UNIVERSITI PUTRA MALAYSIA

HEALTH RISK ASSESSMENT OF ALUMINIUM RESIDUE EXPOSURE IN DRINKING WATER AMONG RESIDENTS IN TWO VILLAGES IN KUALA TERENGGANU, TERENGGANU

BY
AMINAH BINTI ABDUL HALIM

ABSTRACT

HEALTH RISK ASSESSMENT OF ALUMINIUM RESIDUE EXPOSURE IN DRINKING WATER AMONG RESIDENTS IN TWO VILLAGES IN KUALA TERENGGANU, TERENGGANU

AMINAH BINTI ABDUL HALIM

Introduction: Aluminium sulphate $(Al_2SO_4)_3$ is widely used as a coagulant in raw water treatment. Excessive aluminium exposure may cause adverse health effects in humans such as precursor for Alzheimer's Disease. A cross sectional study was conducted at Kampung Tok Jembal and Kampung Pak Tijah in Kuala Terengganu, Terengganu. **Objective**: The objective of this study was to determine the level of aluminium exposure in drinking water and to assess health risk of respondent for exposure to aluminium in drinking water in Kuala Terengganu. **Method:** A total of 69 respondents were selected from the study population based on the inclusion and exclusion criteria. From every respondent's house, 250 ml treated water samples were taken by using high-density polyethylene (HDPE) bottles and pH also was measured. Then, 0.2 ml of nitric acid (69%) was added into the water sample as a preservative. Aluminium level was determined using a Graphite Furnace Atomic Absorption Spectrometer (GFAAS). **Results:** The results showed that mean aluminium levels in drinking water was 0.2063±0.1028 mg/L. There were 27 (39.1%) treated water samples which violated the upper safe limit (0.2 mg/liter). Hazard Index (HI) calculation showed that all respondents had HI of less than 1, which indicated that there was an unlikely potential for health risk from aluminium intake in drinking water. **Conclusion:** Although there was no risk on adverse health effects, it was necessary for some action to be taken in order to reduce aluminium levels in drinking water. The monitoring on aluminium in treated water at household level by the authorities is very important in order to ensure that aluminium level is below the 0.2 mg/liter limit.

Keywords: Aluminium, drinking water, Alzheimer's Disease, health risk, hazard index (HI)

ABSTRAK

PENILAIAN RISIKO KESIHATAN TERHADAP PENDEDAHAN LEBIHAN ALUMINIUM DI DALAM AIR MINUMAN DI KALANGAN PENDUDUK DI DUA BUAH KAMPUNG DI KUALA TERENGGANU, TERENGGANU

AMINAH BINTI ABDUL HALIM

Pendahuluan: Aluminium sulfat $(Al_2SO_4)_3$ digunakan secara meluas sebagai bahan pengumpal dalam rawatan air mentah. Pendedahan terhadap aluminium secara berlebihan akan memberikan kesan buruk terhadap kesihatan antaranya menjadi petanda kepada penyakit Alzheimer. Kajian keratan rentas telah dilakukan di Kampung Tok Jembal dan Kampung Pak Tijah di Kuala Terengganu, Terengganu. **Objektif:** Objektif kajian ini adalah untuk menentukan tahap aluminium di dalam air minuman dan menilai risiko kesihatan responden terhadap pendedahan lebihan aluminium di dalam air minuman di Kuala Terengganu. **Kaedah:** Seramai 69 orang responden telah dipilih daripada populasi kajian berdasarkan ciri-ciri pemasukan dan pengecualian. Sebanyak 250 ml sampel air yang telah dirawat diambil dari setiap rumah peserta dengan menggunakan botol 'high-density polyethylene' (HDPE) dan pH juga telah diukur. Setelah itu, sebanyak 0.2 ml asid nitrik (69%) telah dimasukkan ke dalam sampel air sebagai pengawet dan. Tahap aluminium telah dianalisis dengan menggunakan Spektrometer Serapan Atom Relau Grafit. **Keputusan:** Hasilnya menunjukkan tahap mean aluminium di dalam air minuman adalah 0.2063±0.1028 mg/L. Terdapat 27 (39.1%) sampel air terawat yang melanggar piawaian paras aluminium di dalam air minum (>0.2 mg/L) yang dikeluarkan oleh Kementerian Kesihatan Malaysia. Pengiraan Indeks Hazad menunjukkan kesemua responden mempunyai HI kurang daripada 1, di mana ia menunjukkan tiada risiko kesihatan daripada pengambilan aluminium melalui air minuman. **Kesimpulan:** Kesimpulannya, walaupun tiada risiko kesan buruk terhadap kesihatan, tindakan perlu diambil untuk mengurangkan tahap aluminium di dalam air. Pengawasan terhadap air terawat di rumah oleh pihak berkuasa adalah penting untuk memastikan tahap aluminium berada di bawah paras 0.2 mg/liter.

Kata Kunci: Aluminium, air minuman, penyakit Alzheimer, risiko kesihatan, indeks hazad

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percentage
Al	Aluminium
AD	Alzheimer's Disease
CDI	Chronic daily intake
HDPE	High-density polyethylene
MPKT	Majlis Perbandaran Kuala Terengganu
mg/liter	milligram per litre
NSDWQ	National Standard of Drinking Water Quality
RfD	Reference Dose
SOP	Standard operating procedure
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WTP	Water treatment plant

CHAPTER 1

INTRODUCTION

1.1 Background

Metals that are taken through the drinking water are aluminium, arsenic, magnesium, nickel and others. It is well known that dissolved metals are more readily absorbed from drinking water than from most foodstuffs, and therefore metal toxicity may be higher through drinking water intake (Tahan et al., 1992). Metal are normally a part of both food and pollution, such as the pesticide residue involving metal, waste from the industrial, the passage of metals in the food chain, or result of environmental pollution (Akbulut and Tuncer, 2010). These chemicals also have been suggested to have a risk associated with their presence in potable water (Calderon, 2000).

Aluminium (Al) is the third most abundant element in the earth's crust. It occurs naturally as silicates, and oxides, combined with other elements, such as sodium and

fluoride and as complexes with organic matter (World Health Organisation (WHO), 1998). Since Al can be found in high amounts in the crust, its concentration in the surface water can be high. It also can be present in all foodstuffs, drinking water and other beverages, and as dust in the air (Flaten, 2001).

Al is used as a structural material in the construction, automotive and in food packaging. Most of the water distributed through the municipal water system is treated to remove harmful substances. Therefore, Al salts are widely used as coagulants to reduce organic matter, colour, turbidity, and microorganism levels (WHO, 2010; Tripathi, Mahatra and Raghunath, 2002). The process usually consists of addition of an Al salt (often sulphate) at optimum pH and dosage, followed by flocculation, sedimentation, and filtration. Naturally occurring aluminium as well as aluminium salts used in drinking-water treatment is the primary sources of aluminium in drinking water (WHO, 2011).

Recently, exposure to Al has been a concern because of its potentially toxic effects. Al is widespread through air, water, plants and consequently in all the food chain. The studies have shown that acid rain decreases the pH of the soil and consequently cause Al mobility through ground water by increasing its bioavailability. Humans can be exposing to Al by drinking water, as Al salt is uses in the water treatment. However, Al and its compounds appear to be poorly absorbed, with the absorption of levels of up to about 1% (WHO, 2010).

Al is a causal agent in dialysis encephalopathy, a fatal brain disorder occurring in some patients with chronic renal failure, which cause lack of kidney function where it is the main excretion route for Al. The massive Al exposure or high brain Al concentrations alone are not sufficient to cause full-blown Alzheimer's Disease (AD) neuropathology. However, there is considerable evidence that more clearly implicate a role for Al in AD. The first attempts to relate Al in drinking water to AD was reported in studies in Norway, where it was found that the morbidity of dementia was higher in areas with high concentrations of Al in drinking water (Flaten, 2001). The other study by Rondeau et al. (2000) showed that a high concentration of aluminum in drinking water and Rondeau et al. (2008) high consumption of aluminium from drinking water (> 0.1 mg/liter) might be a risk factor for Alzheimer's disease.

1.2 Problem Statement

Water is one of the routes of the Al exposure to the public. Average adult intake of Al is 5 mg per day and about 0.1 mg per liter (4%) is contributed by Al concentration in drinking water. In humans, absorption of Al and its compounds is poor as with the level of absorption up to about 1% and urine is the route of the Al excretion (WHO, 2010).

Al salts such as Al sulphate (alum) is used as a coagulant in drinking water to enhance the removal of particulate, colloidal and dissolved substances. As aluminium is

widely used in raw water treatment, it may lead to increased concentrations of aluminium in finished water (WHO, 2011). This is because a portion of the alum added to the raw water is not removed during treatment, will remain as residual aluminium in the treated water (Srinivasan, Viraraghavan and Subramaniam, 1999). The presence of this Al in drinking water is discussed as possible health effects because it is suspected to cause Alzheimer's disease or dialysis encephalopathy. Epidemiological studies have suggested a link between high incidence of Alzheimer's Disease, where there are high levels of Al (> 0.1 mg/liter) in drinking water (Rubinos et al., 2005).

Aluminium is added to drinking water as aluminium sulphate at water treatment plants (WTP) to flocculate organic matter and to clarify the water but they are not concern about the doses of alum that is added to raw water for treatment (Tripathi, Mahatra and Raghunath, 2002). Contamination also can occur because of the distribution system or materials that comprise the distribution system. As the result of corrosion or leaching of distribution materials, many of the materials can be found as chemical contaminants in potable water (Calderon, 2000).

1.3 Study Justification

In Malaysia, the exposure limit for Al in drinking water is 0.2 mg/liter, which is safe for consumption by the community (Ministry of Health Malaysia, 2000). It is important to know that the exposure of Al in drinking water is caused by WTP using certain amount of aluminium sulphate to treat water. If Al concentration is above the limit, health effect may appear after in a certain period. Although the health effect cause by exposure to Al takes a time to detect, it can affect the human health. Through this study, we are able to know the concentration of Al in drinking water and to determine whether it fulfils the Malaysian standard of drinking water quality for aluminium.

There has been no study done before in Kuala Terengganu to determine the Al concentration in drinking water. Therefore, it can also be as the surveillance on Al concentration in drinking water. The assessment on drinking water should be measured as a precaution on the level of Al concentration. This evaluation is very important to ensure Al concentration in drinking water is safe to be consuming by the community in Kuala Terengganu.

Although there are few studies showing people exposed to high levels of Al may developed Alzheimer's Disease, other studies have not found this to be true, this study should be consider to avoid consumers who are at risk as the health effect of this

exposure take a long time to appear. Therefore, levels of aluminium in drinking water are important as it is related to the certain diseases such as Alzheimer's Disease.

Through this study, information of the concentration Al in drinking water can be calculated using the Daily Chronic Intake and Hazard Index to determine the risk on the Al exposure from drinking water. Based on this assessment, the risk of the community on the health effect by consumption of drinking water is known.

1.4 Conceptual Framework

The pathway of the exposure to aluminium that will cause adverse effect to humans and to the environmental. The exposure of aluminium comes from three pathway; ingestion, inhalation and dermal contact. The variable that will be studied in this research is exposure of aluminium from drinking water through ingestion pathway. Chronic Daily Intake (CDI) and Health Hazard (HI) will then be calculated in this study to determine the health risk of aluminium exposure in drinking water among respondents.

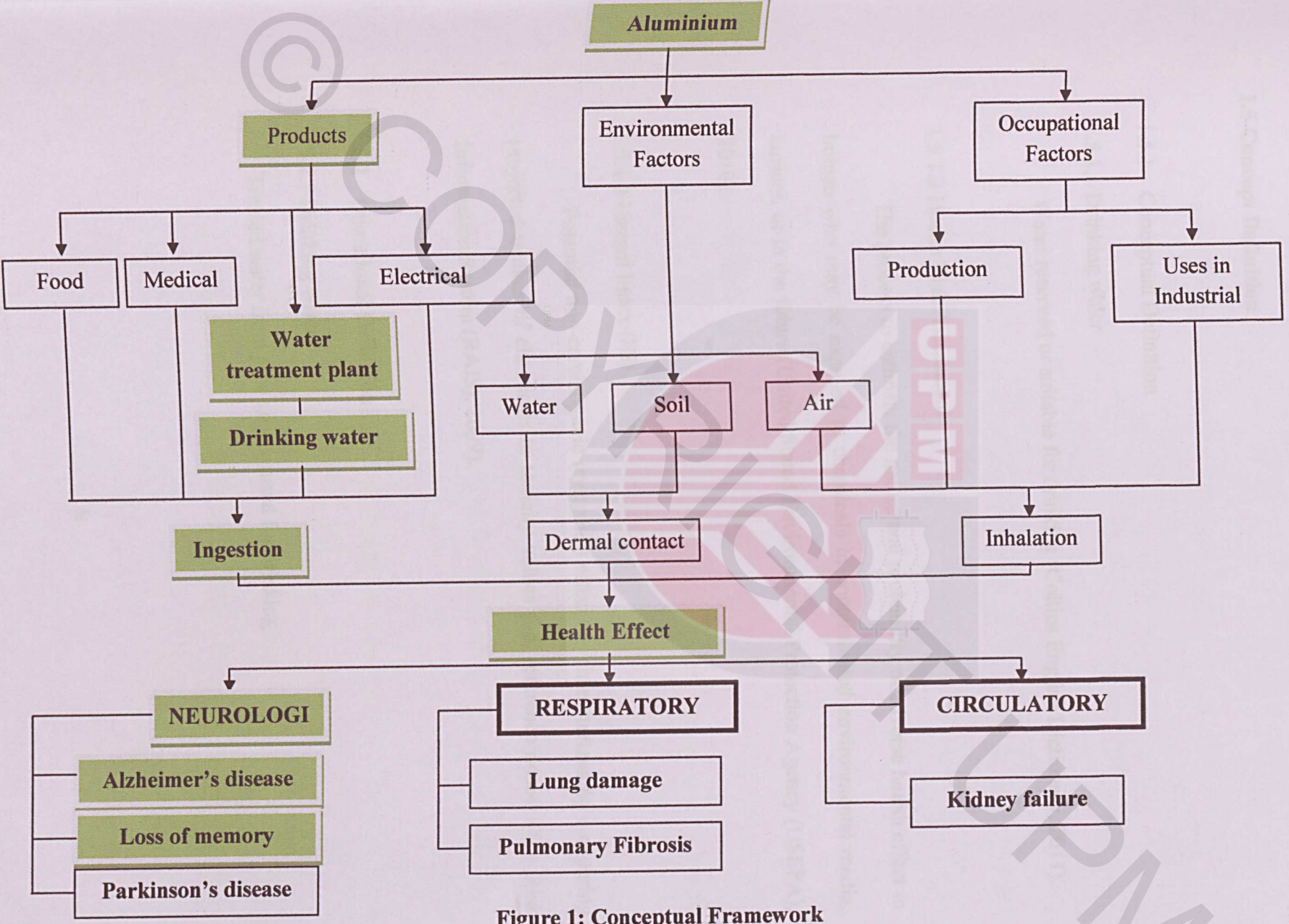

Figure 1: Conceptual Framework

1.5 Concept Definition

1.5.1 Conceptual Definition

1.5.1.1 Drinking water

Water reserved or suitable for drinking (Collins English Dictionary, 2011).

1.5.1.2 Health Risk Assessment

The process to estimate the nature and probability of adverse health effect in human who may be exposed to chemicals in contaminated environmental media, current, or in the future (United Stated Environmental Protection Agency (USEPA), 2010).

1.5.1.3 Hazard Index (HI)

Potential non-carcinogenic (systemic) effect are characterized by comparing projected intakes of chemicals to toxicity values (i.e. reference doses) (The Risk Information System (RAIS), 2009).

1.5.2 Operational Definition

1.5.2.1 Drinking water

Treated water from pipe usually used for drinking.

1.5.2.2 Health Risk Assessment

To estimate the potential health effect in population which been study.

1.5.2.3 Hazard Index (HI)

If the value of HI is greater than 1.0, such exposures may be considered hazardous or a concern for adverse health impact. While, if ratio of HI is less than 1.0, then is unlikely potential for adverse health impact.

1.6 Objective

1.6.1 General Objective

To determine aluminium levels in drinking water and to assess health risk of respondents for exposure to aluminium in drinking water in Kuala Terengganu.

1.6.2 Specific objectives

i. To determine the socio-demographic of respondents in two villages in Kuala Terengganu.

ii. To determine aluminium levels in drinking water in two villages in Kuala Terengganu.

iii. To determine the difference of aluminium levels in drinking water of respondents from two villages with National Standard for Drinking Water Quality (NSDWQ).

iv. To determine the relationship of aluminium levels and pH in drinking water in two villages in Kuala Terengganu.

v. To determine the health risk of aluminium exposure among respondents in two villages in Kuala Terengganu.

1.7 Hypothesis

i. There is significant difference of aluminium levels in drinking water with National Standard for Drinking Water Quality.

ii. There is relationship between of aluminium levels and pH in drinking water in two villages in Kuala Terengganu.

iii. Health Index (HI) among respondents is more than 1.

CHAPTER 2

LITERATURE REVIEW

2.1 Aluminium

Aluminium is identified as the most common metal on earth, forming about eight percent of the earth's crust. It is the third most plentiful element known to man. Aluminium occurs naturally in silicates, cryolite, and bauxite rock. In 1808, Sir Humphrey Davy, the British electrochemist, established the existence of aluminium. Then, the discovery of Al was determination of its specific gravity by the German scientist Wohler in 1845, which established one of Al's outstanding characteristic that is lightness (Cobden and Alcan, 1994).

Most aluminium compounds are solids exhibiting high melting points. The solubility of aluminium salts is governed by pH, because the aluminium (III)-cation (Al3+) has a strong affinity for the hydroxide ion, which promotes precipitation.

Aluminium oxides, hydroxides and oxyhydroxides occur in numerous crystallographic forms, which exhibit different surface properties (Krewski and Yokel, 2006).

Natural processes account for most of the redistribution of aluminium in the environment. Acidic precipitation mobilises aluminium from natural sources, and direct anthropogenic releases of aluminium compounds associated with industrial processes occur mainly to air. Certain uses lead to the presence of aluminium in drinking water and foodstuffs (Krewski and Yokel, 2006). Among potential environmental risk factors for AD, aluminium (Al) has been the most intensively studied neurotoxin substance (Gauthier et al., 2000).

2.2 Sources of Aluminium Exposure to Human

Aluminium is present in large amounts in our environment and widely used in engineering. The largest markets for aluminium metal and its alloys are in transportation, building and construction, packaging and electrical equipment. Transportation uses are one of the fastest growing areas for aluminium use. Aluminium powders are used in pigments and paints, fuel additives, explosives and propellants. It also can be present in all foodstuffs, drinking water and other beverages, and as dust in the air (Flaten, 2001).

Al is used as a structural material in the construction, automotive and in food packaging. Most of the water distributed through municipal water system is treated to remove harmful substances. Therefore, aluminium salts are widely used by adding in to the water treatment process as coagulants to reduce organic matter, colour, turbidity, and microorganism levels (WHO, 2010; Tripathi, Mahatra and Raghunath, 2002). There are various routes, which Al can enter into the human body from the environment, from diet, from food addictives and from administration of Al as an antacid or as an antiphosphate absorber from the gastrointestinal tract (Massey and Taylor, 1989).

Aluminium-containing additives are used to perform various functions in food. For example, sodium aluminium phosphate is used as a source of acid in raising caking agent (Massey and Taylor, 1989). Aluminium oxides are used in the manufacture of, for example, abrasives, refractories, ceramics, electrical insulators, catalysts, paper, spark plugs, light bulbs, artificial gems, alloys, glass and heat resistant fibres. Aluminium hydroxide is widely used in pharmaceutical and personal care products. Food related uses of aluminium compounds include preservatives, fillers, colouring agents, anti-caking agents, emulsifiers and baking powders; soy-based infant formula can contain aluminium (Krewski and Yokel, 2006).

Natural aluminium minerals especially bentonite and zeolite are used in water purification, sugar refining, brewing and paper industries. Interestingly, aluminium levels and its various forms (species) are often similar in source water and after its

treatment with potassium alum as a flocculent during drinking water purification (Krewski and Yokel, 2006).

There is considerable concern throughout the world over the levels of aluminium found in drinking water sources (raw water) and treated water. This has risen mainly for two reasons. First, acid rain has caused the aluminium level in many freshwater sources to increase. A high (3.6 to 6 mg/l) concentration of aluminium in treated water gives rise to turbidity, reduces disinfection efficiency, and may precipitate as Al (OH)3 during the course of distribution. Secondly, the possibility of an association between aluminium and dementia, Parkinson and Alzheimer's disease is frequently hypothesized (Mohamad Pauzi, Md Fauzi and Yang Farina, 2010).

2.3 Drinking Water

Aluminium levels in natural waters can vary significantly depending on various physicochemical and mineralogical factors. Dissolved aluminium concentrations in waters with near-neutral pH values usually range from 0.001 to 0.05 mg/liter but rise to 0.5–1 mg/liter in more acidic waters or water rich in organic matter. At the extreme acidity of waters affected by acid mine drainage, dissolved aluminium concentrations of up to 90 mg/liter have been measured (WHO, 1997).

Aluminium levels in drinking water vary according to levels found in the source water and whether aluminium coagulants are used during water treatment. (WHO, 1998). USEPA (2012) stipulates the acceptable limit of Al level in drinking water to 0.05-0.2 mg/l while in Malaysia, the acceptable upper limit of Al in drinking water is 0.2 mg/l (Ministry of Health Malaysia, 2000).

Al is widely used in water treatment as a coagulant, to reduce the number of small particles and to improve the colour of the water. The main mechanism is that al ions, having a high positive electrical charge, bind to the negatively charged particles and coloured humic compounds and form connective "bridges" between them. Thus, particles are formed that are large enough to be filtered from the water, and most of the added Al is removed by filtration and sedimentation together with the particles and humic compounds. This often results in increased water concentrations of Al, but if the treatment process is functioning optimally, the addition of Al may actually result in lower Al values in the treated water than in the raw water (Flaten, 2001).

Commonly in Malaysia, the conventional treatment is used to treat the water. The water treatment processes method including intake, aeration, coagulation and flocculation, sedimentation, filtration, disinfection, fluoridation and pH correction. During a certain stages in the treatment process, chemical coagulants (aluminium sulphate) are added to react with the remaining small particles in the water to form particles large enough to settle out (Puncak Niaga, 2009).

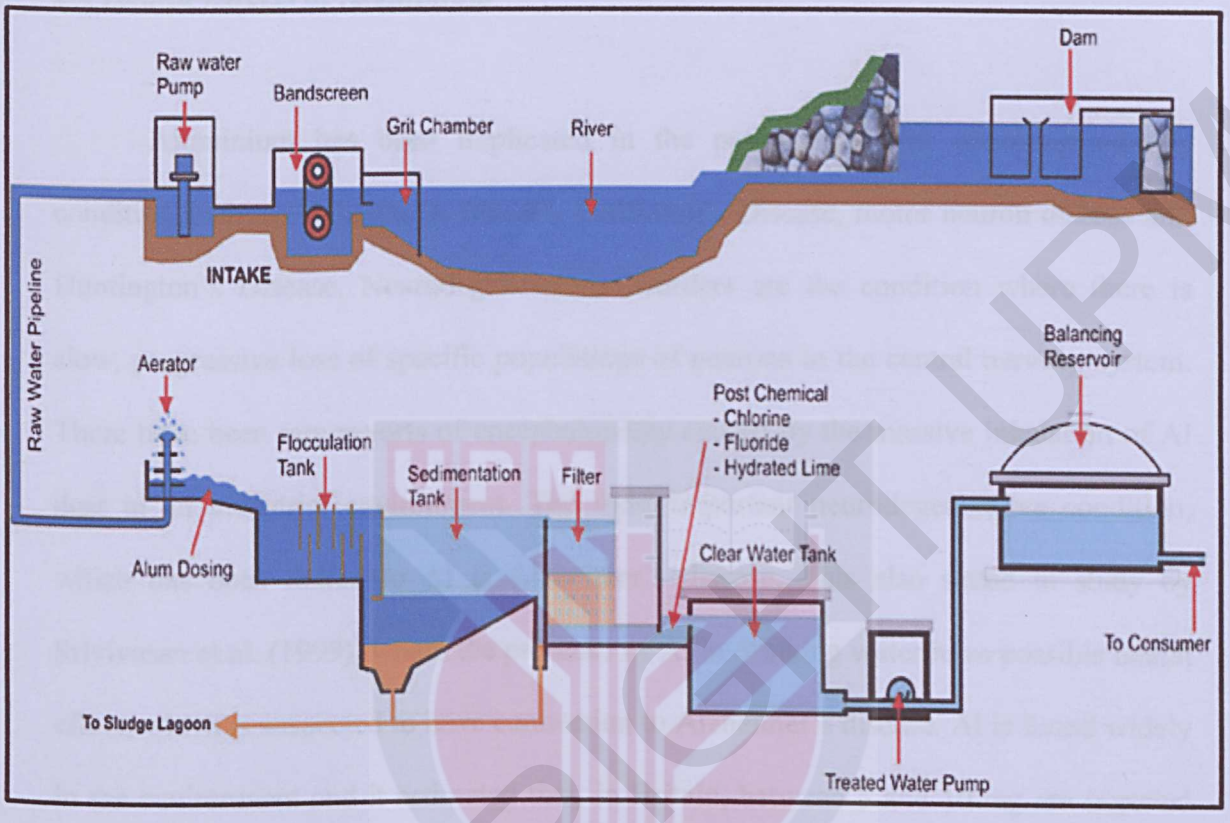

Figure 2.1: The typical processes of conventional treatment plant (Puncak Niaga, 2009)

2.4 Health Effects of Aluminium

Aluminium has been implicated in the pathogenesis for neurodegenerative condition such as Alzheimer's Disease, Parkinson's Disease, motor neuron disease and Huntington's Disease. Neurodegenerative disorders are the condition where there is slow, progressive loss of specific populations of neurons in the central nervous system. There have been rare reports of encephalopathy caused by the massive inhalation of Al dust in an industrial environment. The most important neurodegenerative condition, which has been linked to Al is Alzheimer's disease. This also stated in study by Srivivasan et al. (1999), where the presence of Al in drinking water have possible health effect, which is suspected to have connection to Alzheimer's disease. Al is found widely in the environment and it estimated that, in Britain, between 5 and 10 mg are ingested each day. However, only a very small proportion of this ingested Al is absorbed. The uses of aluminium sulphate as a coagulant in the treatment of raw water in order to remove suspended particulate matter and coloured humid substances, but residual Al may pass into the water supply. Although Al from drinking water focus a small part of the total daily intake but it contributes to the total amount absorbed from the gastrointestinal tract (Massey and Taylor, 1989).

Al is a toxic metal that primarily affects the central nervous system, including dementia-type syndrome e.g. dialysis encephalopathy, in patients with chronic renal failure (CRF). Al in drinking water has been postulated as one of the etiological agents

of Alzheimer's disease (Tahan et al., 1992). Alzheimer's Disease (AD) accounts for more than 60% of dementia cases and is the fourth cause of mortality in the elderly. AD is possibly the result of a multifactorial process involving genetic and environmental components, both modulated by the normal aging process. Among potential environmental risk factors for AD, aluminium (Al) has been the most intensively studied neurotoxin substance. Results suggest the possible presence of an association between organic monomeric Al exposure and AD development (Gauthier et al, 2000). Aluminium also has been added to drinking water as aluminium sulphate at the treatment plants to flocculate organic matter and to clarify the water. The ingestion pathway was the main route of Al intake for Mumbai adults (Tripathi, Mahatra and Raghunath, 2002).

Possible relations between high Al content in tissues and neurodegenerative disorders like Alzheimer's Disease and encephalopathy are the main concerns. There is a report stating increased levels of Al in the bulk brain tissue of Alzheimer's patients (Copestake, 1993). There are two potential sources for Al intoxication in CRF individual, which are intestinal absorption from aluminium-containing phosphate-binding gels (aluminium hydroxide, aluminium carbonate, etc) and transfer of aluminium across the artificial kidney membrane from the dialysate into the patient's blood during haemodialysis (Tahan et al., 1992).

In 1988, a drinking water treatment error led to 20,000 individuals in Cornwall, England being exposed to elevated levels of aluminium sulphate in their drinking water over a three-day period. Although members of the population reported GI disturbances and oral ulcerations, the role of aluminium could not be isolated because of other associated changes in water chemistry, including a decrease in pH and elevation in the concentrations of copper, zinc, and lead (dissolved from domestic plumbing fixtures) (Krewski and Yokel, 2006).

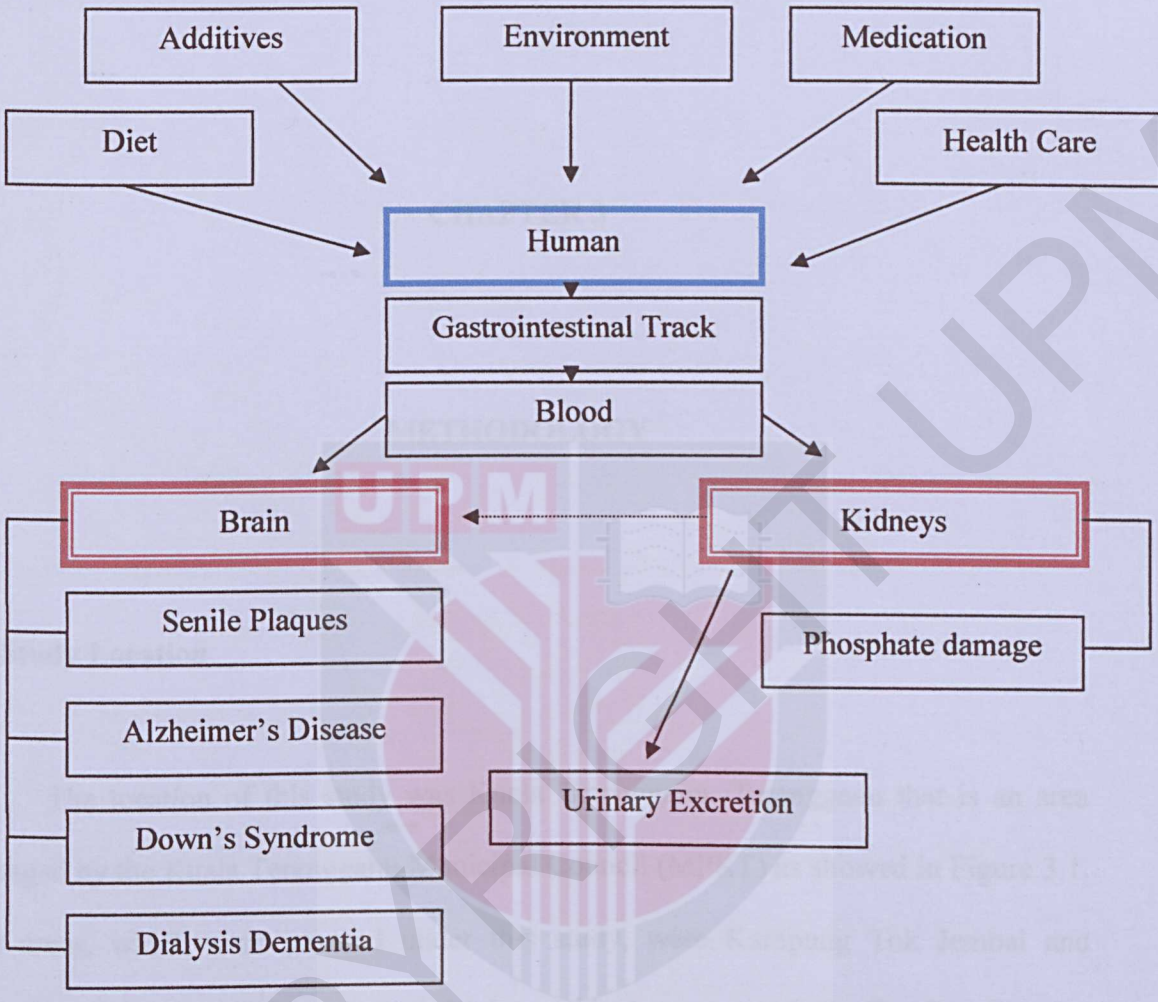

Figure 2.2: Aluminium pathways in human (Massey and Taylor, 1988)

CHAPTER 3

METHODOLOGY

3.1 Study Location

The location of this study was Kuala Terengganu, Terengganu that is an area managed by the Kuala Terengganu Municipal Council (MPKT) as showed in Figure 3.1. The areas, which were covered under this study, were Kampung Tok Jembal and Kampung Pak Tijah. This study took Malay residents as respondents. Syarikat Bekalan Air Terengganu Sdn. Bhd. (SATU) managed the municipal water supply in Kuala Terengganu.

Figure 3.1: Study location

3.2 Study Design

This was a cross-sectional study which was aimed to describe the relationship between effects of aluminium in drinking water and health risk that may exist in a specified population at a particular time, without regards for what may have preceded or precipitated the health status found at the time of the study.

3.3 Study Population

The study population of this study was either male or female adults living in the two villages in Kuala Terengganu and consumed treated water as the main source of drinking water.

3.4 Sampling

3.4.1 Study sample

The study sample consists of respondents who was fulfilled the inclusive and exclusive criteria.

Inclusive criteria: Respondent who live at Kuala Terengganu and respondents who are above 18 years old (Malaysian Law, 2006).

Exclusive criteria: Respondents who are drinking water from the bottles water or filtered water.

3.4.2 Sampling unit

The sample unit for this study was one person from each house who fulfilled the inclusion criteria and using the water for drinking from the water treatment plant. A person who consumed water other than municipal water supply and use personel filtration system at home was excluded.

3.4.3 Sample size

Sample size for this study was calculated using a formula from Kirkwood and Sterne (2009) with the equation below:

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

Where, N=Sample size

P= Prevalence

e= Probability

For a 95% of level of confidence, the margin error is ±2 times the standard errors. Therefore the error, *e*= 0.05. While for the value of P is 0.70 based on the study by Qaiyum et al., (2011).

$$N = \frac{0.70\,(1-0.70)}{(0.05)^2}$$

$$=84$$

Based on the calculation above, the sample size of this study was 84 respondents but increase by 20% for considering non-response and missing data, so the sample size was 100 respondents.

3.4.5 Sampling method

The sampling method that was used in this study is purposive sampling. Purposive sampling targets a particular group of people. Respondents were selected based on the inclusion and exclusion criteria. In this study, people who did not fulfil the criteria were excluded from this study.

3.4.6 Sampling frame

The adopted sampling frame included the name list of respondents who live in a selected population in Kuala Terengganu. The name list of respondent was obtained from the head's village.

3.5 Study Instrument

3.5.1 Questionnaires

A set of questionnaires was prepared. The questions were about social demography such as age, socio-economic background, and water supply information. The respondents were asked to declare personel information such as body weight, gender, age, education, income level, and other relevant information.

3.5.2 Graphic Furnace Atomic Absorption Spectrometer (GFAAS)

The Graphic Furnace Atomic Absorption Spectrometer (GFAAS) was a usable instrument in application as indicated by its specification. In this study, with sufficient sensitivity of AAS, it was used to determine the aluminium level in the drinking water.

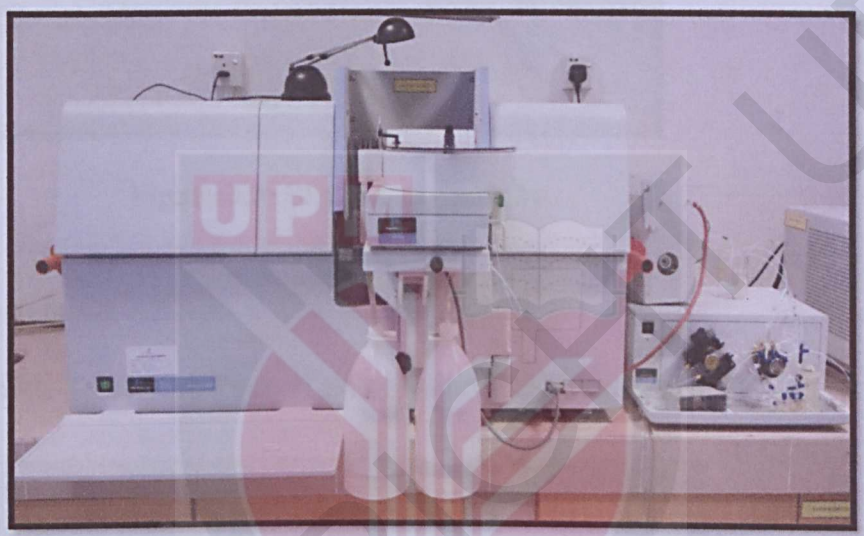

Figure 3.2: Graphic Furnace Atomic Absorption Spectrometer (GFAAS)

3.5.3 SECA Body Weight

Body weight was required to calculate the Chronic Daily Intake (CDI) of aluminium in drinking water. Body weight of respondents was measured by using a SECA Body Weight. Unit of measurement was Kilogram (kg).

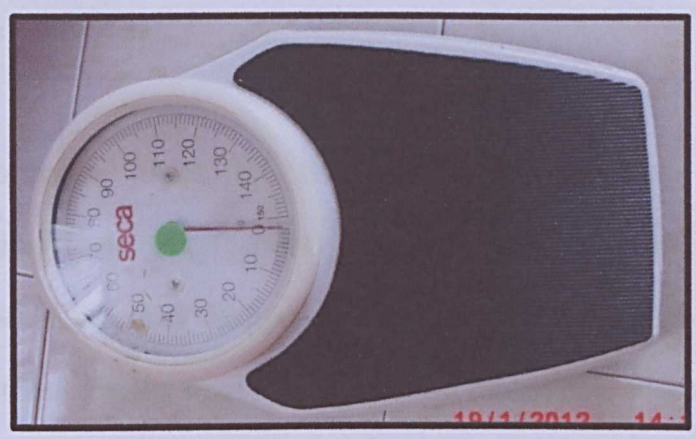

Figure 3.3: SECA body weight

3.5.4 Water Analysis

A Lamotte Tracer Orp PockerTester was used to measure pH.

Figure 3.4: Lamotte Tracer ORP Pocket Tester

3.6 Data Collection

Information about the background of respondents was obtained using questionnaire. Then, body weight of the respondent was measured and later, water samples were taken from the pipe that usually used by the respondent for drinking. The water was taken directly from the pipe without rubber pipe attached to it and poured into a high-density polyethylene (HDPE) bottle.

Water was let to run for 3 to 5 minutes before samples were taken. The sample was taken as close as possible to the pipe. The water was slowly run inside the bottle with gentle stream to avoid turbulence and air bubbles. The water sample was then preserved to pH to 2 or less reading using 65% nitric acid (Kavcar et al., 2008). Before that, pH were measured.

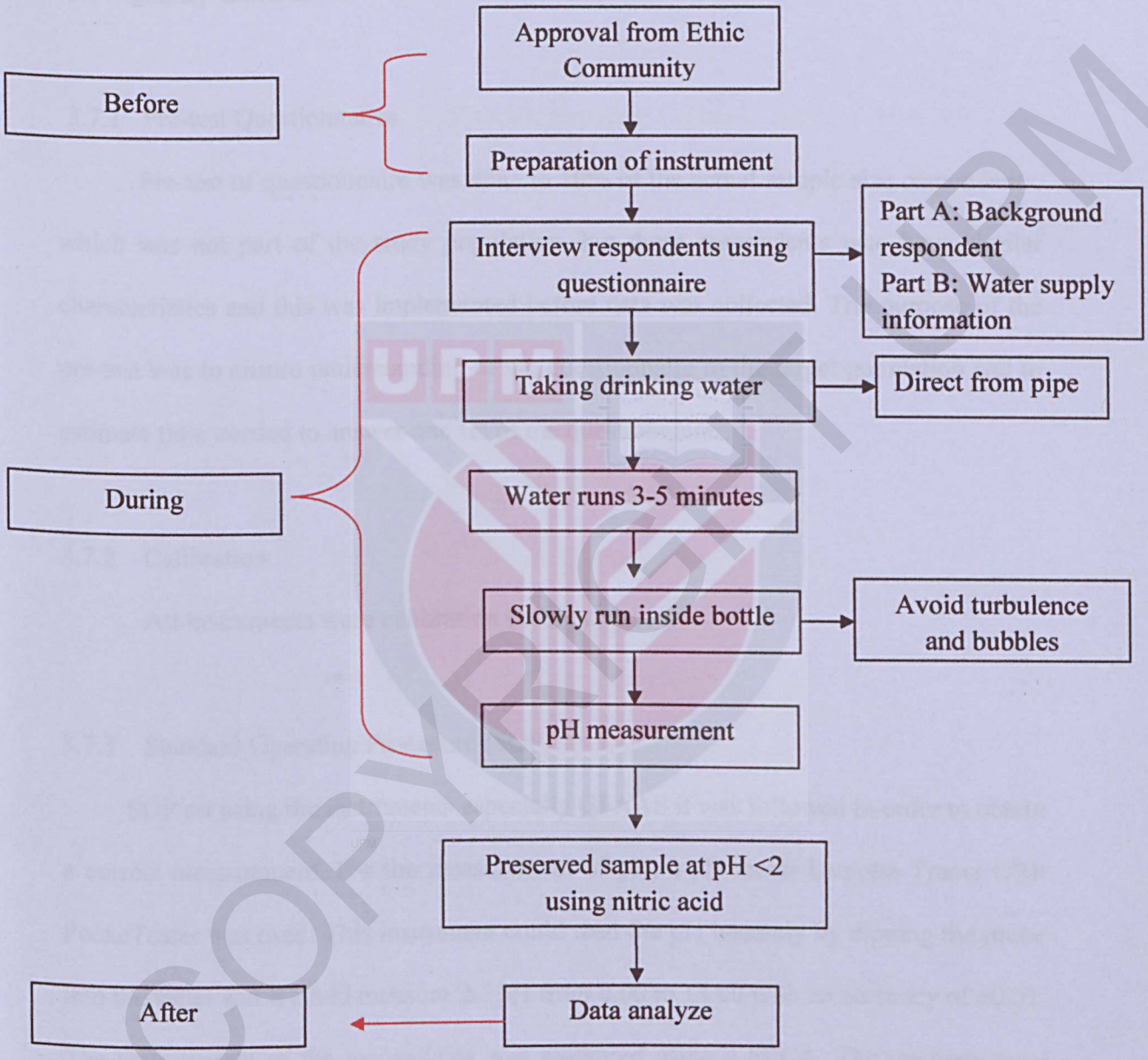

Figure 3.5: Summary on data collection

3.7 Quality Control

3.7.1 Pre-test Questionnaires

Pre-test of questionnaire was done to 10% of the actual sample size respondents, which was not part of the study population, but those respondents who have similar characteristics and this was implemented before data was collected. The purpose of the pre-test was to ensure understanding of the questionnaire to the target population and to estimate time needed to answer one set of the questionnaire.

3.7.2 Calibration

All instruments were calibration before use.

3.7.3 Standard Operating Procedure (SOP)

SOP on using the instruments especially GFAAS it was followed in order to obtain a correct measurement. For the measurement of pH, a pH meter Lamotte Tracer ORP PockeTester was used. This instrument could read the pH instantly by dipping the probe into the water and it could measure the pH from 0.00 to 14.00 with an accuracy of ±0.01. The body weight of the respondents was measured using a SECA. The readings were taken three times and then averaged.

3.8 Risk Assessment

In order to estimate health risk associated with aluminium in drinking water, chronic daily intake (CDI) was used where the calculation using the following equation (United Stated Environmental Protection Agency (USEPA)), 1991):

$$CDI = \frac{(C_1 R_1 F_E D_t)}{W_B T_{AVG}}$$

Where,

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

C_1= Level of Aluminium concentration (mg/l)

R_1= Ingestion rate (l/day)

F_E= Exposure frequency (day/year)

D_t= Exposure duration (year)

WB= Body weight (kg)

TAVG= Average of exposure duration (D×365 days/year)

To estimate non-carcinogenic risk, the hazard index (HI) was calculated using the following equation:

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

Where,

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

RfD = Reference dose (mg/kg/d)

3.9 Data Analysis

Data analysis was performed using the Statistical Program for Social Science (SPSS) version 19. Kolmogorov Smirnov test was used to determine the normality of data. If data was not normal, the data should be $\log_{10}$ to conform the normality. If the data was still not normal, non-parametric tests was used.

3.10. 1 Univariate Analysis

Data collected was analyzed descriptively by measuring mean, range, maximum, minimum and standard deviation. The variables analyzed was income, levels of education, weight and age. This analysis was used for the first and second objectives. Descriptive test was used to determine the third hypotheses which to determine the mean of aluminium level in drinking water and compare it with Malaysia Standard of Drinking Water Quality.

3.10.2 Bivariate Analysis

Kolmogorov-Smirnov test was used to determine the normality of the data. In this study, p-value less than 0.05 were considered to indicate a significant of the difference between compared groups. For the forth objective which to determine the relationship of aluminium and physical properties, Pearson Correlation was used for the data if normally distributed. For the last objective, calculation by using formula to determine the health risk.

3.10 Ethical Clearance

The approval from the Ethic Committee of the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia was obtained before the study was started. Before taking samples, permission as well as written consent signed by respondent is obtained. The detailed explanation about the activities to be carried out was explained. In order to respect the right of the respondents, the identity of the respondents including their personel information remained confidential.

3.11 Study Limitations

i. This study focused on the exposure of aluminium in drinking water, which was to assess the health risk of this exposure to residents. This risk assessment could not establish causal effect for aluminium exposure and Alzheimer's Disease.

ii. Recall bias was unavoidable as the respondent were asked based on the standard 200ml cup to estimate the daily intake of drinking water per day.

iii. This study took only drinking water. No biological samples were taken from respondents to determine the actual aluminium level in the body.

iv. This health risk assessment was specific to aluminium concentration in drinking water source only. Risks arising from other environmental and occupational sources of aluminium were not studied.

CHAPTER 4

RESULTS

4.1 Respondent Background

The study was conducted in Kuala Terengganu, Terengganu which involved two villages, Kampung Tok Jembal and Kampung Pak Tijah. The aim of this study was to determine the aluminium concentration in the drinking water and to assess associated health risk among the respondents. There were 69 respondents involved in this study.

There were 23 (33.3%) male and 46 (66.7%) female respondents involved in this study. All respondents were Malay. Most of the respondents (26, 37.7%) had primary school education, while the remaining has education level from no education to degree holders as showed in Table 4.1.

Table 4.1: Sex and education level distribution

Variable	N	%
Sex :		
Male	23	33.3
Female	46	66.7
Education level:		
Primary school	26	37.7
PMR	14	20.3
SPM	18	26.1
STPM/Diploma	3	4.3
Bachelor	3	4.3
No education background	5	7.2

N= 69

The age range was 19 to 90, with a mean of 47.84 and standard deviation, 15.918. Most of the respondent's age was between 28 to 37, which encompass 18 (26.1%) respondents. For income, most of the respondents (44-63.8%) had income between RM500-RM1999. Please refer to Table 4.2.

Table 4.2: Age and income contribution

Variable	N	%	Mean ± S.D	Range
Age:				
18-27	6	8.7		
28-37	18	26.1		
38-47	10	14.5		
48-57	15	21.7	47.84±15.918	19-90
58-67	13	18.8		
68-77	5	7.2		
78-87	1	1.4		
88-97	1	1.4		
Income (RM):				
<500	21	30.4		
500-1999	44	63.8		
2000-3999	4	5.8		
>4000	0	0		

N= 69

For the duration of using piped water system, 32 (46.4%) respondents have used pipe system for more than 20 years. The mean duration was 21.43 with standard deviation of 16.067 while the range was from 1 year to 61 year. Most of the respondents

(66-95.7%) had drank between 5 to 10 glasses (200ml) of water per day with a mean of 7.42, standard deviation 1.528 and range was from 2 to 10. Please refer to Table 4.3.

Table 4.3: Duration using piping water supply and the number of glass of water

Variable	N	%	Mean ± S.D	Range
Duration:				
<10	23	33.3		
10-20	14	20.3	21.43±16.067	1-61
>20	32	46.4		
Glass of water (200ml):				
<5	3	4.3		
5-10	66	95.7	7.42±1.528	2-10
>10	0	0		

N=69

4.2 Aluminium level in drinking water samples in two villages in Kuala Terengganu

Aluminium levels were analysed using Atomic Absorption Spectrometer (AAS). The unit of measurement was mg/liter. Descriptive test was used to determine mean, standard deviation and range using SPSS 19. The mean aluminium level in drinking water in the two villages was 0.2063 with standard deviation of 0.1028 and range was from 0.027 to 0.611. Please refer to Table 4.4 and Figure 4.1.

Table 4.4: Aluminium level in drinking water

Variable	Mean ± S.D	Range
Aluminium level (mg/L)	0.2063±0.1028	0.027-0.611

N=69

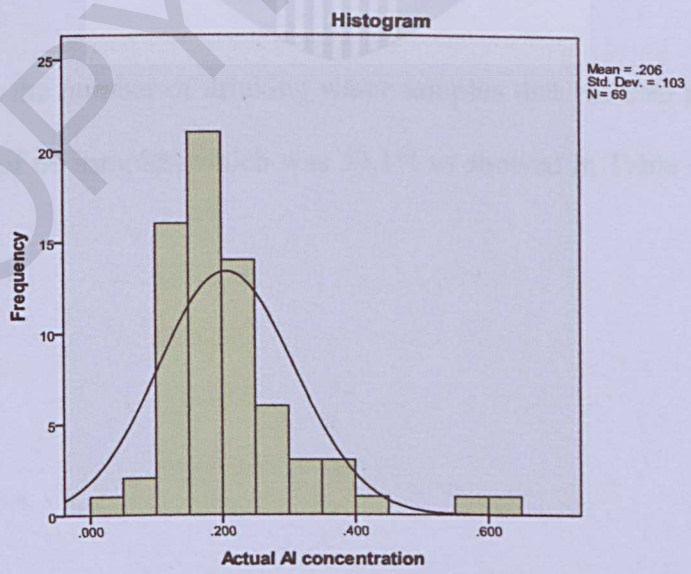

Figure 4.1: Normality curve of the aluminium level

4.3 The difference of mean aluminium level in drinking water samples compared with National Standard for Drinking Water Quality (NSDWQ)

Descriptive test was used to determine mean of aluminium level in drinking water samples. The mean of aluminium level in this study was 0.2063 mg/liter and The National Standard for Drinking Water Quality (NSDWQ) Malaysia stated that the safe upper limit for aluminium level in drinking water is 0.2 mg/liter. Please refer to Table 4.5.

Table 4.5: Difference of mean aluminium level with NSDWQ

Variable	Mean	NSDWQ
Aluminium Level (mg/liter)	0.2063	0.2

In this study, the number of drinking water samples that violated the upper limit was 27 from a total of 69 samples, which was 39.1% as showed in Table 4.6 and Figure 4.2.

Table 4.6: Violation of aluminium level

National Standard for Drinking Water Quality	Frequency	%
Violation (>0.2 mg/liter)	27	39.1

N=69

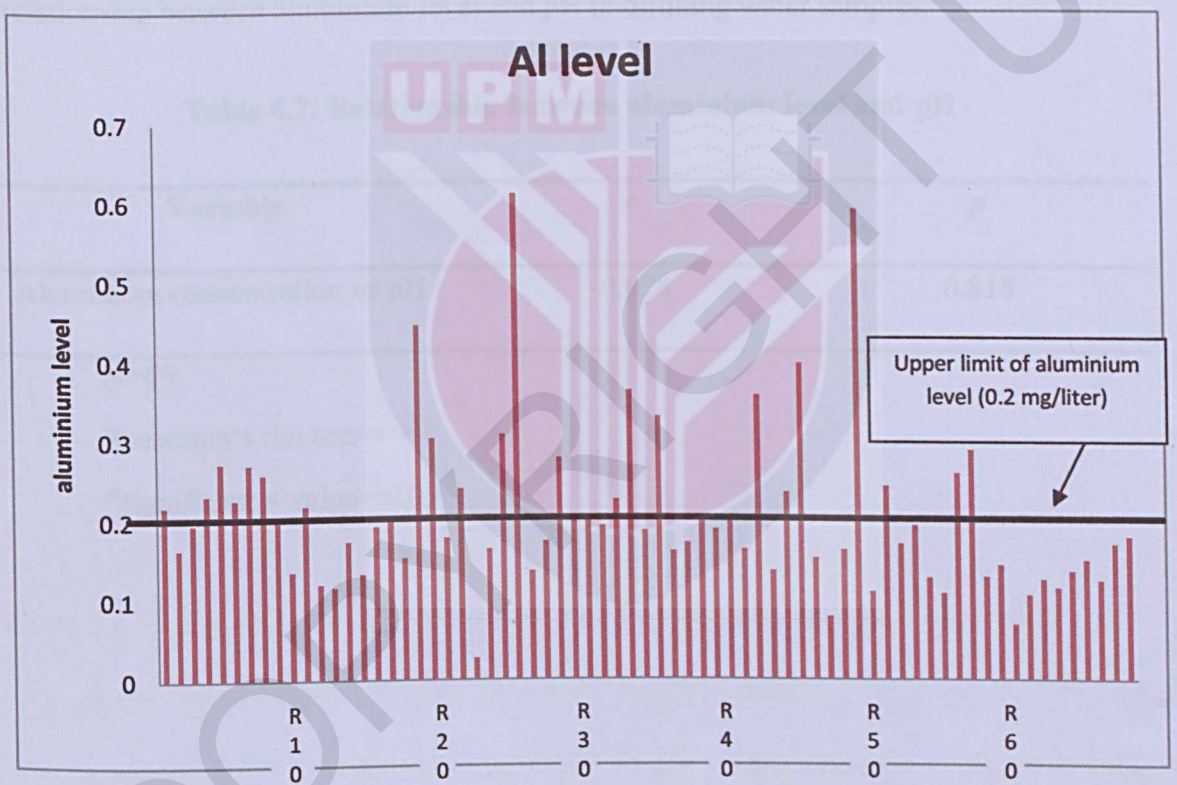

Figure 4.2: Aluminium level

4.4 The relationship between aluminium level and pH in drinking water samples

Spearman's rho test was used to determine the relationship between aluminium level and pH in drinking water samples. It was found that the r-value was -0.028 and p value was 0.818 as showed in Table 4.7. This indicated that there was no significant relationship between aluminium level and pH in drinking water samples.

Table 4.7: Relationship between aluminium level and pH

Variable	*r*	*p*
Aluminium concentration vs pH	-0.028	0.818

N=69

Spearman's rho test

*significant *p*-value <0.05

4.5 Health risk of aluminium exposure among respondents

In order to determine the health risk of aluminium exposure among respondents, chronic daily intake (CDI) was calculated. By using descriptive test, the mean CDI value was 0.00566 with the standard deviation of 0.00363 and range from 0.001 to 0.0233. Please refer to Table 4.8.

Table 4.8: Chronic daily intake

Variable	Mean ± S.D	Range
CDI	0.00566±0.00363	0.001-0.0233

N=69

Hazard index (HI) was calculated to determine the health risk of aluminium exposure among respondents. HI was determined by dividing the value of CDI with reference dose (RfD). Based on the World Health Organization (WHO) recommendation, the RfD for aluminium exposure is 7 mg/kg/day. From the calculation, it was found that all respondents have a HI of less than 1 with a mean of 0.0008 and standard deviation of 0.0005. Please refer to Table 4.9.

Table 4.9: Hazard Index of respondents

Hazard Index (HI)	Frequency	(%)	Mean ± S.D
HI<1	69	100	0.0008±0.0005
HI>1	0	0	

N=69

CHAPTER 5

DISCUSSION, CONCLUSION & RECOMMENDATION

5.1 Discussion

5.1.1 Respondent Background

A total of 69 respondents were chosen from two villages in Kuala Terengganu, which are Kampung Tok Jembal and Kampung Pak Tijah. Syarikat Bekalan Air Terengganu (SATU) was responsible in supplying treated water to these areas.

Based on sample size calculation, 100 respondents were needed, but only 69 respondents were involved in this study due to several factors. There were the respondents who did not give cooperation, limited time frame on collecting data and most of the people in these two villages did not used piped water supply (using well) and some of the residents using water filter. The respondents consisted of 23 males and 46 females. More females were involved in this study because males refused to be

interviewed and females were mostly available during the data collection time (i.e. during working hours).

Most of the respondents have an age range from 28 to 37 and for income, most of the respondents had income of between RM500-RM1999 (63.8%). The areas of study were about 15 km from town, which contributed to the better income bracket. Duration of using piped system is very important because it showed the duration of respondents being exposed to aluminium in drinking water. In this study, 46.4% respondents have pipe system more than 20 years, which showed the respondents being exposed to aluminium for a long time.

5.1.2 Aluminium level in drinking water samples in two villages in Kuala Terengganu

The use of aluminium sulphate as a coagulant in the water treatment process has major and substantial public health benefits. If there is an additional of certain material during the aeration process for acidic raw water, this process may influence aluminium levels in treated water. With the use of aluminium in water treatment, it is impossible not to have some low level of aluminium in treated water (Diaconu and Nanau, 2009).

The concentration of a chemical in water may be reduced before the water reaches consumers – physical, chemical and biological processes may reduce the

concentration of particular chemicals between their sources and consumers (WHO, 2007). The design and operation of process at water treatment plants also influence the Al levels in treated water that is delivered to consumers. The addition of aluminium sulphate in raw water as a coagulant that is not removed during treatment will remain as residual Al in the treated water (Srivinasan et al., 1999). This may cause the Al level in finished water to be higher than allowable levels as found in this study, where the aluminium level is 0.611 mg/liter. Based on Health Canada (2008), high contamination in raw water or inadequate pH control during treatment also can contribute to higher aluminium levels in drinking water.

In this study, there is possible excessive alum dosage used during the water treatment, which cause high aluminium residues in drinking water. Aluminium level in drinking water can be affected by other factors such as pH and conductivity.

Based on a previous study by Qaiyum et al. (2011) in two villages in Batu Pahat, Johor, the mean of aluminium level in drinking water of 0.200 mg/liter and 0.22 mg/liter that was similar with mean of aluminium level in this study (0.206 mg/liter). Aluminium levels in drinking water in this study ranged from 0.027 to 0.611 mg/liter, which is almost similar to finding from a study conducted by Rubinos et al. (2005) in Northwest Spain, which varies from 0.008 to 0.650 mg/liter. The possibility of source water and

dosage of alum causes the varying differences of aluminium levels between different places.

5.1.3 The difference of aluminium level in drinking water samples compared with National Standard for Drinking Water Quality

There was no significant difference in aluminium level in drinking water compared with National Standard for Drinking Water Quality. There were 39.1% water samples violating the upper safe limit (0.2 mg/liter). Although the results showed less that half of the water samples violated the upper safe limit, its still did not meet the requirement stated by National Standard for Drinking Water Quality (0.2 mg/liter). This may be due to the high alum dosage, which was added to raw water during water treatment, therefore the residual aluminium in the treated water becomes high. High dosage of alum will be added to the raw water during water treatment if the raw water source is highly contaminated with organic matters, turbidity, and microorganism levels.

A previous study by Srinivasan (2002) also stated the most of the aluminium level in drinking water were below the guideline value of 0.1 mg/liter (100 µ/ liter) by Health Canada Guideline. Another study by Rubinos and Arias (2005) showed that only 19% of water samples contained aluminium level above the maximum allowable concentration level of 0.2 mg/ liter. A study in Romania (Diaconu and Nanau, 2009)

found that there was a variation of the aluminium level in water sample (raw water, coagulation, filtration and drinking water) collected from water treatment plants. The highest aluminium level is at the coagulation process and getting less in drinking water. From that study, 15.9% of the samples have residual level of aluminium greater than 0.2 mg/liter (Diaconu and Nanau, 2009).

5.1.4 The relationship of aluminium level and pH in drinking water sample

Based on the study by Srinivasan et al. (1999), temperature, pH and turbidity of the water are important factors in determining aluminium solubility and consequently residual aluminium in the finished water. Basically, aluminium is soluble at extremely acidic (pH<6) and alkaline (ph>8.5) conditions, but is insoluble at near natural pH values (7.0 to 7.5) (Srinivasan, 1999). In water treatment process, additional of aluminium sulphate will caused low pH in water, which is suitable to coagulated the raw water. Then, lime is added to increased pH to 7 before being distributed to the population because low pH will caused erosion to the pipes. However, in natural pH, the aluminium in the water is insoluble and it remains as residue.

In this study, pH was measured to determine the relationship between aluminium level and pH in drinking water samples. In the water treatment process, alum was added; consequently, the aluminium levels in treated water are often higher than those in raw water. Therefore, the presence of aluminium in water supply was either due to the

addition of aluminium salts such as aluminium sulphate during water treatment as coagulation and flocculation or caused by a low pH.

With regards to the National Standard for Drinking Water Quality (2000), the suitable pH for drinking water is 6.5 to 9.0. In this study, the range of pH was 5.35-8.14 and the aluminium level was 0.027 to 0.611 mg/liter. From the result showed that there are no significant relationship of aluminium level and pH in drinking water. This may be due to influence of other heavy metals such as lead, zinc and copper. A study by Akbulut and Tuncer (2009) stated that an increase in pH generally decreases the solubility of toxic heavy metal.

5.1.5 The health risk of aluminium exposure among respondents

There are several factors that need to be considered in calculating the chronic daily intake (CDI) in humans such as aluminium level (mg/liter), body weight (WB), amount of water consumed (liter) and duration of exposure (D).

This study found that mean CDI of respondents was 0.00566 mg/kg/day, which less than the CDI in a previous study in Batu Pahat, which was 0.00619 mg/kg/day (Qaiyum, Shaharuddin and Syazwan, 2011). However, it was higher than a study conducted by Dzulfakar (2011) which was 0.0035 mg/kg/day. This may be due to several factors such as aluminium levels in drinking water for the locations, respondent's

body weight, exposure duration to aluminium in drinking water and the amount of water consumed.

Hazard Index (HI) was used to determine the hazard risk, where, if HI value is less than 1, it indicates there are no potential for adverse health effects (non carcinogenic), while if HI more than 1, it indicates there are potential adverse health effect or the need for further study. In this study, the related health risk by exposure of high aluminium level such as Alzheimer's disease and Parkinson's disease. The result showed that 100% of respondents have a HI of less than 1, which means that the risk was acceptable. Its means that the population at these two villages were not at risk if only taken to account aluminium exposure via drinking water. This finding was similar with the previous studies conducted in Batu Pahat and Kuantan, which found HI value of less than 1.

5.2 Conclusion

The result showed that all hypotheses in this study were not accepted. The first hypothesis of this study was not accepted because there are no differences between aluminium levels in drinking water sample with the National Standard for Drinking Water Quality. There are no significant relationships between aluminium level and pH in the drinking water, therefore the second hypothesis was also not accepted. In the other finding in this study, there are no respondents with HI more than 1, which showed that the risk was negligible.

In conclusion, this study found that the mean aluminium level in two villages in Kuala Terengganu was 0.206 mg/liter, therefore when compared to the National Standard for Drinking Water Quality (0.2 mg/liter), there are no significant differences between drinking water sample and the upper safe limit. However, there are 27 (39.1%) out of 69 water samples exceeded the upper limit of aluminium level in treated water. From the findings, HI for all were respondents less than 1, so this showed that the study areas were considered safe from having risk related to the disease like Alzheimer's disease.

5.3 Recommendation

This study was conducted at two villages in Kuala Terengganu, which involved 69 respondents, and the results only represent those two areas. For further studies, increasing the total of the respondents (larger sample size) and additional villages are needed to know the actual aluminium level expose on the population of Kuala Terengganu.

This study can be improved by comparing between two or more treatment plants, which has same system of operation on water treatment. It is important to collect water samples from different locations, which is supplied by different treatment plants to know the aluminium levels. By comparing the treatment plants, we can know which treatment plant has good service and maintenance. Water treatment plants should optimize the water treatment processes as well as have a regular maintenance in order to produce drinking water with the lowest possible aluminium content.

This study only focused on ingestion of aluminium from drinking water and did not consider the exposure from the other sources such as food and occupation and estimated the risk of aluminium exposure in drinking water by using a formula. For future studies, these sources should be considered by the researcher in their studies to determine the exposure of aluminium in humans. There were no biological samples (i.e. blood, urine) taken to determine the actual aluminium level in the body. This study can

be improved by taking biological samples such as blood to know actual aluminium level exposure on the population.

The monitoring on treated water at the house by the authorities is very important in order to ensure that aluminium levels are below the upper safe limit (0.2 mg/liter) and to ensure that consumers received the treated water are safe and no adverse effect to their health.

The levels after treatment are should be below 0.2 mg/liter. However, if the source water has lot of organic material from the soil and the rivers, then a lot more alum is needed to coagulate it. Therefore, to avoid adding high dosage of alum in the raw water, highly contamination raw water should not be treated and should be allowed to pass.

Alternative coagulants, such as iron salts, may be useful as replacements for aluminium sulphate and will result in lower aluminium residuals, originality from raw water. Alternative coagulants should be used only following a thorough on-site evaluation of their performance.

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APPENDICES

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

PENERANGAN KEPADA RESPONDEN

Sila baca maklumat berikut. Jika ada sebarang soalan, sila rujuk penyelidik.

TAJUK KAJIAN

Penilaian Risiko Kesihatan Terhadap Pendedahan Lebihan Aluminium Di dalam Air Minuman di Kalangan Penduduk di Dua Buah Kampung di Kuala Terengganu, Terengganu.

PENDAHULUAN

Air mentah akan dirawat terlebih dahulu dengan melalui pelbagai process rawatan sebelum boleh digunakan oleh penduduk. Dalam proses tersebut, terdapat beberapa bahan akan ditambah ke dalam air mentah untuk merawat air resebut. Antaranya adalah aluminium sulphate ($Al_2(SO_4)_3$), dimana ia akan ditambah ke dalam air sebagai bahan pengumpalan dalam rawatan air. Aluminium sulphate ditambah ke dalam air kerana ingin mengurangkan kekeruhan, bahan organic, warna dan mikroorganisma. Pendedahan terhadap lebihan aluminium secara berlebihan akan memberikan kesan buruk terhadap kesihatan antaranya menjadi prekusser kepada penyakit Alzheimer. Terdapat kajian yang menyatakan penyakit Alzheimer ada kaitan dengan kandungan aluminium di dalam otak manusia, akibat pendedahan terhadap aluminium di dalam air minuman dalam jangkamasa yang lama. Berdasarkan Kementerian Kesihatan Malaysia, piawaian paras aluminium di dalam air minuman adalah 0.2 ml/liter.

APAKAH YANG ANDA AKAN LAKUKAN?

Anda akan di temubual dan perlu menjawab standard soalan yang telah di ubah suai. Anda perlu menandatangan borang persetujuan responden, dimana ia menunjukkan anda berminat dalam kajian ini. Selain itu, anda perlu memulangkan borang persetujuan tersebut kepada penyelidik apabila menjawab soalan tersebut.

SIAPAKAH YANG TIDAK PERLU MENYERTAI KAJIAN INI?

Sesiapa yang tidak memenuhi ciri-ciri pemasukan di dalam kajian ini adalah tidak perlu menyertai kajian ini. Ciri-ciri kemasukan tersebut ialah orang dewasa daripada setiap rumah yang tidak menggunakan sistem penapisan, dimana mereka mengunakan air secara terus daripada paip untuk minum atau memasak dalam urusan harian. Rumah yang menggunakan sistem penapisan akan dikecualikan daripada kajian ini.

APAKAH KEBAIKAN KAJIAN INI:

(a) KEPADA RESPONDEN

Kajian ini ini akan memberikan maklumat tentang tahap kebersihan bekalan air di kawasan kediaman anda. Ini termasuklah tahap aluminium yang terdapat di dalam air paip. Di samping itu, melalui pengiraan kronik pengambilan harian air paip, responden akan dapat menganggarkan kesan buruk terhadap kesihatan daripada minum air paip yang tidak ditapis.

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FACULTY OF MEDICINE AND HEALTH SCIENCES
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SELANGOR, MALAYSIA

b) KEPADA PENYELIDIK

Kajian ini akan membantu penyelidik dalam menentukan hubung kait antara pengambilan harian aluminium dalam air paip dengan indikator kesihatan dalam kawasan kajian. Penemuan dalam kajian ini akan dijadikan baseline data dan membantu penyelidik dalam mendapatkan degree dalam B.S. Kesihatan Persekitaran dan Pekerjaan.

ADAKAH TERDAPAT APA-APA RISIKO?

Tidak, kajian tidak memberi apa-apa risiko kepada responden.

APAKAH KEMUNGKINAN MENARIK DIRI?

Kajian ini adalah berdasarkan penyertaan secara sukarela. Jika respoden berasa tidak selesa untuk meneruskan kajian ini, respondent boleh menarik diri daripada kajian ini pada bila-bila masa.

ADAKAH MAKLUMAT PERIBADA DAN IDENTITI SAYA KEKAL RAHSIA?

Ya, semua maklumat berkaitan dengan anda akan dirahsiakan dan hanya diketahui oleh penyelidik sahaja.

SIAPAKAH YANG PATUT SAYA HUBUNGI JIKA SAYA ADA MAKLUMAT TAMBAHAN SOALAN?

AMINAH BINTI ABDUL HALIM (019-4027221)- Penyelidik

DR. SHAHARUDDIN MOHD SHAM (03-89472407)- Supervisor

FAKULTI PERUBATAN DAN SAINS KESIHATAN
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BORANG PERSETUJUAN (RESPONDEN)

TAJUK KAJIAN : PENILAIAN RISIKO KESIHATAN TERHADAP PENDEDAHAN LEBIHAN ALUMINIUM DI DALAM AIR MINUMAN DI KALANGAN PENDUDUK DI DUA BUAH KAMPUNG DI KUALA TERENGGANU, TERENGGANU.

PENYELIDIK : AMINAH BINTI ABDUL HALIM

Saya .....No. Kad pengenalan .....
alamat.....
..... dengan ini secara sukarela bersetuju menyertai dalam penyelidikan klinikal *(kajian klinikal, kajian soal selidik/ percubaan ubat) yand dinyatakan diatas.

Saya telah dimaklumkan tentang sifat penyelidikan klinikal dari segi metodologi, risiko dan kemungkinan komplikasi (rujuk kepada Lembaran Maklumat). Saya faham bahawa saya mempunyai hak untuk menarik diri daripada penyelidikan klinikal ini pada bila-bila masa tanpa memberi apa sahaja alasan. Saya juga faham bahawa kajian ini adalah sulit dan semua maklumat yang diberikan mengenai identiti saya akan kekal sulit dan rahsia.

Saya berharap untuk *tahu/ tidak berharap untuk mengetahui keputusan yang sampel saya.

* padam mana yang berkenaan

Tandatangan ..... Tandatangan .....
(*Responden*) (*Saksi*)

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

No. K/P :.....

Saya mengesahkan bahawa saya telah memberitahu kepada responden tentang sifat dan tujuan kajian seperti di atas- penyelidikan klinikal.

Tarikh ..... Tandatangan .....
(Penyelidikan)

UNIVERSITI PUTRA MALAYSIA

BERILMU BERBAKTI

FAKULTI PERUBATAN DAN SAINS KESIHATAN

UNIVERSITI PUTRA MALAYSIA

TAJUK KAJIAN:

Penilaian Risiko Kesihatan Terhadap Pendedahan Lebihan Aluminium di dalam Air Minuman di kalangan Penduduk di Dua Buah Kampung di Kuala Terengganu, Terengganu

No.responden: ☐☐☐

Tarikh soal selidik:

Masa:

Tempat:

Terima kasih kerana sudi untuk turut serta dalam kajian ini. Kerjasama anda amat dihargai. Segala maklumat adalah rahsia dan hanya untuk kajian ini sahaja. Sekian. Terima kasih.

BAHAGIAN A

No Kad Pengenalan | | | | | | | | | | | | |

Nama:

Alamat:

No Tel. Rumah:

Bimbit:

1. Jantina

   Lelaki ☐ Perempuan ☐

2. Bangsa

   Melayu ☐ Cina ☐

   India ☐ Lain-lain ☐

   .....(Nyatakan)

3. Tahap pendidikan

   Sekolah Rendah ☐ PMR ☐

   Tidak belajar ☐ SPM ☐

   Pengajian Tinggi ☐ Lain-lain ☐

   .....(nyatakan)

4. Pekerjaan

   Kerajaan ☐ Swasta ☐

   Sendiri ☐ Tidak bekerja ☐

   Lain-lain ☐

   ..... (Nyatakan)

5. Jumlah pendapatan isi rumah

   ..... (Nyatakan)

BAHAGIAN B

6. Berapa lama tinggal di kawasan ini?

   .....(Tahun).....(bulan)

7. Apakah bekalan air yang digunakan

   Paip air JBA ☐

   Telaga ☐

   Gabungan diatas ☐

   Lain-lain ☐

   .....(Nyatakan)

8. Berapa lama anda menerima bekalan air paip

   .....(Tahun).....(bulan)

9. Berapa gelas air yang anda minum sehari

   .....Gelas sehari

10. Pernahkah air paip berbau?

Ya

Tidak

11. Pernahkah air paip mengalami kekeruhan

Ya

Tidak ☐

12. Apakah sumber air yang anda kerap gunakan?

Air paip ☐
Air botol ☐

13. Adakah anda mengambil ubat-ubatan?

Ya ☐

Tidak ☐

14. Jika Ya, apakah ubat-ubatan tersebut

..... (Nyatakan)

BAHAGIAN C: Kegunaan penyelidikkan

15. Berat badan responden

.....KG

16. Kepekatan aluminium dalam air

.....mg/L

17. Adakah seringkali anda bersifat pelupa?

☐ Ya ☐ Tidak

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

☐ Ya ☐ Tidak

*Baseline, descriptive and time, National Human Exposure Assessment Survey (NHEXAS)-Arizona study

(Kavcar et. Al, 2009)