFS) di Malaysia adalah salah satu bekalan air dari sungai tanah tinggi kecil, ditahan dalam dilindungi tadahan dan ianya adalah satu contoh teknologi bekalan air yang mampan tidak memerlukan rawatan di kawasan luar kampung. Terdapat risiko aluminium (Al) yang akan terkandung dalam air minuman GFS hasil daripada proses semula jadi hujan asid dan ia juga terdapat secara semulajadi di dalam batu-batu dan tanah air bawah tanah. Oleh itu, bagi para pengguna yang menggunakan air dengan kuantiti aluminium yang tinggi didalam air minum cenderung mempunyai risiko penyakit “neurodegenerative”. **Objektif:** Tujuan kajian ini adalah untuk menentukan dan membandingkan kepekatan aluminium dan tahap pH dalam sampel air GFS dengan “National Standard for Drinking Water Quality”(NSDWQ). Kajian ini juga dijalankan untuk menentukan penilaian risiko kesihatan yang berkaitan dengan aluminium dalam air minuman di kalangan Orang Asli di Kampung Sungai Lalang Baru. **Metodologi:** Satu kajian keratan rentas telah dijalankan di Kampung Sungai Lalang Baru, Hulu Langat , Selangor dengan 102 responden. Pengumpulan data dengan menggunakan soal selidik bagi setiap responden telah dilakukan untuk mengumpul maklumat mereka. Sampel air sumber air dari setiap rumah responden telah dikumpulkan dengan menggunakan botol HDPE 250ml dan dianalisis dengan menggunakan “Inductively Coupled Plasma Mass Spectrometry” untuk mengukur kepekatan Al. The pH sampel air juga diukur dengan menggunakan meter pH. **Keputusan:** Terdapat hubungan korelasi yang signifikan antara kepekatan aluminium dengan tahap pH air apabila terdapat kuat negatif persatuan dengan ($r = -0,268$, $p = 0.007$). Selain itu, terdapat perbezaan yang signifikan apabila kepekatan aluminium adalah lebih rendah daripada had yang boleh diterima dalam NSDWQ (0.2 mg / L) apabila $p < 0.01$ dengan nilai minima 0.1mg/L dan maksima 0.15mg/L. Akhir sekali, tidak ada risiko kesihatan pendedahan aluminium kalangan responden apabila semua HI adalah kurang daripada 1 ($HI < 1$). **Kesimpulan:** Kajian ini mendapati bahawa purata aluminium adalah 0.07mg / L, yang masih di tahap selamat dan di bawah had yang boleh diterima dalam NSDWQ (0.2mg / L). Selain itu , Indeks Hazard yang dikira daripada penemuan tidak melebihi 1. Oleh itu , ia telah menunjukkan responden di kawasan kajian telah dianggap selamat daripada mempunyai risiko kesihatan kronik yang berkaitan dengan pendedahan aluminium ke arah sistem saraf dalam jangka masa kajian dijalankan.

Kata kunci: Aluminium, Orang Asli, GFS , tahap pH air , air minuman, “National Standard for Drinking Water Quality”, Indeks Hazard, Penyakit Alzheimer.

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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	Gravite Feed System
HI	Hazard Index
HRA	Health Risk Assessment
mg/L	Miligram 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 Study Background

Generally, safe drinking water is an essential need for human wellbeing health, development and necessity, and therefore, it is internationally recognized as fundamental human rights (WHO, 2003). In addition, water is a major importance to all living things, in some organism, up to 90% of their body weight comes from water and up to 60% of the human body consist of water (USGS, 2011). In Malaysia, drinking water is managed on a state by state basis to cater different demand in supply either by public or private water supply.

According to Engineering Services Division (ESD) of Ministry of Health (MOH), public water supply is systematically treated by the government or legislative authorities (EDWQP, 2004) .Meanwhile, private water supply is defined as water supply which is not provided by the legislative authority and the maintenance relies on the owner of the area, typically in rural areas (MOH, 2003).

By focusing on the rural water supply projects in Malaysia that constructed under the Environmental Cleanliness Program, examples of systems that are suitable and implemented in the rural areas are including 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. However, Gravity Feed Piped Water supply system is being used the most (MOH, 1984). The usage of the Gravity Feed Piped Water supply System also called as Gravity Feed System (GFS) in Malaysia is one of the water supply from a small upland river, stream or spring, impounded within a protected catchment, is an example of a sustainable water supply technology requiring no treatment (WaterAid technology, 2013).

Due to the river source itself, it may contaminated caused by surrounding activities such as industrial metal mining (Huang et al., 2010). A study in Tibetan Plateau, the researcher found high level of Mg, Al, Fe and Pb in four major Asian rivers contributed by the mining and agricultural activities, domestic sewage, traffic density (Huang et al., 2008) as well as the climate change factor (Huang et al., 2009).

Therefore, water from GFS has a potential of contamination and exposed to microbes (Bobeldijk et al., 2001), heavy metals (Hu, 2000), pesticides and pathogens which could lead to water-borne disease outbreaks and ill health (Swistock and Sharpe, 2005). In addition, 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).

One of the heavy metal contaminants of great concern is aluminium (Al). Aluminium is a naturally occurring element that appears in the second row of Group 13 (IIIA) the periodic table (O'Neil et al., 2001). Aluminium is the most abundant metal and the third most abundant element in the earth's crust, comprising about 8.8% by weight (88 g/kg). It is rarely found free in nature and is found in most rocks, weathering igneous rocks, which contain aluminium as alumina-silicate (Staley and Haupin, 1992), soil and natural component in surface and ground water (Hydro, 2012).

Besides that, the presence of aluminium can be observed in the water source of GFS by several factors that may influence aluminium mobility and subsequent transport within the environment. The factors are including chemical speciation, hydrological flow paths, soil-water interactions and the composition of the underlying geological materials. In addition, acid environment that caused by acid mine drainage or acid rain also can increase the dissolved aluminium content of the surrounding waters (ATSDR, 1992; WHO, 1997).

The ecological effects of acid rain are most clearly seen in the aquatic, or water, environments, such as streams, lakes, and marshes. Acid rain flows into streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Most of lakes and streams have a pH between 6 and 8, although some lakes are naturally acidic even without the effects of acid rain. Acid rain primarily affects sensitive bodies of water, which are located in watersheds whose soils have a limited ability to neutralize acidic compounds (called "buffering capacity"). Lakes and streams become acidic when the pH value goes down and its surrounding soil cannot buffer the acid rain enough to neutralize it. In areas where buffering capacity is low, acid rain releases aluminum from soils into lakes and streams; aluminum is highly toxic to many species of aquatic organisms and other users (USEPA, 2012).

Health risks associated with exposure in drinking water containing aluminium can be distinguished into two terms which are acute and chronic toxicity. 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, 1997). According to Malaysia Drinking Water Quality 2010, the permissible level of aluminium in water must not exceed 0.2 mg/L (MOH, 2010). Exceeding level of the intake of aluminium in a long time can lead to chronic toxicity and associated with severe diseases of the nervous system such as Alzheimer's disease, Parkinson's dementia and also Amyotrophic Lateral Sclerosis (ALS) disease (ATSDR, 2008).

Alzheimer's disease is a neurodegenerative disorder, which is manifested clinically as a progressive deterioration of memory and cognition (ATSDR, 2008). The health risk assessment is used to estimate whether current exposure will pose health risks to community studied by calculating the hazard index (Shaharuddin et al., 2009; EPA, 2001) when there were eighteen drinking water studies that have linked aluminium level to elevated risks AD and elderly cognitive impairment (Janson et al., 2005). It was hypothesized that aluminium exposure is a risk factor for the development or acceleration of onset Alzheimer's Disease in humans (WHO, 2001).

1.2 Problem Statement

People might be exposed to aluminium via drinking water with areas naturally high in aluminium level (ATSDR, 1999). The chronic toxicity of aluminium might affect health according to the determination of the dose (how much), the duration (how long) and the route of exposure (ATSDR, 2011). Aluminium that naturally present in surface water and groundwater (Hydro, 2012) may also present in water supply by using GFS. The high aluminium concentration in drinking water may cause the chronic nervous system disease if ingested (WHO, 2001).

In addition, human exposure to high aluminium level by oral exposure effects a large number of health outcomes as reported by a number of studies in various countries (Nieboer et al., 1995). A study by Azlina (2011), reported an increasing number of Alzheimer's Disease (AD) in Malaysia that may be as a consequence of consuming high aluminium in the drinking water for a long period of time. Besides that, Alzheimer's Disease Foundation of Malaysia has stated 50,000 of Alzheimer's Disease cases was recorded in our country in 2009 and it became rise (ADFM, 2009).

Moreover, there is lack of previous studies on aluminium level in naturally water supply by using Gravity Feed System (GFS) in Malaysia even though this system has been practiced in this country for more than a decade (Sulaiman et al., 2005). Furthermore, very limited studies reported on aluminium exposure among the consumer of untreated water (GFS) among rural population in Malaysia and realizing the facts that excessive aluminium content is detrimental to health (Siti Farizwana et al., 2010).

1.3 Study Justification

This study was strengthened with a reported case of British women had died with Alzheimer's Disease after 16 years drink the water that contaminated with aluminium in Nature News (Michael Hopkin, 2006). This case was clearly shows there is relationship of high risk of AD with high level of aluminium in drinking water that may be caused by the chemical used at the treatment water plant. Therefore, this research aims to examine the level of aluminium in the untreated water from GFS.

This study were conducted at the Kampung Orang Asli Sungai Lalang Baru, Hulu Langat, Selangor which is included Orang Asli as main respondents. By refer to previous study, Orang Asli is classified as the vulnerable group and high in poverty. They are also categorized as a group which has low immunization and lower education level (Masron et al., 2014). Therefore, this study may help this population to let them have the information regarding to the safety of their drinking water and also to give them early prevention to avoid the Alzheimer's Disease happens among them.

Besides that, this study also was carried out to determine the exposure of Orang Asli in this area towards the aluminium from the water sources through the oral ingestion. Information from Jabatan Kemajuan Orang Asli (JAKOA) Malaysia was used by focusing areas with GFS as their main water supply. Therefore, the Orang Asli villagers have the potential risk of health effect of aluminium exposure when the aluminium may present naturally in rocks and soils (ATSDR, 2008) in which also can present in the river .

In Kampung Sungai Lalang Baru, all the villagers are using GFS as main source of water supply. Therefore, aluminium in the water supply by GFS may exist due to its natural characteristic which may be present in the upland source of water. Therefore, by obtaining quantitative data on the aluminium concentration which to calculate the Hazard Index was essential for further plan to overcome the adverse health effect if any aluminium exposure among villagers.

1.4 Research Objective

1.4.1 General Objective

To determine the Aluminium in Gravity Feed System (GFS) water and health risk assessment among Orang Asli at Kampung Sungai Lalang Baru, Hulu Langat, Selangor.

1.4.2 Specific Objectives

- To determine socio – demographic information of the residents in Kampung Sungai Lalang Baru, Hulu Langat, Selangor.
- To determine aluminium concentration and pH level in GFS water sample.
- To compare aluminium level in GFS water with National Standard Drinking Water Quality (NSDWQ).
- To determine significant relationship between aluminum concentration and pH level of GFS water sample.
- To calculate Chronic Daily Intake (CDI) of aluminium exposure among respondents.
- To determine Hazard Index (HI) with health risk exposure of Al in GFS water among respondents.

1.5 Research Hypothesis

- There is a significant relationship between aluminium level with pH level of GFS water samples as drinking water sources in Kampung Sungai Lalang Baru, Hulu Langat.
- There is a significant difference between aluminium level in GFS water with National Standard Drinking Water Quality (NSDWQ).
- There is no health risk of Aluminium exposure among respondents when the Hazard Index of the respondents is less than 1 ($HI < 1$).

1.6 Conceptual Framework

Source : ATSDR, 2008 ; Othman, 2011

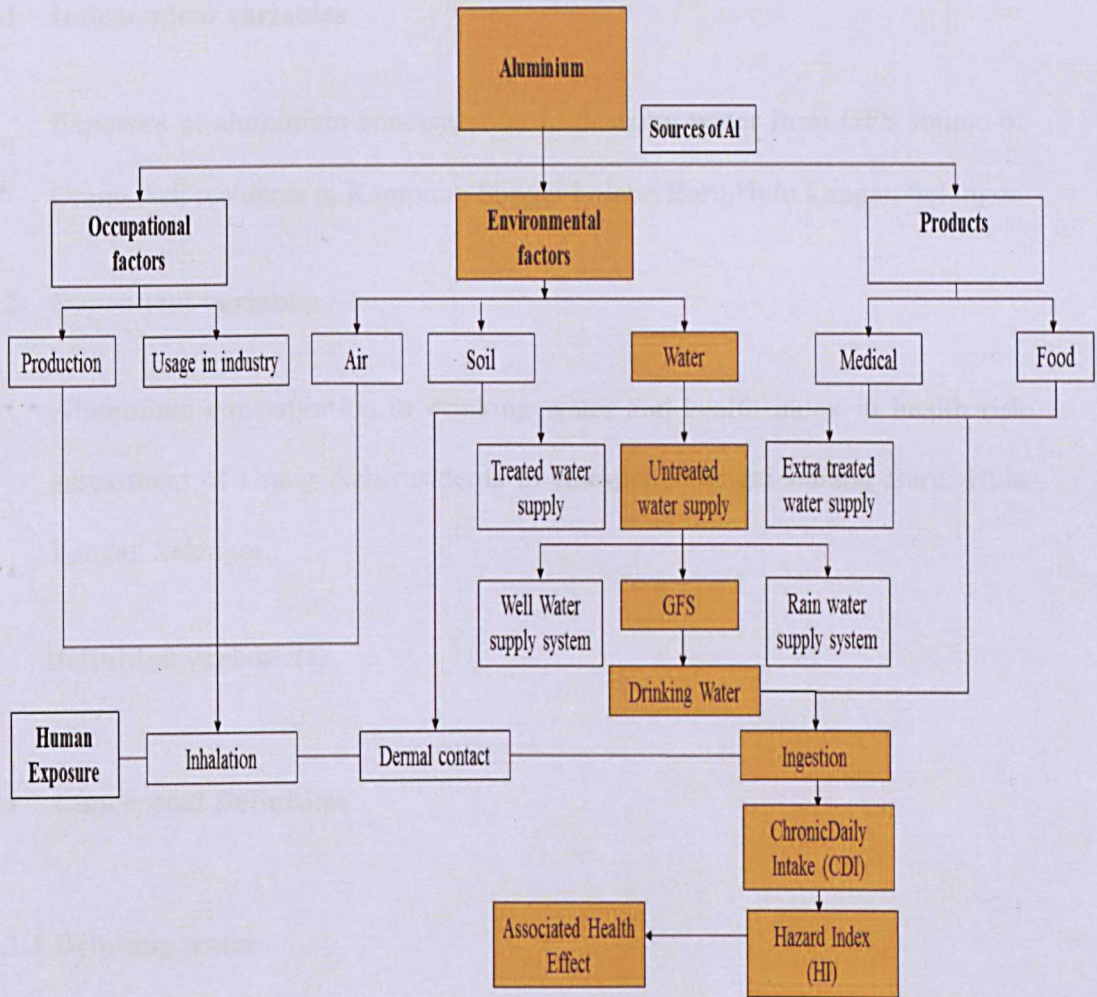


Figure 1.1: Conceptual framework

1.7 Study Variables

Below are variables that was measured in this study

1.7.1 Independent variables

Exposure of aluminium concentration in drinking water from GFS source of Orang Asli residents in Kampung Sungai Lalang Baru, Hulu Langat, Selangor.

1.7.2 Dependent variables

Aluminium concentration in drinking water and health index in health risk assessment of Orang Asli residents in Kampung Sungai Lalang Baru, Hulu Langat, Selangor.

1.8 Definition variable(s)

1.8.1 Conceptual Definition

1.8.1.1 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, 2004).

Safe drinking-water, as defined by the Guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages (WHO, 2003).

1.8.1.2 Aluminium concentration in water and soil

The maximum concentration of aluminium in natural waters (e.g., ponds, lakes, streams) that allowed by Agency for Toxic Substances and Disease Registry (ATSDR, 2008) is generally below 0.1 milligrams per liter (mg/L).

For the aluminium in drinking water, water is sometimes treated with aluminium salts while processed to become drinking water. But, even then, aluminium levels generally do not exceed 0.2 mg/L (ATSDR, 2008).

1.8.1.3 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.

1.5.1.4 Chronic Daily Intake (CDI)

Estimation of health association with specific toxicant and the calculation of daily exposure for ingestion route (OEHHA, 2001).

1.5.1.5 Hazard index (HI)

Hazard index (HI) is the sum of two or more hazard quotients for multiple substances and/or multiple exposure pathways. (USEPA, 2007).

1.8.2 Operational Definition

1.8.2.1 Drinking water sample

Drinking water samples was collected direct from each of respondent's water source at their home that only using GFS. Then, the water is pour into pre-clean 250 ml high density polyethylene (HDPE) bottles.

1.8.2.2 Aluminium analysis

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) methods are applicable for the determination of aluminium in water with detection level less than 0.2 ppb according to the method 200.8 (USEPA, 1994).

1.8.2.3 Calculation of Chronic Daily Intake (CDI)

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

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

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

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

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

BW = body weight (kg).

1.5.2.4 Calculation of Hazard index (HI)

The hazard index (HI) was calculated to estimate non-carcinogenic risk using the equation :

$$HI = CDI / RfD$$

Where, HI = Hazard Index

RfD = reference dose ($\mu\text{gkg}^{-1}\text{day}^{-1}$)

CHAPTER 2

LITERATURE REVIEW

2.1 Characteristic of Aluminium

General characteristic of aluminum is it one of the organic chemical which are ubiquitous which the third most common element of the earth's crust. It is naturally released to the environment from the weathering of rocks and volcanic activity (Siti Farizwana et al., 2010). In general, background levels of aluminum in the atmosphere are low, typically ranging from about 0.005 to 0.18 $\mu\text{g}/\text{m}^3$. Much higher levels are routinely observed in urban and industrial locations. Aluminum levels in surface water is usually very low ($<0.1 \text{ mg}/\text{L}$) but in acidic waters or water high in humic or fulvic acid content, the concentration of soluble aluminum increases due to the increased solubility of aluminum oxide and aluminum salts. Its concentration in soils varies widely, ranging from about 7 to over 100 g/kg (ATSDR, 2008).

2.2 Presence of Aluminum in environment

Aluminium is released to the environment mainly by natural processes. Several factors influence aluminium mobility and subsequent transport within the environment (USEPA, 2012). These include chemical speciation, hydrological flow paths, soil-water interactions, and the composition of the underlying geological materials. Acid environments caused by acid mine drainage or acid rain can cause an increase in the dissolved aluminium content of the surrounding waters (ATSDR, 1992; WHO, 1997).

In addition, aluminium can occur in a number of different forms in water. It can form monomeric and polymeric hydroxy species, colloidal polymeric solutions and gels, and precipitates, all based on aquated positive ions or hydroxylated aluminates. Besides that, it can form complexes with various organic compounds (e.g. humic or fulvic acids) and inorganic ligands (e.g. fluoride, chloride, and sulfate), most but not all of which are soluble (CCME, 1988).

The chemistry of aluminium in water is complex, and many chemical parameters, including pH, determine which aluminium species are present in aqueous solutions. In pure water, aluminium has a minimum solubility in the pH range 5.5–6.0; concentrations of total dissolved aluminium increase at higher and lower pH values (ISO, 1994).

2.3 Aluminium and its adverse health effect

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, 1997). It has been hypothesized that aluminium exposure is a risk factor for the development or acceleration of onset of Alzheimer's disease (AD) in humans (Virginie et al., 2000).

Based on previous study, some 20 epidemiological studies that have been carried out to test the hypothesis that aluminium in drinking-water is a risk factor for AD has been evaluated. Study design was ranged from ecological to case-control. Six studies on populations in Norway, Canada, France, Switzerland and England were

considered of sufficiently high quality to meet the general criteria for exposure and outcome assessment and the adjustment for at least some confounding variables (WHO, 1997). Result from three out of six studies found positive the relationship between aluminium in drinking water and dementia or Alzheimer's Disease above. However, each of the studies had some deficiencies in the study design (e.g. ecological exposure assessment; failure to consider aluminium exposure from all sources and to control for important confounders, such as education, socioeconomic status, and family history; the use of surrogate outcome measures for AD and selection bias (WHO, 1997;ATSDR, 2008).

In general, the relative risks determined were less than 2, with large confidence intervals, when the total aluminium concentration in drinking-water was 0.1 mg/litre or higher. Based on current knowledge of the pathogenesis of AD and the totality of evidence from these epidemiological studies, it was concluded that the present epidemiological evidence does not support a causal association between AD and aluminium in drinking-water (WHO, 1997).

Moreover, there are study reported about the memory loss, fatigue, depression, behavioral changes, and learning impairment were reported in five children who, over a 5-day period, consumed drinking water containing unknown levels of aluminum sulfate, which was accidentally placed in a water-treatment facility in England (Ward 1989). Acute-duration oral exposure to aluminum phosphide (19– 157 mg Al/kg) caused altered sensorium in 4 of 16 persons who ingested it either accidentally or in suicide attempts (Khosla et al., 1988). Restlessness and loss of consciousness were observed in 10 of 15 people who ingested unknown amounts of aluminum

phosphide. The toxicity associated with aluminum phosphide ingestion was probably due to the formation of highly toxic phosphine gas rather than the aluminum exposure (ATSDR, 2008)

In addition, Amyotrophic lateral sclerosis (ALS), Alzheimer's Disease (AD) and Parkinsonism-dementia (PD) are neurodegenerative diseases that have also been associated with aluminum exposure (Srinivasan et al., 1999). Alzheimer's Disease is a progressive mental deterioration manifested by memory loss, inability to calculate, visual spatial disturbances, confusion and disorientation (Virginie et al., 2000).

2.4 Gravity Feed Water System (GFS) used

A gravity-feed water supply is one of the sustainable water system technology that no require any treatment. The source of this system is naturally from a small upland river or stream that have been impounded with a protected catchment or called as a dam (Othman, 2011). This system are practising water transportation and distribution to the tapstand placed near to homes and residence's houses by through a series of pipework that using the gravity force. Thus it was reducing the work and energy involved in carrying water (WaterAid technology, 2013).

In Malaysia there three types of main water supply that commonly used which are :

- i. Gravity system,
- ii. Pumped system, and
- iii. Combined gravity and pumped system

The Figure 2 below are shows the difference between the three types of water supply distribution system. The choice of type of water supply distribution system depends on the topography, location and extent of the distribution area, elevation and site conditions (Othman, 2011) .

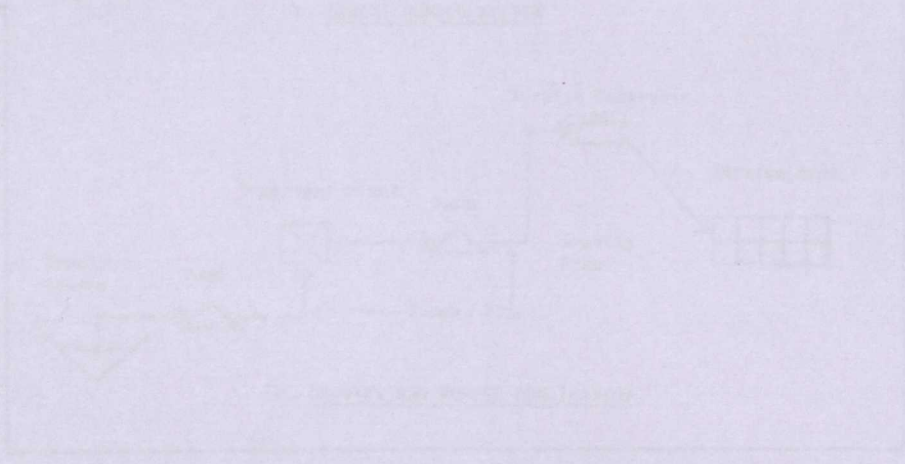


Figure 1.1 Three different type of water supply system

Source: (Othman, 2011)

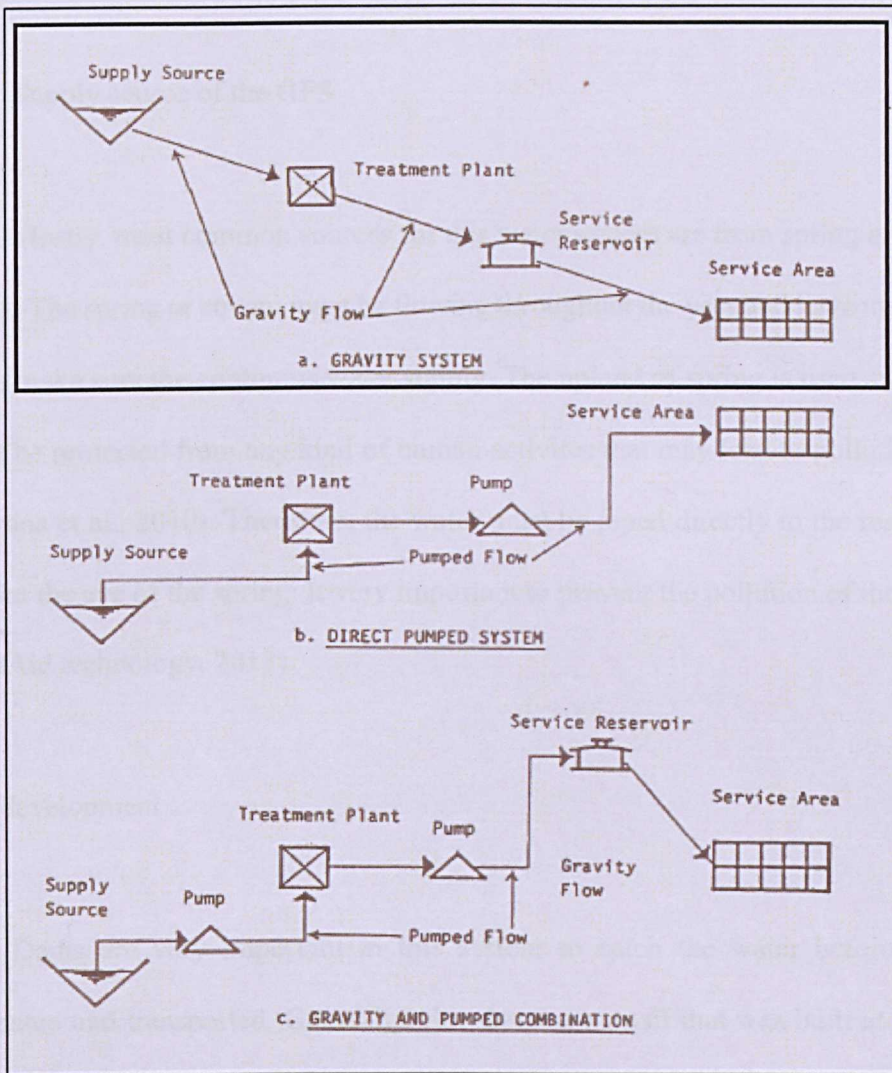


Figure 2.1 :Three different type of water supply system

Source: (Othman, 2011)

According to the technical brief by Wateraid technology Organization (2013) about GFS scheme, there are three important part of GFS in Malaysia which are dam at source, reservoir storage tank and pipeline of distribution of water.

2.4.1 Supply source of the GFS

Mostly, most common sources for this water system are from spring and small streams. The spring or stream must be flowing throughout the year and have maximum flow to make sure the continuous water supply. The upland of spring is used as source, it must be protected from any kind of human activities that may lead to pollution (Siti Farizwana et al., 2010). Therefore, the water must be piped directly to the residential area from the eye of the spring. It is very important to prevent the pollution of the supply (WaterAid technology, 2013).

Dams development :

Dams are very important in this system to catch the water before it was distributed and transported. Generally, these dams are small that were built at the level of stream's upland and act as small ponds with controllable draw-off pipes that were built at the wall of dam. A dam is usually constructed with solid rock, concrete, block work or any rock that can function as a basin of the impoundment. Then, the intake pipes which are usually Medium Density Polyethylene (MDPE) type were built at the wall of dams to allow the water to flow from the sources downward to the residential area by gravity force (WaterAid technology, 2013).

2.4.2 Reservoir Storage Tank

Reservoir tank was constructed within the system between water source and the residential area to provide an enough total water volume of storage sufficient for one day's consumption. Thus, tanks were used to serve and store water provided during low demands period which mostly overnight and during high demand periods which early morning (WaterAid technology, 2013).

2.4.3 Distribution pipelines and tapstands

A distribution system of small diameter MDPE pipes was used to support the water distribution to the maximum number of consumers. The length of the pipes is depend on how far the water can be distributed. For the tapstands, there have several components which mostly of the consumer was used a direct pipes which Polyvinyl Chloride (PVC) type to reduce the cost. The systematic pipeline from the source to tapstands is very important to prevent any water pollution to occur (WaterAid technology, 2013).

2.5 Health Risk Assessment

Health risk assessment provides us a systematic approach to protect the public health through characterization the nature and magnitude of the risks associated with environmental health hazards (enHealth, 2004).

The process of Health Risk Assessment was outlined by enHealth (2004):

- Hazard Identification
- Exposure Assessment
- Dose – response Assessment
- Risk Characterisation

2.5.1 Hazard identification

The hazard identification is the first step in health risk assessment and aimed to identifying those chemicals that contribute to the majority of exposure and risk toward humans. The “contaminants of potential concern” (COPCs) are chemicals chosen because of their occurrence, distribution, fate, mobility and persistence in the environment. Each chemical’s concentration and toxicity are also considered to quantify the actual hazard exposed by human (US EPA, 1989).

2.5.2 Exposure Assessment

The exposure assessment evaluates the type and magnitude of exposures to chemicals among human. The exposure assessment considers the source from which a chemical is released to the environment, the pathways by which chemicals are transported through the environmental medium, and the routes by which individuals are exposed (US EPA, 1989).

2.5.3 Dose – response Assessment

The dose-response assessment examines relationship between the dose of a particular hazard and the adverse health effects in humans. This relationship is conveyed by the accepted toxicological principle of ‘the dose makes the poison’. Therefore, the dose-response relationships need to take into account during this assessment as a range of potential variables. The relationship between dose and the health effects of a substance is often very different for different substances (enHealth, 2004).

2.5.4 Risk characterization

This final step (US EPA, 1989) will come out with the conclusion which brings together all the information from whole steps to describe the risks to different groups. The conclusions will be made by referring all the information and taking into consideration about the quality of the data, the amount of evidence and levels of uncertainty. This step is to prepare an overall picture of risk. The health risk assessment process should have the capacity to feed back significant issues to earlier steps in the process to gather new and relevant information (USEPA 1989; USEPA 2007).

CHAPTER 3

METHODOLOGY

3.1 Study design

A cross sectional study was conducted among Orang Asli at Kampung Sungai Lalang Baru to evaluate relationship between aluminium exposure in GFS water and Hazard Index (HI) .

3.2 Sampling frame

The respondents were selected based on the name list of head of household of study area given by Jabatan Kemajuan Orang Asli (JAKOA) Hulu Langat.

3.3 Sampling method

Stratified random sampling method was used in this study based on the name list of head of households in Kampung Sungai Lalang Baru. The study area was divided into three areas which area A, area B and area C. Therefore, the total name of head of household that represented number of houses (N=114) was stratified followed by their areas. As a result, at least 17 houses from each area was selected with 102 respondents which include head of household with their partner.

3.4 Sampling unit

The sampling unit for this study were Orang Asli villager in Kampung Sungai Lalang Baru was selected for who fulfill these inclusion criteria.

Inclusion criteria :

1. The respondents must aged 18 years old and above which considered as an adult.
2. The respondents has a lifelong resident of Kampung Sungai Lalang Baru 10 years and above.
3. The respondents only use GFS water as their main source of water supply for their daily usage.

Exclusion criteria :

1. The respondents that aged below than 18 years old.
2. The respondents that lived in the village less than 6 months.
3. The respondents who used treatment piped and filtered water system as water supply for their daily usage.

3.5 Sample size

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

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

Equation 3.1

Where,

N= sample size

P=Prevalence or proportion

e=Probability standard error or mean (0.05)

Based on the formula equation, P was the expected proportion with 0.7 when there are 70% of prevalence of water samples that exceeding the aluminium acceptable limit under acceptable limit in NSDWQ under MOH 2004 (Qaiyyum et al., 2009).

Where the $P = 0.7$, $e = 0.05$, the sample size was ,

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

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

$$N = 84$$

Therefore, the minimum sample size needed for this study is 84 people. This sample size will be rounded up to 20 % to recover any loss of respondents (Noraina Nadia, 2015) throughout the study.

Therefore,

$$20 \% \text{ of } 84 = 18$$

$$\text{Minimum size of the sample population} = 84 + 18$$

$$= 102$$

Thus, the total size population of this study were 102 respondents.

3.6 Location of study

This study was conducted at the Kampung Sungai Lalang baru, Hulu Langat, Selangor. The village has located near by Kem PLKN Setia Ikhlas area. Mostly houses in this area are using the GFS water as their main water sources for their daily use by 114 family. There was no previous study about aluminium exposure in GFS water in done this study area.

Study location at Kampung Sungai Lalang Baru, Hulu Langat, Selangor.

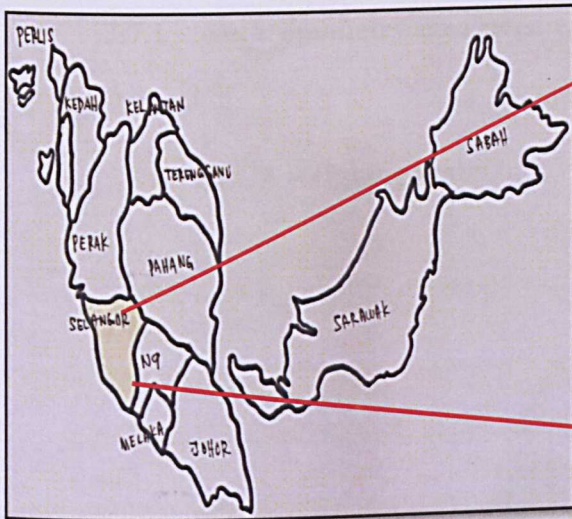


Figure 3.1: Malaysia's map

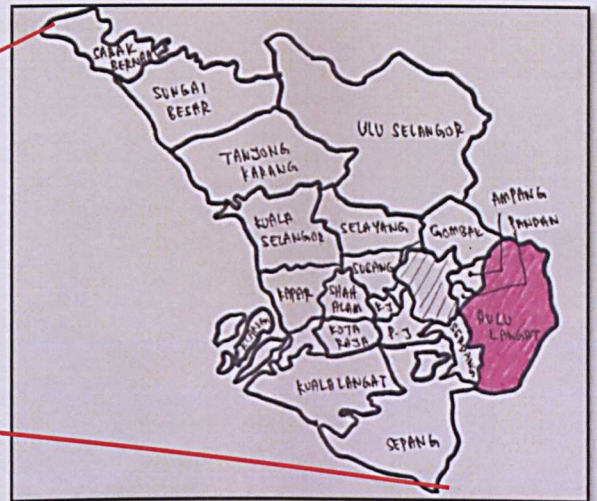


Figure 3.2: Selangor's map

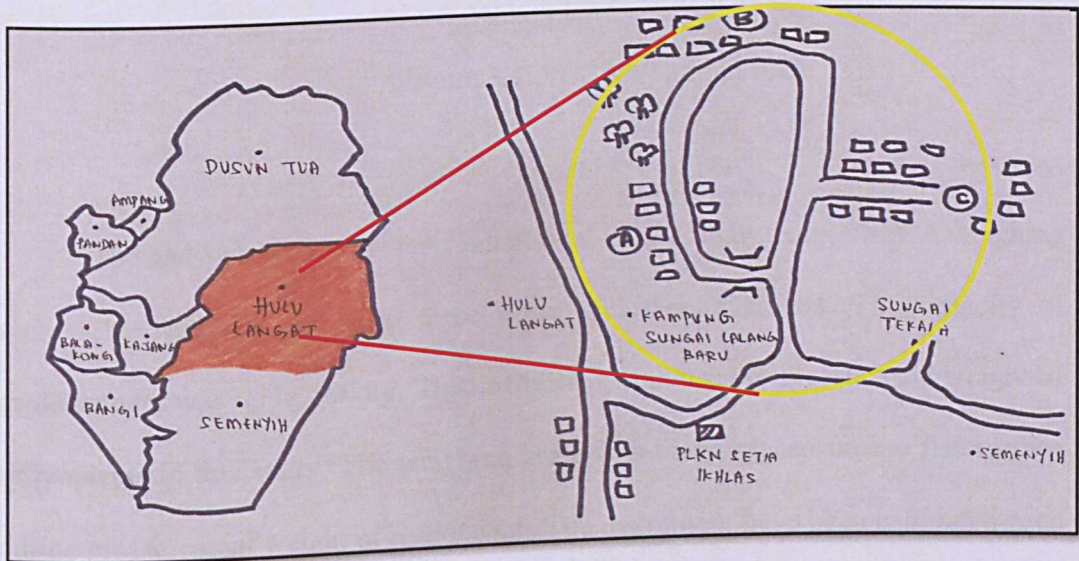


Figure 3.3: Hulu Langat and study location's maps

Source: Google Maps

3.7 Instrumentation(s)

3.7.1 Anthropometry measurement equipment

a. SECA weighing scale



Figure 3.4: SECA weighing scale

The body weights of the respondents was measured by using a SECA weighing scale. The readings has taken three times and then averaged. The capacity of measurement was up to 150 kg. This instrument was used to measure the weight of respondents in this study. The weighing scale was being placed on the flat surface during measurement weight of respondents. The instrument have been calibrated each time before it was used.

3.7.2 Water sampling equipments

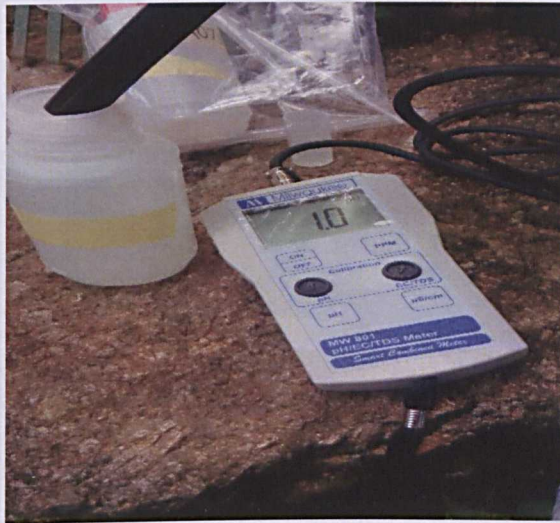
a. HDPE bottle

The water sample have been collected by using 250 mL HDPE plastic bottle from each of houses in the study location that using GFS water. The water sample was collected with two replicates at the same time. The time of collected and whether condition also was recorded of each of samples. The HDPE bottles was used because this bottle was chemical and impact resistant besides it price also was affordable.



Figure 3.5: 250 mL HDPE bottles

b. MILWAUKEE MW100 Standard Portable pH Meter (0.1 resolution)



Firgure 3.6:MW100 Portable pH Meter

This pH meter was used to measure the pH level of water samples that have been collected in the bottle. The water pH was measured immediately after the water samples was taken and it called as on – site pH measurement. The pH value of each water samples was recorded and it was classified either the pH level are under acidic (1-6), neutral (7) or alkaline (8-14). The instrument was calibrated before used by using their standard solution (acid and alkaline) to make sure the pH meter can detect the exact pH value (Hajira, 2015).

3.7.3 Water analysis equipments

a. Inductively Coupled Plasma Mass Spectrometry (USEPA,1994)

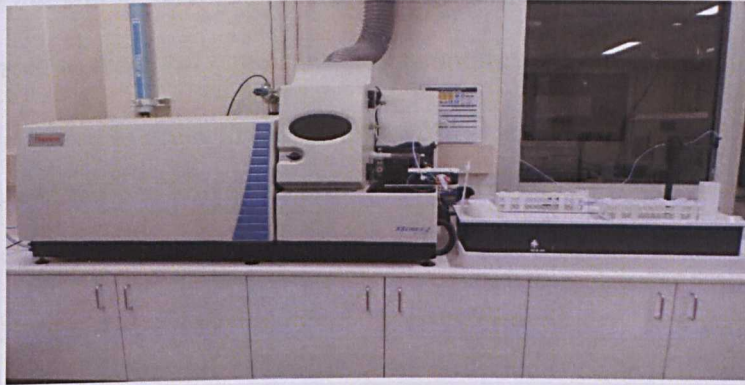


Figure 3.7: ICP-MS

Aluminium concentration in the water samples was measured by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). By using method 200.8, it can give the best reading for determination of element in ground, surface and drinking including aluminium (USEPA, 1994). It can measure the aluminium level with low detection level which were 0.2 part per billion (ppb) of aluminium concentration in water samples.

3.7.4 Drinking water daily intake

The daily intake rate of water among respondents was measured by using a standard cup of 250 ml, and different level of water bottles (500mL, 1,5mL and 5L). Every respondents need to recall back their water consumption amount in a day based on that standard level given in order to calculate the Chronic Daily Intake (CDI) and Hazard Index (HI).

3.8 Data Collection

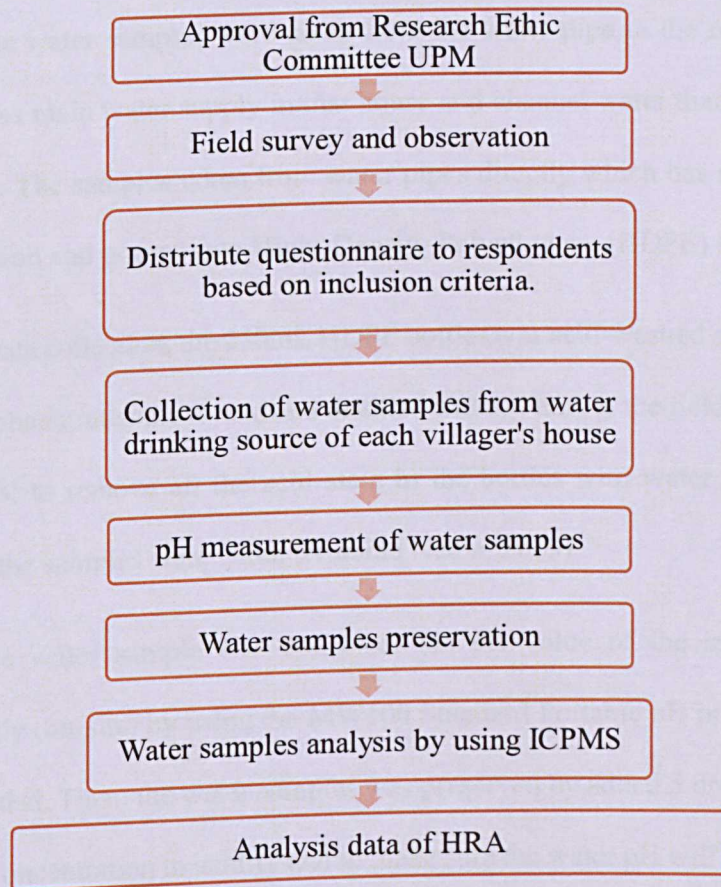


Diagram 3.1: Flowchart of data collection

This study was described about the aluminium concentration level in GFS drinking water and also health risk assesment among the Orang Asli residents in Kampung Sungai Lalang Baru related to aluminium exposure. Field survey and observation of the study area were done after got an approval from the Research Ethic Committee UPM. The visit of source or dam of GFS was conducted during field survey to learn how the water was distributed to the villagers.

During data collection, two main things have been highlighted which were questionnaires and water samples. The questionnaire was used to obtained information about the socio- demographic and also health status of respondents. The questionnaire only distributed to the respondents that fullfil the inclusion criteria. Afterwards, the body weight of respondents was measured for calculation of their health index.

Duplicate water samples were taken from the water pipe in the respondent's houses that act as main water supply in that house and channel water that come from the GFS's river. The samples taken from water pipes directly which has not undergo any water filtration and poured into High- Density Polyethylene (HDPE) bottles.

Before data collection, the 250mL HDPE bottles was acid-washed at laboratory by using 10% concentrated nitric acid and distilled water. Then, at the field, the bottles was washed first to remove all the acid stain in the bottles with water within 3- 5 minutes before the samples were taken (Noraina Nadia, 2015).

After the water sample was collected, the pH value of the samples was measured directly (on-site) by using the MW100 Standard Portable pH meter and the value was recorded. Then, the water samples was preserved by added 5 drops of nitric acid with 69% concentration to acidify and to make sure the water pH will be less than 2 (pH<2) (Kavear et al., 2009).

The aluminium concentration in each water samples were analysed by using ICMPS. After that, the result of data collection were analysed by using statistical analysis with regards to health risk assesment result of respondents.

3.8.1 Questionnaire

A questionnaire comprising of four parts were administered to each respondents. Part A of the questionnaire contain questions regarding the socio-demographic information. For part B contain questions related to daily intake of drinking water and water usage information. Part C contained questions about the information of residence environment of the respondents and for the part D, the questions was focused on the health status of respondents.

The questionnaire was adapted from the previous study (Noraina Nadia, 2015). For the quality control of questionnaire, pre-test was conducted by Noraina Nadia (2015) on 10% of the sample size to determine the validity and reliability of the questionnaire. She was conducted the pre – test at another Orang Asli villagers to test and the reliability value (Cronbach alpha) was determined. Besides that, the pre-test result also was adapted from this study and the questionnaire was reliable when alpha value was more than 0.7.

3.8.2 Data analysis

The data collected was analysed by using Statistical Packages for Social Sciences (SPSS) version 22.0 and Microsoft Excel 2010. Statistical methods that were used included one sample T test to compare the aluminium level in water sample with the water national standard. Besides that, correlation test also was used to determine the relationships between aluminium and pH water.

In addition, some of data was analysed by using descriptive analysis in statistical analysis such as personal information, socio-demographic information, family history based on health status, water daily usage and so on.

3.8.3 Health Risk Assessment (Calculation)

In order to determine exposure of aluminium in drinking water, chronic daily intake (CDI) were calculated by using the following equation 3.2 (US EPA, 1989).

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

Equation 3.2

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 Aluminium in drinking water, the Hazard Index (HI) was calculated by using the following equation 3.3 (US EPA, 1989):

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

Equation 3.3

Where,

HI = Hazard Index,

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

RfD = Reference dose (mg/kg/day)

If 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 impact. RfD value that used in this study was 1.0 mg/kg/day (ATSDR, 2008).

RfD also known as MRL, therefore in this study, the amount of RfD refer to the ASTDR that has derived an intermediate –duration oral minimal risk level (MRL) of 1 mg aluminum /kg/day for aluminium within 15- 364 days (ATSDR, 2008).

3.8.4 Quality Control

3.8.4.1 Pre-test Questionnaire

Based on the previous study (Noraina Nadia, 2015), the pre – test of questionnaire was conducted at the different location to test the variability and reliability of the questionnaire. Ten respondents from Kampung Melayu Ampang was selected and answered the questionnaire. The purpose of this pre – test was for preventing bias and help to strengthen the result during the actual research.

3.8.4.2 Calibration

All the instruments used in this study which were MW100 portable pH meter, Seca weighting scale and ICPMS was calibrated before conducting the study. The calibration method was referred to the standard operation procedure based on the type of instruments.

3.9 Ethical Consideration

The present study had obtained approval from the Committee of Ethics of University Putra Malaysia to conduct this study. The permission to conduct this study also was granted by the head of Orang Asli village. This research were conducted on voluntary basis where briefing were given to all the respondents about this research and the permission of each respondents were asked by using respondent's agreement consent form. Then, all the information data of the respondents were remain private and confidential whereas the data will not be exposed in this study.

3.10 Study Limitations

- i. The information given from respondents could not be determined to be 100 % valid because the respondents may not understand all the requirement of questionnaire or interview that may lead to have information bias.
- ii. Confounding factor that cannot be excluded which were the other exposure that contributed to the health risk of respondents.
- iii. Samples of water can not be analysed by duplicates reading because of the budget constraint.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Descriptive analysis

Socio – Demographic Data of Study Respondents

This study was conducted among 102 respondents started from January until February 2016 at Kampung Sungai Lalang Baru, Hulu Langat and the response rate was 100%. Table 4.1 shows socio-demographic data of respondents i.e gender, age, occupational background, monthly income and educational background. The study respondents comprised of 50 (49%) males and 52 (51%) females. For age, mostly the respondents were among 31-40 years old with n=36 (35.3%), followed by 21-30 years old with n=27 (26.5%), 41-50 years old with n=22 (21.6), 51-60 years old with n=11 (10.8%) and lastly were 61-70 years old with n=6 (5.9%).

Based on respondent's occupational background, majority of them were self-employed with n=39 (38.2%), not working, n=31 (30.4%), followed by private employment with n=28 (27.5) and lastly 4 (3.9%) of them worked as government employees. The monthly income of the respondents, it showed that most of respondents have an income in range RM 500-1000 when n=33 (32.4%) then several of them that do not have an income with n=33 (30.4%), followed by respondents that have an income in range RM 300-500 with n=27 (26.5%), RM1000-2000 with n=6 (5.9%), then <RM300 with n=4 (3.9%) and lastly only 1 (1%) respondent has an income that >RM 2000.

For the educational background, most of the respondents have education at primary school with n=41 (40.2%), then followed by secondary school experience, n=33 (27.5%), not schooling with n=28 (27.5%) and lastly none (0%) of respondents have university education level experience. Table 4.2 shows the anthropometrical information of respondents which has the mean of the respondent's weight were 65.76 ± 13.77 kg.

Table 4.1 Socio- demography of respondents

Variables	n = 102	Percentage (%)
Gender		
Male	50	49.0
Female	52	51.0
Age		
21-30	27	26.5
31-40	36	35.3
41-50	22	21.6
51-60	11	10.8
61-70	6	5.9
Occupational Background		
Government employment	4	3.9
Private employment	28	27.5
Self – employed	39	38.2
Not working	31	30.4
Monthly Income		
<RM 300	4	3.9
RM 300-500	27	26.5
RM 500 – 1000	33	32.4
RM 1000 – 2000	6	5.9
>RM 2000	1	1.0
No income	31	30.4
Education Background		
Did not attend school	28	27.5
Primary school	41	40.2
Secondary school	33	32.4
University	0	0

Table 4.2 Anthropometrical measurement of respondents

Variable	Mean	Standard Deviation(SD)	Median	IQR	95% CI	
					Lower	Upper
Weight (kg)	65.76	13.77	64.00	72.00	42.00	114.00

Water intake and usage information among respondents

The respondents were interviewed during the data collection about their water intake and usage information which were to determine the relationship between taking water and perceived health risk exposure after consume GFS water in their daily life. The table 4.3 shows the data about water intake and usage information among study respondents.

Overall, all the respondents where n=102 (100%) in this study area was used GFS water as their main water source and none (0%) of them that used water from SYABAS or other sources. This shows that the respondents was consumed and use the same water source and supply.

Based on the result of water quantity intake among the respondents, there were 66.7 % of respondents consumed GFS water as much 1.5 – 3.0 L and followed by 19.6% of them consumed 0.5 – 1.5L water in daily, followed by 9.8% of respondents that consume <0.5 L water and lastly 3.9% of respondents consumed 3.0-5.0 L water, daily.

Next, all the respondents (100%) answered that they used GFS water as their main water source for their daily activities such as cooking, drinking and also for domestic use. Besides that, all the respondents (100%) satisfied with the GFS water quality at their area. The water quality were including from the condition of water odour, colour and also its turbidity.

Table 4.3: Water usage information among respondents in their daily life

Variables	n = 102	Percentage (%)
Water source		
SYABAS	0	0
GFS water	102	100
Others	0	0
Water quantity intake per day (L)		
< 0.5 L	10	9.8
0.5 L-1.5 L	20	19.6
1.5 L-3.0 L	68	66.7
3.0 L -5.0 L	4	3.9
Water usage from kitchen		
Cooking, drink and domestic use	102	100
Others usage	0	0
Water quality satisfaction		
Yes	102	100
No	0	0
Not sure	0	0

N = 102

Environmental information of study area location

The respondents also was asked about environmental information at their residential area which has related to the surrounding environment condition, type of water piping and also years of the respondent's houses was build. As overall, all the respondents (100%) agreed that no nearby industrial activity that present around them and they are also was used PVC type for their water piping.

Majority of the respondents was stayed at study location and consumed GFS water less than 15 years. Next, it was followed by some of respondent's houses (21.6%) was built around year 1990-2000 and only 7.8% houses of respondents was built around year 1980-1990 where it was less than 40 years build.

Table 4.4: Environmental condition of study area location

Variables	n = 102	Percentage (%)
Nearby industrial activity		
Yes	0	0
No	102	100
Not sure	0	0
Water piping type		
Metal	0	0
MDPE	0	0
PVC	102	100
Not sure	0	0
Years of house was build		
Year 2001-2005	72	70.6
Year 1990-2000	22	21.6
Year 1980-1990	8	7.8

DISCUSSION

The study was conducted at Kampung Sungai Lalang in which all the respondents were consumed water only from Gravity Feed System (GFS) at their area. Based on site visit observation that was done in January 2016, the GFS source for this village was located at upstream of Sungai Tekala, Hulu Langat. Jabatan Kemajuan Orang Asli (JAKOA) Hulu Langat was responsible on supplying and management of any matters related to GFS in this village.

The socio-demographic data, showed that 102 of respondents from this study comprised from both gender with different age level. The occupational background, monthly income and education background data of respondents was showed that Orang Asli at this area still have low education and low life expenses in their daily life when majority of them only working as self – employed with small amount of income and also unemployed. Therefore, they are classified as the vulnerable group and live in poverty beside they are also classified as group that has lower education level (Masron et al., 2014).

Based on the water usage information among respondents data, this study can carried out when all the respondents are used GFS water only for their daily life activities including of cooking, drinking and domestic use. Therefore, they was consumed the same water quality and potentially similar level of aluminium contamination. From the result, it was showed that all the respondents are satisfy with the quality of the GFS water when there were no disturbance of water supply, odor, colour or turbidity.

In the environmental condition of study location data, it was clearly shows that there was no nearby industrial activity and also all the respondents used PVC as their

main water piping. This data was very important to recognize the causes of aluminium present in the water drinking. The duration of consumed and using GFS water as main water intake also important to shows the duration of respondents was exposed to the aluminium exposure in drinking water. In this study, majority of them (72%) used GFS water more than 10 years and above since their houses was build. Therefore, this showed that all the respondents have consumed and exposed to the presence of aluminium for a long time.

4.2 Aluminium concentration and pH level in drinking water samples

To achieve the main objective of this study, two important parameters of drinking water samples which are pH level and aluminium concentration in samples were analyzed. The result of these parameter was shown and summarized in the Table 4.5. Overall, the result shows that the mean of aluminium concentration (mg/L) and pH level are 0.07 ± 0.03 and 6.30 ± 0.28 respectively.

Table 4.5: Aluminium concentration and pH level of water samples

Variables	Minimum	Maximum	Mean \pm SD
Aluminium concentration (mg/L)	0.1	0.15	0.07 ± 0.03
pH level	5.80	7.10	6.30 ± 0.28

N = 102

DISCUSSION

By refer to the USEPA 1994, aluminium concentration in ground water, surface and drinking water can be determined by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) with lowest detection level which were 0.2 part per billion (ppb). Therefore, ICP-MS method was applied in this study and result of aluminium concentration was recorded.

Generally, there was no specific study assessing the risk of exposure to aluminium in GFS water was found in this study location. However, by refer to the related previous from Noraina Nadia (2015) at Kampung Orang Asli Kuala Pangsun, Hulu Langat was found that mean of aluminium concentration in GFS water samples collected from the respondent's houses were 0.456 with standard deviation 0.198. The study also found that 90% of the water samples has exceed the aluminium concentration value in NSDWQ. The range of aluminium concentration in this study are 0.028 to 0.949 mg/L (Noraina Nadia, 2015).

As compared to this study, there was a huge difference between the mean of aluminium concentration. The previous study shown that mean aluminium concentration from Kampung Orang Asli Kuala Pangsun was around 7 times higher than in Kampung Sungai Lalang Baru. In this study, the mean of aluminium concentration were only 0.07 with standard deviation 0.03. Other than that, the range of aluminium were 0.1 to 0.15 mg/L.

Aluminium concentration in Kampung Sungai Lalang Baru were slightly lower than that previous study. The reason was because the GFS water source of this village was located at the upstream river of reserved forest which were Sungai Tekala. Therefore, there were no human activities such as mining, deforestation, industry and

so on happen surrounding the river that may contribute to the aluminium released. The safety and cleanliness of this forest was maintained and observed by Ministry of Forestry.

Even though the aluminium concentration were low, but there are still have potential of aluminium chronic exposure among the respondents when the highest concentration level were 0.15mg/L and slightly to exceed 0.2mg/L by NSDWQ (MOH 2010).

In this study, the mean pH value which was 6.30 and standard deviation 0.28 were in the range of acceptable value in NSDWQ (MOH 2010). The range of pH that stated in result was from 5.80 to 7.10. The pH level of water samples was measured immediately (in-situ) after the water was collected.

4.3 Comparison of Aluminium (Al) concentration and pH level with National Standard for Drinking Water Quality (NSDWQ)

Based on the result in the table 4.5, the mean of the aluminium concentration (mg/L) (0.07) and standard deviation (0.03) were compared to the acceptable limit of aluminium concentration in drinking water that have stated in the National Standard for Drinking Water Quality (NSDWQ). Based on the NSDWQ, the aluminium concentration in drinking water samples must not be more than 0.2 mg/L. Therefore, one sample T -test was conducted to determine the difference between mean of aluminium concentration of samples with the standard in NSDWQ.

Table 4.6: One sample T-Test

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

Based on the one sample T-test result in the Table 4.6, it shown that there was a significant difference between the aluminium concentrations in drinking water samples with the acceptable limit value in NSDWQ which were 0.2 mg/L. This was because the p-value of the test were less than 0.01 when $p = 0.001$.

By refer to the figure 4.1, it clearly shown that all the aluminium concentration in water samples not exceed the acceptable limit in NSDWQ which below than 0.2 mg/L.

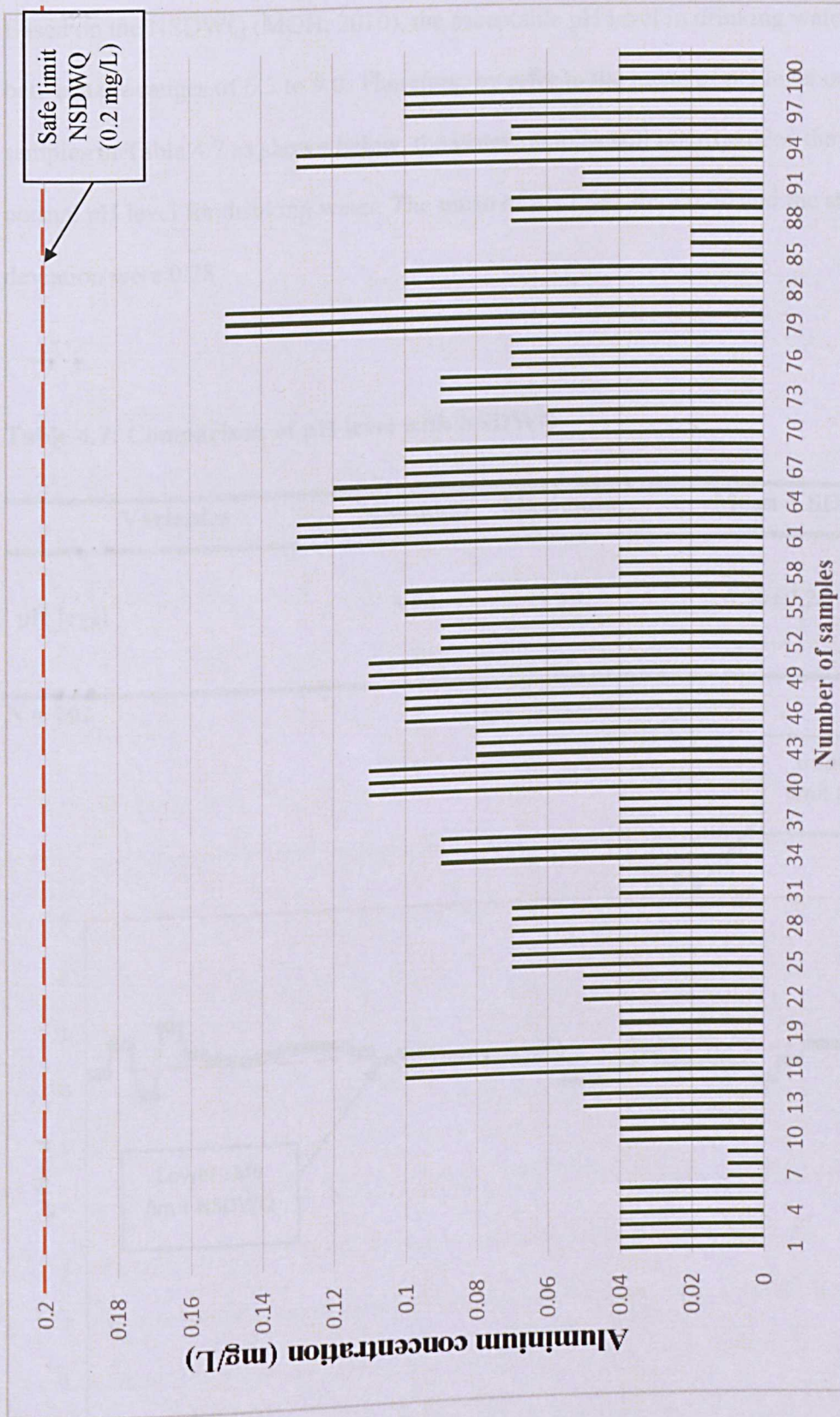


Figure 4.1 Aluminium concentration in water samples

Based on the NSDWQ (MOH, 2010), the acceptable pH level in drinking water were between the ranges of 6.5 to 9.0. Therefore, by refer to the mean of pH level of water samples in Table 4.7 as shown below, the water samples still not exceeded the normal pH level for drinking water. The mean of pH level were 6.30 and the standard deviation were 0.28.

Table 4.7: Comparison of pH level with NSDWQ

Variables	Minimum	Maximum	Mean \pm SD
pH level	5.80	7.10	6.30 \pm 0.28

N = 102

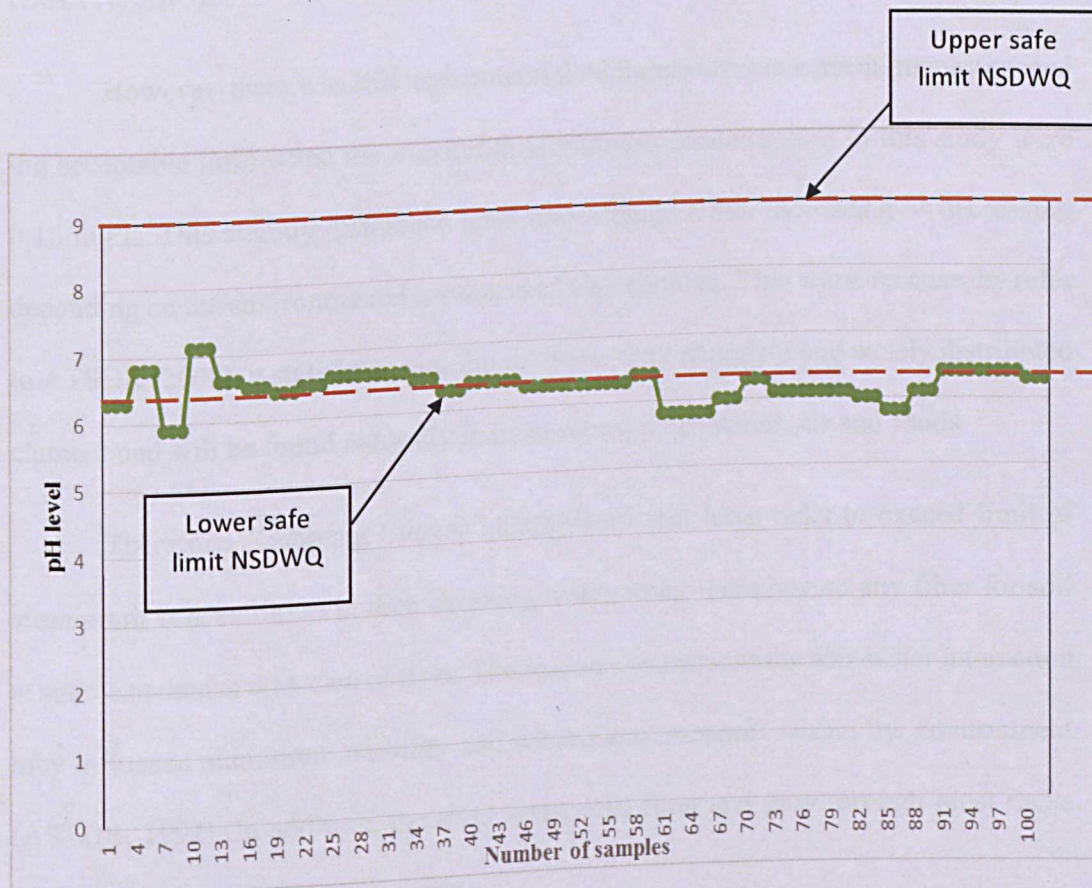


Figure 4.2: pH level of water samples

DISCUSSION

The mean of aluminium concentration was compared with acceptable range in National Standard Drinking Water Quality (NSDWQ). Based on the NSDWQ, the maximum level for aluminium concentration in drinking water must be below than 0.2 mg/L. Overall in this study, all the samples do not exceed the standard and still below the maximum level when the mean of aluminium was 0.07 mg/L. Besides that, the one sample t-test (Table 4.5) was showed that there was a significant difference between aluminium concentration of each samples with NSDWQ acceptable limit when $p < 0.01$. By refer to the United State Environmental Protection Agency (USEPA), aluminium was fall under secondary contaminant which aluminium did not consider present health risk to human at the secondary maximum contaminant level (USEPA, 2015).

However, there was still high potential of aluminium concentration may exceed the acceptable limit when the maximum aluminium concentration in this study were 0.15 mg/L. This slightly difference level may change either increasing or decreasing depending on the environmental condition of water source. This were because, by refer to ATSDR (2008), it stated that aluminium was a very abundant and widely distributed element and will be found naturally in most rocks, soils, water, air and foods.

Therefore, Kampung Sungai Lalang Baru still have risks to exceed limit of aluminium concentration in their drinking water when there has no any filter for soil at source or dam at upstream of river. The reason was because the soil-water interaction may influence aluminium mobility and subsequent transport within the environment (ASTDR, 1992). In addition, the river water will flow and pass through most rocks before it channeling to the consumers.

NSDWQ for Malaysia that was standardized by Engineering Services Division in Ministry of Health has stated that the acceptable value for water pH level ranged from 6.5 to 9.0. In this study, the drinking water pH level was ranged from 5.80 to 7.10 with mean 6.30 and standard deviation 0.28 (Table 4.7). Based on figure 4.2, it shown that 67% of the water pH level in the range 5.8 – 6.4 which were below the minimum acceptable pH level for drinking water.

Even though the pH level of drinking water samples still in the safe range and not too acidic, but it still have risks to be lower until it become unsafe to be consumed. These scenario of low pH level in GFS water may causes by buffering capacity that was occurred by acid rain. The reason was because when acid rain flows into streams after falling on forest or nearby building, it will affects sensitive bodies of water and then limit the ability of soils to neutralize acidic compound. (USEPA, 2012).

4.4 Relationship between Aluminium concentration and pH level of GFS drinking water

Spearman's correlation was used to determine the relationship between aluminium concentration and pH level since both variables were not normally distributed. The r value was -0.268 and p – value was less 0.01 when $p = 0.007$. Thus, there was negatively significant correlation between pH level and aluminium concentration ($r = -0.268, n=102, p < 0.05$).

Based on the result, the r^2 has equal to 0.072 which means 7.8% of the variation in aluminium concentration were explained by pH level.

Table 4.8: Relationship between aluminium concentration and pH level

Variable	Correlation Coefficient, r	Co-efficient determination, r ²	p
Aluminium concentration vs pH level	-0.268**	0.072	0.007

** . Correlation is significant at the 0.01 level (2-tailed)

N=102

DISCUSSION

Based on Spearman's correlation result in Table 4.8, it was stated that there was a strong negatively significant association between pH level and aluminium concentration of water samples from Kampung Sungai Lalang Baru when r value were -0.268 and $p < 0.01$ when $p = 0.007$. This result was consistent with the study done by Hajira (2015), that negative significant correlation between aluminium concentration and pH were observed.

Moreover, in a study of drinking water with a low alkalinity and a fairly low pH, high level of aluminium were found in the GFS drinking water of household that had used GFS water as their main water supply (Hajira, 2015). The study also has showed that there still have significant correlation between aluminium and pH level in water samples even though the pH was ranged from 6.53 to 7.93. It was concluded that the lower pH level (acidic) will contribute to the higher aluminium concentration in drinking water (Srinivasan et al, 1999).

In this study, pH was slightly significant correlated with aluminium concentration most probably because the pH level of the water samples were just slightly alkaline, with mean of 6.30 with standard deviation 0.28. Therefore, it might not contribute more to an increasing of aluminium concentration level compared to lower water pH (acidic) level.

4.5 Exposure Assessment

4.5.1 Daily intake rate of water (DI)

The mean of volume of water consumed by respondents was calculated in Table 4.8 by refer to the result of daily water intake rate among the respondents in the descriptive analysis. Therefore, the mean of volume of water consumed by respondents (L/day) were 1.86 ± 0.84 with minimum and maximum value 0.2L and 5L respectively.

Table 4.9: Daily intake rate of water intake among respondents

Variables	Minimum	Maximum	Mean \pm SD
Volume of water consumed (L/day)	0.2	5.0	1.86 ± 0.84

N=102

4.5.2 Chronic Daily Intake (CDI) calculation

Table 4.10 shows the Chronic Daily Intake (CDI) calculated by using the standard formula stated in the methods in Chapter 3 (page 36) to determine the health risk of aluminium among the respondents. Mean of CDI of 102 respondents was 0.022 with Standard deviation, SD = 0.002. The minimum and maximum value of CDI of respondents were 0.002 and 0.010 respectively.

Table 4.10: Total of CDI among the respondents

Variables	Minimum	Maximum	Mean \pm SD
Chronic Daily Intake (mg/kg/day)	0.002	0.010	0.022 \pm 0.002

N= 102

DISCUSSION

In the exposure assessment, the Chronic Daily Intake (CDI) of the respondents was calculated to determine the aluminium exposure in drinking water through ingestion route. The factors of exposure including the dose (how much), the duration (how long) and how the way contact with the exposure (ATSDR, 2008). Therefore, the CDI value was used in Hazard Index (HI) calculation of respondents.

The 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) as shown in equation in

Chapter 3. All this type of variables need to be considered when it will influence the CDI calculation thus HI result.

In this study, the mean and standard deviation of CDI of aluminium concentration measured in drinking water were 0.022 and 0.002 respectively. By comparing the CDI with the previous studies, there were huge difference spotted when CDI mean value of this study were 0.022 mg/kg/day while the previous study conducted at Kampung Orang Asli Kuala Pangsun by Noraina Nadia (2015) was 0.728 mg/kg/day. This result was showed that Kampung Sungai Lalang Baru 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 Sungai Lalang Baru were lower compared to study at Kampung Orang Asli Kuala Pangsun since this was main factor for CDI calculation.

Other than that, another study about aluminium exposure at two different river water at Kuantan by Dzulfakar et al., (2011), showed that CDI value of consumer Sungai Lembing (SL) and Bukit Ubi (BU) was 0.0035 mg/kg/day and 0.0037 mg/kg/day respectively. It was clearly shown that the CDI value of this previous study was almost same with CDI in this study. Thus, these CDI value was used for HI calculation.

4.6 Health Risk Assessment Information

To fulfill the Health Risk Assessment (HRA) requirement, Hazard Index (HI) calculated to determine the health risk of aluminium exposure among the respondents. HI was determined by dividing the value of CDI in table 4.9 with the recommended

Reference Dose (RfD). Based on the ATSDR (2008), recommendation of RfD for aluminium exposure were 1.0 mg/kg/day. From the calculation result in table 4.11, it shows that all the respondents have HI less than 1 ($HI < 1$) with a mean 0.022 and standard deviation of 0.002. The range was from 0.002 to 0.01.

Table 4.11: Hazard Index (HI) value of the respondents

Variable	Frequency	(%)	Minimum	Maximum	Mean \pm SD
HI			0.002	0.010	0.022 \pm 0.002
HI < 1	102	100			
HI > 1	0	0			

N = 102

Health status information of respondents

Based on the Table 4.12, the result of health status of respondents was determined by using descriptive analysis. The result was comprised with data of respondents either they are have smoking, consume alcohol, and several health body condition that related to the symptom of related disease of aluminium risk exposure.

The result shows that 42% of the respondents are smoker when another 57.8% of them are not smoker. Majority of the respondents (80.4%) are not consume alcohol while another 19.6% are alcoholic. All the respondents also was asked about their body condition regarding to the several symptom of the aluminium risk exposure.

For serious body tremor symptom, mostly of the respondents (89.2%) didn't have this health problem but 10.8% of them said that they have this problem. Then, followed by slow body movement problem when majority of respondents (95.1%) didn't have this problem while only 4.9% of respondents said that they feel like had this health problem. Same goes with forgetfulness behavior, mostly of respondents

(87.3%) didn't had this health problem but several of them (12.7%) had this health problem.

Next, 93.1% of respondents said that they didn't have difficulty in writing or speaking while only 6.9% of them had this problem. Lastly, majority of the respondents (87.3%) didn't have any family history with Alzheimer's Disease (AD) but 11.8% of respondents have Alzheimer's Disease family history.

Table 4.12: Perceived health risk exposure among respondents

Variables	n = 102	Percentage (%)
Smoking		
Yes	43	42.2
No	59	57.8
Alcohol consumption		
Yes	20	19.6
No	82	80.4
Not sure	0	0
Serious body tremor		
Yes	11	10.8
No	91	89.2
Not sure	0	0
Slow body movement problem		
Yes	5	4.9
No	97	95.1
Not Sure	0	0
Forgetfulness behavior		
Yes	13	12.7
No	89	87.3
Not Sure	0	0

Difficulty in writing and speaking		
Yes	7	6.9
No	95	93.1
Not Sure	0	0
Family history of AD		
Yes	12	11.8
No	89	87.3
Not Sure	1	1.0
<hr/>		
N = 102		

DISCUSSION

In order to estimate risk, Hazard Index (HI) was calculated by dividing CDI with the Reference Dose (RfD) which were 1.0 mg/kg/day that suggested by ATSDR (2008). As result shown in table 4.11, the mean of HI among respondents at Kampung Sungai Lalang Baru was 0.022 with standard deviation 0.002. The HI value was ranged from 0.002 to 0.010. This study showed that HI of all respondents (100%) was found that less than 1 ($HI < 1$) which indicate to be in an acceptable value and the health risk was negligible.

The Hazard Index (HI) uses the sum of hazard quotients for substances that affect the same target organ or organ system. 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).

Therefore, based on several studies, the risk of aluminium in drinking water and relationship with cognitive function in Alzheimer's Disease (AD) was found

(Campbell et al., 2004). Based on some review paper, nine out of 13 published epidemiological studies of aluminium in drinking water and AD shown statistically significant positive relations (Trond, 2011). It was strengthened with finding from Virginie et al. (2000) for an 8-year follow up study at France (1988-1989) study that found a total of 253 incident cases of dementia (with 17 exposed to high levels of aluminium), including 182 AD (with 13 exposed to high aluminium levels), were identified.

In Malaysia, based on previous study by Noraina Nadia (2015), HI of respondents at Kampung Orang Asli Kuala Pangsun were 0.148 which indicate this value was higher than the HI in this study with ranged from 0.002 to 0.881. A previous study by Qaiyum et al. (2011), he found that the HI result between two different villages at Batu Pahat, Johor (HI=0.00088 and 0.00101) which were much lower compared to HI in this study (HI=0.022). However, the HI value of this previous study still less than 1 (HI<1).

The overall results of HI for this study indicates that the health risk of aluminium in drinking water samples was relatively safe even some of the water samples taken approximately to the maximum acceptable limit of aluminium concentration that recommended by the NSDWQ (0.2 mg/L). The HI value may be less than 1 due to the low CDI value of respondents. Even though the HI in the safe range (HI<1), the health status of respondents regarding to AD symptoms still were recorded and analysed.

Therefore, by refer to the health status of respondents in the table 4.12, it was clearly shown that majority of respondents didn't have any health problem related to the Alzheimer's Disease's symptom. However, for some of respondents that had any

health problem such as serious body vibration, slow body movement problem, forgetfulness behaviour or difficulty in writing and speaking it might be caused by heavy smoking or alcohol intake side effect. Alcohol consumption has been one possible risk factor for AD. Alcoholism were associated with extensive cognitive problems (Evert and Oscar-Berman, 1995), including alcoholic dementia (Smith and Atkinson, 1997). Because alcohol's effects on cognition, brain disorders, and brain chemistry share some features with AD's effects on these three areas, it was plausible that alcohol use might also increase the risk of developing AD (Tyas, 1996).

Furthermore, the prevalence of concurrent alcohol and tobacco dependence suggests that alcohol and tobacco may share mechanisms that lead to dependence (Anthony and Echeagaray-Wagner, 2000). These mechanisms may have a genetic basis (Madden et al., 2000). This were because, tobacco and alcohol use may be related at least partially because both nicotine and alcohol affect brain nicotinic cholinergic receptors (Collins, 1990; Little, 2000).

For some of respondents (11.8%) that have family history with AD, they must be observed and take some precaution to prevent themselves from AD. This were because, as suggested by Taylor et al. (1992), it were plausible that there has an increase in aluminium absorption with age, so the effect of aluminium may be larger after age 75 years than before. In addition, genetic factors are more influential in the etiology of presenile dementia.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The overall quality of water supply in Kampung Sungai Lalang Baru was found to be satisfactory because all the parameters tested i.e aluminium concentration, water pH level and Hazard Index of respondents in this study was within the range of acceptable and safe limit.

In conclusion, the main objective of this study which was to determine the concentration of aluminium in drinking water and its health risk to respondents has been achieved. This study found that mean aluminium concentration and water pH level of study was lower than acceptable limit in National Standard of Drinking Water Quality (NSDWQ) and still in the safe range. Therefore, GFS water at Kampung Sungai Lalang was safe to be consumed since there no risk of aluminium exposure among respondents.

Based on the results, it showed that all of three hypotheses of this study were accepted. For the first hypothesis, it was accepted as there was significant correlation relationship between aluminium concentration and pH level even negatively associated. Next, for the second hypothesis, it also was accepted when there was significant difference between aluminium concentration and pH level with NSDWQ when $p < 0.01$. Moreover, the last hypothesis also was accepted as there was no health

risk of aluminium exposure among respondents when all the Hazard Index of respondents was less than 1 ($HI < 1$) thus it indicated that non-carcinogenic risk of exposure of aluminium in drinking water among residents in Kampung Sungai Lalang Baru was negligible.

Therefore, all the respondents in Kampung Sungai Lalang Baru are considered to be safe from the risk of aluminium in drinking water which were related to neurodegenerative diseases including Alzheimer's Disease (AD) when all the result was below the acceptable limit by standard.

5.2 RECOMMENDATIONS

As overall of this study, the GFS drinking water was safe to be consumed by the residences in this study area. However, some of action need to be taken to make sure there was no risk of aluminium exposure among the water consumer of Kampung Sungai Lalang Baru as consideration to ensure quality and safety of the drinking water sources. There are some of improvement that should be highlighted for the next study.

First, for the next related study, it is suggested that researcher to conduct a long term study or called as cohort study at the same study location and respondents. This kind of study should be conducted with purpose to observe and investigate the effect of aluminium in drinking water on the risk of dementia and AD with large prospective cohort as study that have done by Virginie (2000). Therefore, the data of aluminium concentration at this study area can be recorded continuously.

Besides that, this study also can be improved with get an extra information related to this study such as factors that can influence the aluminium concentration and also pH water level. The example of an extra information are the type and soil characteristic of water source at the upstream of river. These kind of information can be achieved from Ministry of Agriculture or conduct self-soil monitoring. By doing this, researcher can know the characteristic of the river's soil either it is already high in aluminium or another heavy metals. Other than that, researcher also is suggested to get the rainfall information especially acid rain distribution in Hulu Langat from Malaysian Meteorological Organization.

In addition, government body should be give some attention to improvise the facilities and also quality of this GFS. Even though the Hazard Index (HI) calculation showed that 100% less than 1, but the analysis showed that aluminium concentration was slightly higher and it can exceeding the acceptable limit (0.2 mg/L) by NSDWQ. Therefore, some of precaution must be taken before the aluminium exceeding the safe limit. Up to now, GFS at Kampung Sungai Lalang Baru is monitored by villagers for maintenance and JAKOA for supervision. Thus, there is no official body or organization that will monitor the quality and safety of these GFS water regularly. As recommendation due this situation, the GFS in this village should be monitored by local authority such as Pejabat Kesihatan Daerah Hulu Langat. Therefore, water safety status will be keep on updated by local authority.

The last but not least, the residents at Kampung Sungai Lalang Baru should be advised to use water filter in their house to make sure their water sources is safe from any hazard and heavy metal including aluminium. By refer to The Natural News 2014, some researcher was reported that one organization was done the testing of certain water filter brand and lab analysis. This testing were about the ability of water filter to

remove toxic heavy metals and elements with radioactive isotopes. From the testing, it was proven that there has water filter that can removed 100% of all aluminium which called as zero water (Mike Adam, 2014).

Therefore, there is no possible to advise all the Orang Asli residents at Kampung Sungai Lalang Baru to practice and use water filter at their house due to aluminium concentration at this area were slightly high (0.15 mg/L) to exceeding the acceptable limit (0.2 mg/L).

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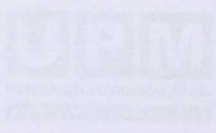
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PEJASAT TIMBALAN NAIB CANSOLOR (PENYELIDIKAN DAN INOVASI)
OFFICE OF THE DEPUTY VICE CHANCELLOR (RESEARCH AND INNOVATION)

HAL: UPRM/PHARMCI/1111/UR/2019/02
Date: 7 January 2019

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APPENDIX 1

EVIDENCE OF APPROVAL ETHIC BY MEDICAL RESEARCH ETHICS COMMITTEE

APPENDIX 2

CONSENT FORM (MALAY VERSION)



UPM
UNIVERSITI PUTRA MALAYSIA

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

BORANG B1: PENERANGAN DAN PERSETUJUAN RESPONDEN

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

1.TAJUK KAJIAN

Jumlah Aluminium (Al) di dalam air yang menggunakan Gravity Feed System (GFS) dan penilaian risiko kesihatan dikalangan Orang Asli daripada kawasan Kampung Sungai Lalang Baru, Hulu Langat, Selangor.

2. PENGENALAN

Umumnya, air minuman yang bersih dan selamat adalah satu keperluan dalam kehidupan seharian untuk memastikan kesihatan, pembangunan dan keselamatan pengguna terjamin. Namun begitu, dengan era pembangunan dan kemajuan teknologi yang diguna pakai di negara kita mungkin akan menyumbang kepada kesan-kesan yang negatif kepada kesihatan pengguna apabila pelbagai sistem sumber air yang digunakan. Sistem sumber air yang terdapat di negara kita terbahagi kepada dua samaada sistem yang berawat ataupun tidak berawat. Fokus kepada air tidak berawat Gravity Feed System (GFS) yang digunakan dikalangan Orang Asli disekitar Selangor mungkin akan menyumbang kepada masalah kesihatan jangka panjang iaitu Alzheimer's Disease (AD) bergantung kepada jumlah Aluminium yang diminum oleh mereka. Hal ini demikian kerana, Aluminium adalah logam yang juga terhasil secara semulajadi di kawasan yang berpasir dan juga berbatu. Maka, kajian ini akan dijalankan untuk menilai risiko kesihatan dikalangan penduduk dan juga tahap Aluminium di dalam air minum mereka.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Mengambil sampel air minum di setiap rumah yang hanya mendapatkan air secara terus dari sumber GFS.

- Soal selidik mengenai maklumat peribadi, maklumat penggunaan air, maklumat persekitaran tempat tinggal dan maklumat kesihatan.
- Mengambil berat badan dan tinggi responden.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

- Penduduk yang berumur di bawah 18 tahun
- Penduduk yang menggunakan penapisan air minum di rumah

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?

- Mengetahui dengan lebih mendalam mengenai sumber air dikawasan tempat tinggal.
- Mengetahui kesan air minuman yang mengandungi Aluminium yang tinggi kepada kesihatan.

9. PERSETUJUAN

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

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

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

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

*potong yang tidak berkenaan

Tandatangan
(Responden)

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)

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

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

Bahagian A: Maklumat responden

1. No tel. :

2. Tarikh lahir hr bln Thn
:

3. Umur tahun :

4. Jantina : Lelaki Perempuan

5. Pekerjaan : Kerja Kerajaan Kerja Swasta
 Bekerja sendiri Tidak Berkerja

6. Pendapatan sebulan : < RM 300 RM 300 -500 RM 500 -1000
 RM 1000- 2000 > RM 2000 Lain - lain : _____

7. Taraf pendidikan :
 Tidak bersekolah
 Sekolah rendah
 Sekolah menengah
 Universiti
 Lain-lain

8. Berat :kg

Bahagian B: Maklumat penggunaan air paip

9. Apakah sumber air minum di rumah?

Syarikat Bekalan Air Selangor (SYABAS) Air dari *Gravity Fed System* (GFS)

Lain-lain, sila nyatakan

10. Berapa kuantiti air yang anda minum setiap hari?

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

11. Penggunaan air dari dapur:

Memasak Minum Kegunaan domestik Lain-lain : _____

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

Ya Tidak Tidak pasti

Bahagian C: Maklumat persekitaran tempat tinggal

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

Ya Tidak Tidak pasti

14. Apakah jenis pempaipan air di rumah?

Logam polyethylene) MDPE (Medium - density

PVC (polyvinyl chloride) Tidak pasti

15. Bilakah rumah ini dibina?

Tahun 2001 – 2005

Tahun 1990an – 2000

Tahun 1980an – 1990an

Bahagian D: Maklumat kesihatan

16. Adakah anda merokok?

Ya

Tidak

17. Adakah anda mengambil minuman beralkohol?

Ya

Tidak

Jika ya, sila nyatakan berapa botol sehari?botol

18. Adakah anda mengalami kegetaran badan yang serius?

Ya

Tidak

Tidak pasti

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

Ya

Tidak

Tidak pasti

20. Adakah anda sering kali bersifat pelupa?

Ya

Tidak

Tidak pasti

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

Ya

Tidak

Tidak pasti

22. Adakah keluarga anda mempunyai sejarah penyakit Alzheimer?

Ya

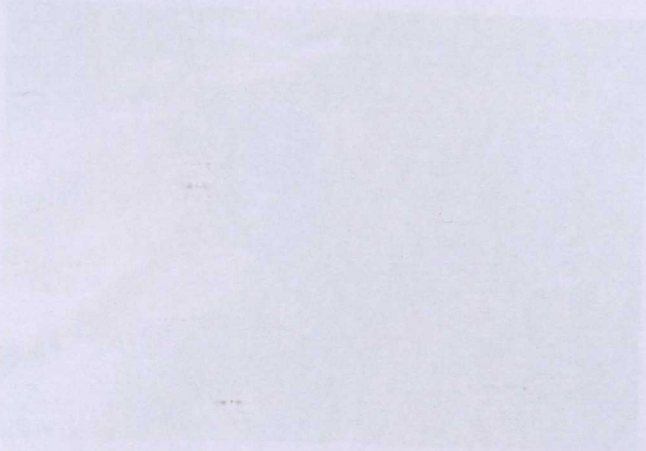
Tidak

Tidak pasti

TERIMA KASIH ATAS KERJASAMA ANDA

-TAMAT-

SITE VISIT OF GIS WATER SOURCE OF KAMPUNG SUNGAI
BALANG BAKU, BULI LANGAT AT SUNGAI TEKALA



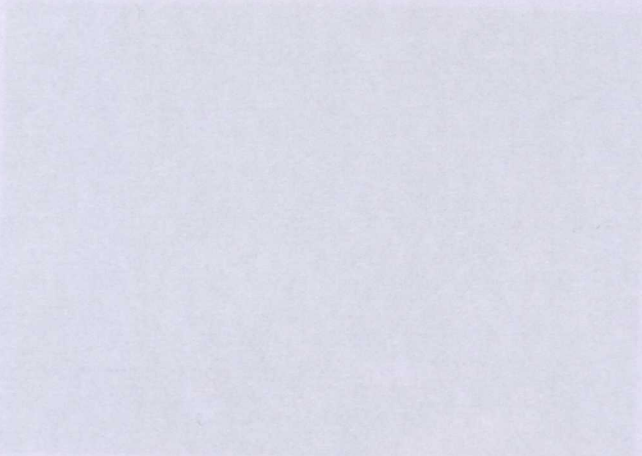
Water collection in the upland of
Sungai Tekala as a source of
GIS water.

APPENDIX 4

DATA COLLECTION'S PHOTO



Water collection in the upland of
Sungai Tekala as a source of
GIS water.



Water collection in the upland of
Sungai Tekala as a source of
GIS water.

1. SITE VISIT OF GFS WATER SOURCE OF KAMPUNG SUNGAI LALANG BARU, HULU LANGAT AT SUNGAI TEKALA



Water catchment at the upland of Sungai Tekala as a source of GFS water.



MDPE pipeline series of GFS at Sungai Tekala from the catchment.



Water reservoir tanks at the median pathway from the source before distribute to the residential area.

2. DATA COLLECTION OF STUDY AT KAMPUNG SUNGAI LALANG BARU, HULU LANGAT



Face to face interview with respondents and collect data by using questionnaire.



Weight of respondents was measured by using SECA weight scale.



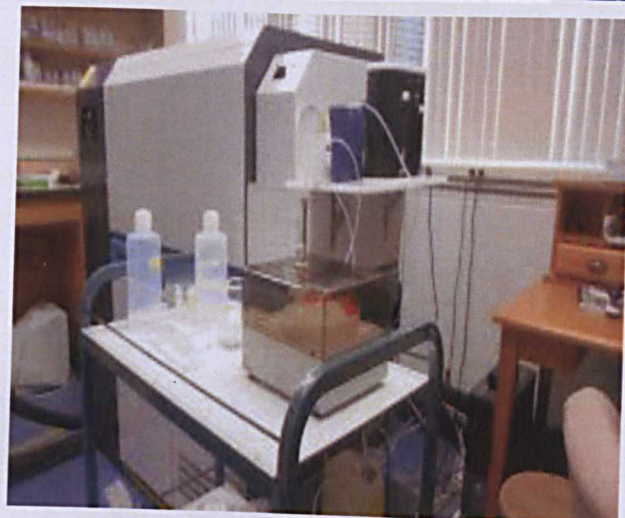
Water samples was collected from the main source of drinking water of each respondents's houses.



In-situ pH level measurement was taken by using MW100 Portable pH meter.



Water samples preservation by using a few drop of nitric acid.



Aluminium concentration in water samples was analyzed by using ICP-MS.