



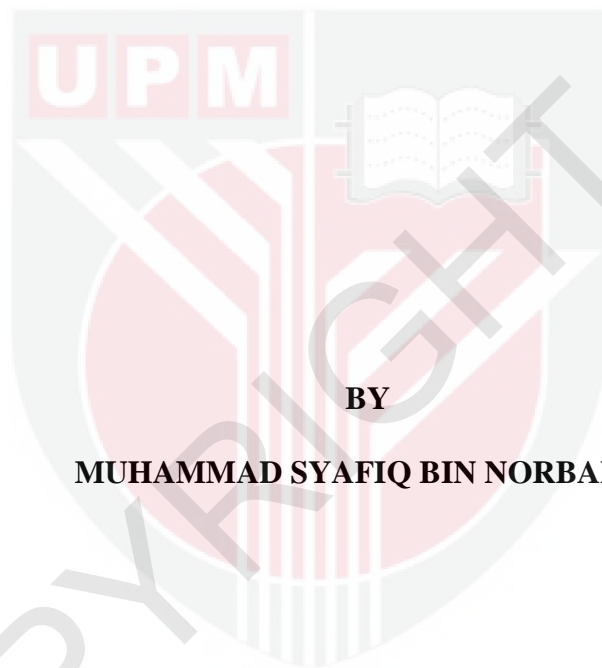
UNIVERSITI PUTRA MALAYSIA

***CONTAMINATION OF NITRATE IN GROUNDWATER AND HEALTH
RISK ASSESSMENT IN TANAH MERAH, KELANTAN: A CROSS-
SECTIONAL STUDY***

MUHAMMAD SYAFIQ BIN NORBAHRI

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RISK ASSESSEMENT IN TANAH MERAH, KELANTAN: A CROSS-
SECTIONAL STUDY**



BY

MUHAMMAD SYAFIQ BIN NORBAHRI

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

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ABSTRACT

CONTAMINATION OF NITRATE IN GROUNDWATER AND HEALTH RISK ASSESSMENT IN TANAH MERAH, KELANTAN: A CROSS-SECTIONAL STUDY

MUHAMMAD SYAFIQ BIN NORBAHRI

Introduction: Contamination of nitrate is one of the most common groundwater problems worldwide. Around 70% of Kelantan residents still depend on groundwater as their primary source of water supply. Extensive usage of pesticides in agriculture area may cause nitrate leaching into the groundwater. **Objective:** To determine nitrate level in groundwater and to perform health risk assessment among residents at Buloh, Pasir Besar and Bukit Merbau Villages in Tanah Merah, Kelantan. **Methodology:** This research was carried out during January 2020. Fifty-two respondents were chosen based on inclusion criteria such as long life residents, age 18 years old and above, as well as using groundwater as their primary source of drinking supply. A set of questionnaire consist of four sections was provided to the respondents in order to gather the information related to socio-demographic, water usage, house living environment and health status. The water samples were duplicated and then analysed by using the Portable PH/ORP/ISE Meter Model H198191 and Probe Model H14113. **Result and Discussion:** The reading from 52 wells show the range of nitrate level in groundwater was from 0.22 to 8.81 ppm, while the Mean \pm SD was 2.94 ± 2.27 ppm. Statistical analysis indicated that there is a significant difference between the age of wells and nitrate level ($p < 0.05$). However, the nitrate level showed no significant relationship with depth and distance of wells from the nitrate source. All respondents have the Hazard Quotient (HQ) below 1, which means the respondents does not pose a significant health risk due to exposure of nitrate in drinking water. **Conclusion:** The nitrate level from all sampling points was below the maximum acceptable limit, which is 10 ppm according to National Drinking Water Quality Standard (NDWQS). The continuous monitoring from health authority is essential so that the contamination of nitrate in groundwater can be prevented in the future.

Keywords: Nitrate, Groundwater, Levels, Hazard Quotient, Tanah Merah

ABSTRAK

PENCEMARAN NITRAT DIDALAM AIR BAWAH TANAH DAN PENILAIAN RISIKO DI TANAH MERAH, KELANTAN: KAJIAN KERATAN RENTAS

MUHAMMAD SYAFIQ BIN NORBAHRI

Pengenalan: Pencemaran nitrat adalah salah satu masalah air bawah tanah yang paling biasa di seluruh dunia. Kira-kira 70% penduduk Kelantan masih bergantung pada air bawah tanah sebagai sumber bekalan air utama mereka. Penggunaan racun perosak secara meluas di kawasan pertanian boleh menyebabkan nitrat menyerap masuk ke air bawah tanah. **Objektif:** Untuk menentukan tahap nitrat di air bawah tanah dan melakukan penilaian risiko kesihatan di kalangan penduduk di Kampung Buloh, Pasir Besar dan Bukit Merbau di Tanah Merah, Kelantan. **Metodologi:** Kajian ini dilakukan pada Januari 2020. Lima puluh dua responden dipilih berdasarkan kriteria inklusi seperti penduduk umur panjang, berumur 18 tahun ke atas, serta menggunakan air bawah tanah sebagai sumber bekalan minuman utama mereka. Satu set soal selidik yang terdiri daripada empat bahagian diberikan kepada responden untuk mengumpulkan maklumat yang berkaitan dengan sosio-demografi, penggunaan air, persekitaran tempat tinggal dan status kesihatan. Sampel air diduplikasi dan kemudian dianalisis dengan menggunakan Portable PH / ORP / ISE Meter Model H198191 dan Probe Model H14113. **Hasil dan Perbincangan:** Pembacaan dari 52 telaga menunjukkan julat tahap nitrat di air bawah tanah adalah dari 0,22 hingga 8,81 ppm, sementara Purata \pm Sisihan Piawai adalah $2,94 \pm 2,27$ ppm. Analisis statistik menunjukkan bahawa terdapat perbezaan yang signifikan antara umur telaga dan tahap nitrat ($p < 0.05$). Walau bagaimanapun, tahap nitrat tidak menunjukkan hubungan yang signifikan dengan kedalaman dan jarak telaga dari sumber nitrat. Semua responden mempunyai Faktor Bahaya (HQ) di bawah 1, yang bermaksud responden tidak menimbulkan risiko kesihatan yang ketara kerana pendedahan nitrat dalam air minuman. **Kesimpulan:** Tahap nitrat dari semua titik persampelan berada di bawah had maksimum yang boleh diterima, iaitu 10 ppm menurut Standard Kualiti Air Minum Nasional (NDWQS). Pemantauan berterusan dari pihak kesihatan adalah penting agar pencemaran nitrat di air bawah tanah dapat dicegah pada masa akan datang.

Kata kunci: Nitrat, Air Bawah Tanah, Tahap, Faktor Bahaya, Tanah Merah

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LIST OF ABBREVIATIONS

| | |
|--------|---|
| HQ | Hazard Quotient |
| ADD | Average Daily Dose |
| RfD | Reference Dose |
| NDWQS | National Drinking Water Quality Standard |
| US EPA | United State Environmental Protection Agency |
| WHO | World Health Organisation |
| CWC | Community Water Centre's Health & Drinking Water Series |
| IRIS | Integrated Risk Information System |
| Ppm | Part per million |

CHAPTER 1

INTRODUCTION

1.1) Background

Nitrate contamination is one of the world's most common groundwater issues (Ako et al., 2014). Nitrate is water-soluble, quickly drains from the soil and then deposited in groundwater (Wongsanit et al., 2015). According to Almasri (2007), nitrate contamination in groundwater can be derived from different sources including from point source (Industrial activity, livestock waste) and non-point source (Extensive usage of nitrogen fertiliser, atmospheric deposition). Nitrogen fertilisers are widely used in agricultural production to increase crop yield, but excess nitrogen supplies can contaminate water, air and soil. One of the most common and detrimental consequences of agricultural overuse of nitrogen fertilisers is the deterioration of groundwater quality and pollution of drinking water sources, which may present significant threats to human health (Wick et al., 2012). Several studies have shown that there is a correlation between nitrate contamination and agricultural activity as a result of heavy use of nitrate fertiliser (Shamsuddin et al., 2016).

Greer & Shannon (2005) mentioned that infants who consumed formula milk prepared using water contaminated with nitrate could lead to nitrate poisoning and

Methemoglobinemia. Methemoglobinemia or "Blue Baby Syndrome" disturbs the blood cells ability to carry oxygen (Ward et al., 2018). An ecological study from Slovakia found a positive association between colorectal cancer and cancers in all digestive system with nitrate levels in drinking water. (schullehner et al., 2018). Risk of bladder cancer reported being increased among postmenopausal women that associated with long-term ingestion of nitrate in drinking water (Jones et al., 2016). Health risk assessment may be carried out to determine whether or not consumers have been exposed to diseases. A health risk assessment is a tool for evaluating the degree and likelihood of adverse health effects to persons who could be exposed to pollutants in environmental media (USEPA, 2016). As mentioned in the National Drinking Water Quality Standard (NDWQS) formulated by the Ministry of Health, Malaysia, the maximum acceptable limit of nitrate in drinking water is 10 ppm (Engineering Services Division, Ministry of Health, Malaysia, 2010).

1.2) Problem Statement

The sole provider that provide water services in Kelantan is Air Kelantan Sdn. Bhd. (AKSB). The conflict began when most of the people complain about the water services provided by AKSB was smelly and coloured water supply (Kamaludin et al., 2013). In addition, Association of Water and Energy Research Malaysia (2011) stated that water supply in Kelantan was dirty and smelly, frequent water disruptions and low coverage performance. This situation leads the consumers to use groundwater and there are about 70% of the population in Kelantan still depends on groundwater as their main source of water supply (Safeen & Azmi, 1998; Azwan et al., 2010). Kamil

et al. (1990) stated that agriculture is one main field in Malaysia's economy in which the production of rubber, oil palm, cocoa, fruit and vegetables has grown significantly. The development of agriculture activities have also resulted in increased use of commercial fertilisers.

Moreover, nitrate is one of the most common contaminants in groundwater that come from either fertiliser or sewage that leads to nitrate contamination of groundwater (Community Water centre., 2013). The problem to be highlighted is whether the level of nitrate in well water is safe for drinking as some part of Kelantan still use well water as the main source of water.

1.3) Study Justification

The study was conducted to access the nitrate levels in groundwater at Tanah Merah, Kelantan since most people in Tanah Merah, engaged in farming activities. Agriculture sector covers around 60% of Tanah Merah area (Tanah Merah District Council, 2020). The most common crops are Paddy, tobacco, watermelon and vegetables. Their agricultural practices are expected to cause high application of urea and Nitrogen, Phosphorus and calcium (NPK) fertiliser to support plant growth. Many studies showed high usage of fertiliser in the agricultural activities.

Nitrate in well water also exists, especially near the paddy field, so it is important to take future action to solve this issue because it is very much linked to the

health of consumers. This research also compared the nitrate levels in well water with the National Standard for Drinking Water Quality (NDSWQ) in Malaysia.

1.4) Research Question

Is there any significant health risk due to the nitrate level in groundwater?

1.5) Research Objectives and Hypothesis

1.5.1) General Objective

To determine the nitrate level in groundwater and to perform health risk assessment among respondents at Buloh, Pasir Besar and Bukit Merbau villages in Tanah Merah, Kelantan.

1.5.2) Specific Objectives

- I. To determine the nitrate level in groundwater and compare nitrate level between each sampling points
- II. To compare the nitrate level in groundwater with the National Drinking Water Quality Standards (NDWQS)

- III. To determine the association between age of well, depth of well, and distance of well from agricultural area with the nitrate level
- IV. To determine the health risk associated with nitrate level in groundwater

1.5.3) Research Hypothesis

- I. There is a significant difference of nitrate levels in groundwater among each study location.
- II. The concentration of nitrate levels in groundwater is higher than National Drinking Water Quality Standards (NDWQS).
- III. There is an association between the age of well, depth of well, and distance of well from paddy field area with the level of nitrate.
- IV. Hazard Quotient of respondents < 1

1.6) Conceptual Framework

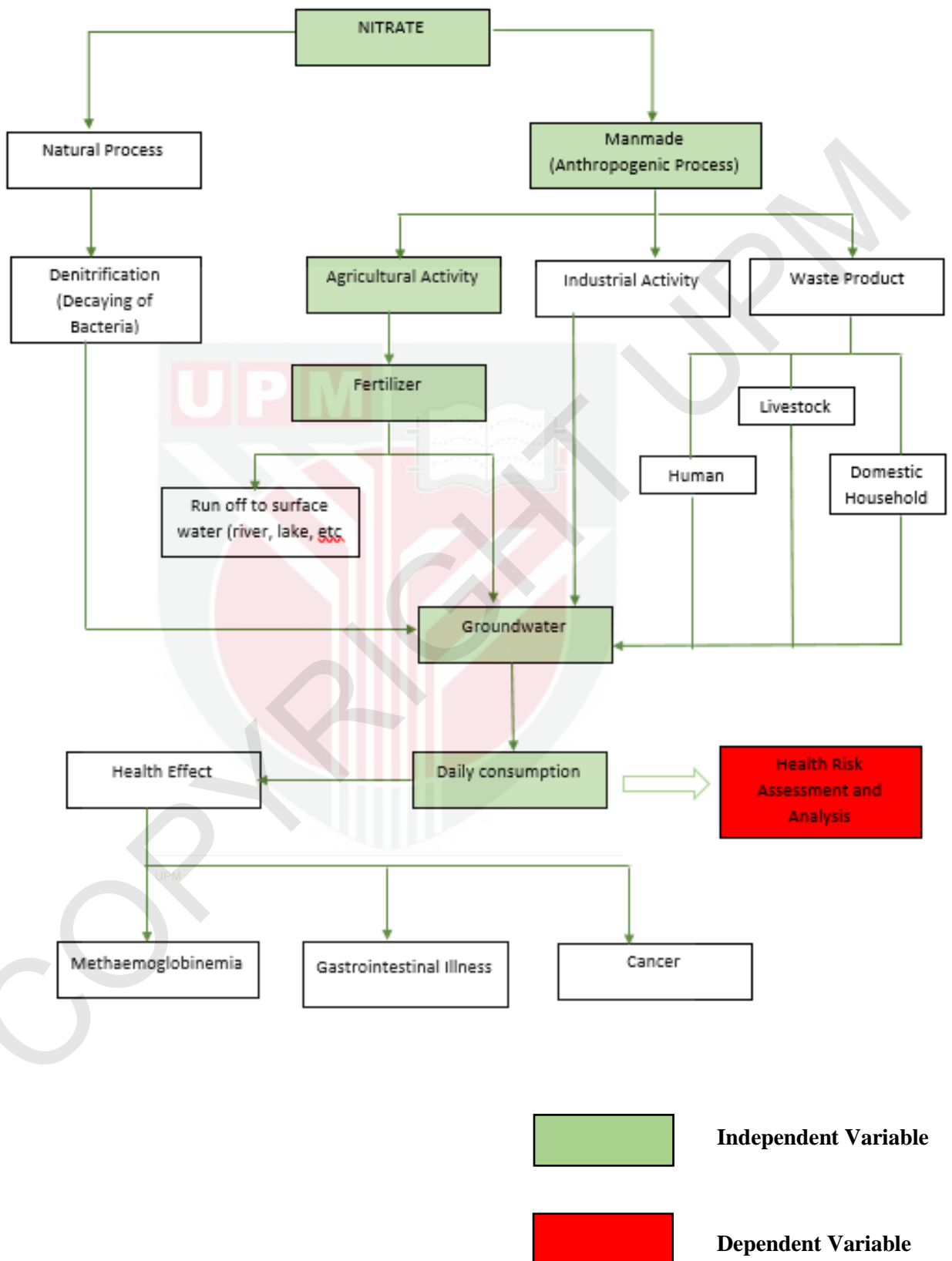


Figure 1.1 Conceptual Framework

1.7) Conceptual Definition

- Drinking Water

Drinking water must be clear, with no unpleasant taste, colour, or smell. It must be good to drink and free in amounts of all harmful species, chemical substances, and radionuclides, which could pose a risk to the consumer's health.

- Nitrate Level

According to National Drinking Water Quality Standards (2000) stated that the acceptable limit for nitrate in drinking water is 10 ppm.

- Health Risk Assessment

According to the United States Environmental Protection Agency (2016), health risk assessment is a method for assessing the extent and likelihood of adverse health effects to people who may be exposed to chemicals in polluted environmental media, from this time forward. Human health risk assessment comprises four basic steps, begins with preparation and scoping process:

- Step 1 – Hazard identification

- Step 2 – Dose-response assessment
- Step 3 – Exposure assessment
- Step 4 – Risk characterisation

1.8) Operational Definition

- Drinking water

The drinking water sample reading was measured three times and the average reading can be obtained directly from each respondents groundwater source.

- Nitrate level

The nitrate level in the water sample was analysed by using the Portable PH/ORP/ISE Meter model HI98191 and Probe Model HI4113. The reading of the nitrate level will be obtained on-site and no laboratory analysis is required.

- Health risk assessment

According to the United States Environmental Protection Agency (1992), the estimation of daily exposure of individuals for nitrate through ingestion is by calculating the Average Daily Dose (ADD). Then, to determine

the non-carcinogenic risk of nitrate, Hazard Quotient (HQ) was then calculated by using the equation provided in chapter 3.



CHAPTER 2

LITERATURE REVIEW

2.1) Nitrate

Nitrate (NO_3^-) occurs naturally and is an important plant nutrient in the environment. It occurs at different concentrations and is part of the nitrogen cycle. Nitrate is readily soluble in water, easily leaches through the soil and then it accumulates in groundwater (Hallberg, n.d.). Over the last century, the nitrogen cycle has been dramatically altered by human activities and causes nitrate (NO_3^-) to accumulate in water sources such as in groundwater and surface water (Shamsuddin et al., 2014). A study by Shuval and Gruener. (n.d.) mentioned that nitrogen accumulation in the environment can occur due to massive use of inorganic nitrogenous fertilisers and increasing accumulation rate of organic wastes from the growing human and animal population.

2.2) Nitrogen Cycle

Nitrogen is important for all creatures as it is a part of biological molecules in protein and nucleic acid. There is 78% of nitrogen gas (N_2) in atmosphere

(Environment, 2004). Nitrogen is in stable condition at atmosphere and need to be separated in order for the nitrogen atoms bind with other elements to produce nucleic acids and proteins. Five main steps in the nitrogen cycle are nitrogen fixation, nitrification, assimilation, ammonification, and denitrification.

Nitrogen fixation is the conversion of atmospheric nitrogen to ammonia, performed by nitrogen-fixing bacteria, including cyanobacteria in soil and aquatic environments (Weisany et al., 2013). Nitrification is the process of conversion of ammonia or ammonium to nitrate, performed by nitrifying bacteria (Environment, 2004). The reduction of nitrate to ammonium and then followed by ammonium assimilation into amino acid, which is nutrient for plants is called nitrogen assimilation (Masclaux-Daubresse et al., 2010). Ammonification is specifically referring to the microbial conversion of organic-nitrogen into ammonia (NH_3) or ammonium (NH_4^-) (Ammonification, 2018). Denitrification is the reduction of nitrate to nitrogen gas, completed by denitrifying bacteria. This process occurs when soil bacteria use oxygen in nitrate for respiration (International Plant Nutrition Institute, n.d.).

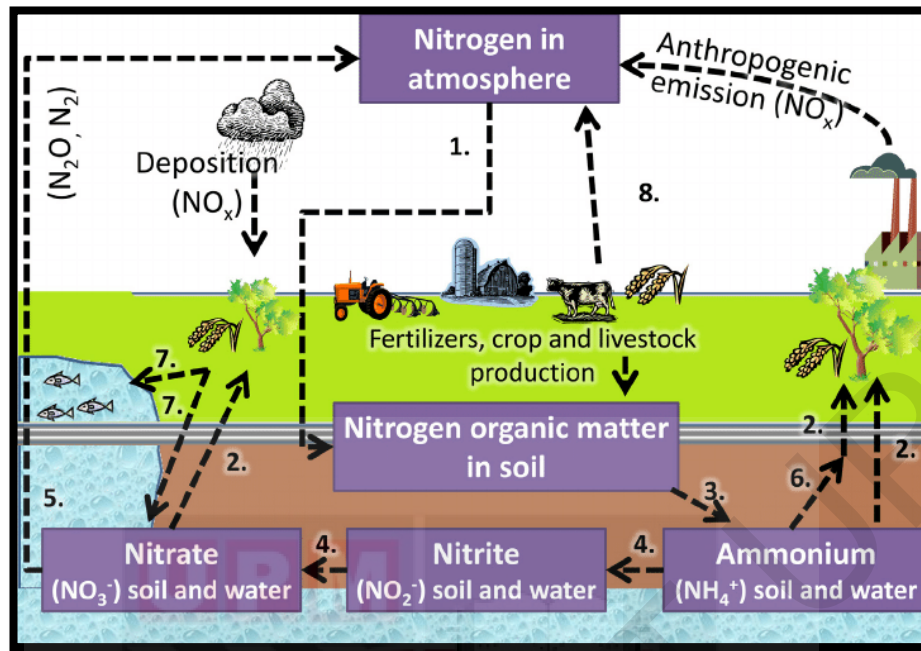


Figure 2.1 Nitrogen Cycle

Source (Bednarek et al., 2014)

2.3) Source of Nitrate

According to Almasri (2007), nitrate contamination in groundwater can be derived from different sources including from point source (Industrial activity, livestock waste) and non-point source (Extensive usage of nitrogen fertiliser, atmospheric deposition). From another study also mentioned that some of the possible sources of nitrate in groundwater including animal feedlots, nitrogen – containing fertilisers and improper disposal of sanitary wastes (Edokpolo et al., 2016). According to Mina Parvizishad et al. (2016), nitrite and nitrate are also present in foods as food additives. These compounds were identified in the vegetables and processed meat and act as promoters of some food colours and preservatives in order to prevent growth of

Clostridium botulinum bacteria. Another study also stated that nitrite is also a compound that used for the colour and flavour of cured meats (Bedale., 2016).

2.4) Nitrate in Groundwater

Groundwater contamination usually originate from chemical substances from either fertilisers or raw sewage (Fakhri & MS, 2017). Sadler et al. (2016) also reported that, there were various source of nitrate in groundwater such as animal feedlots, improper disposal of sanitary wastes, agricultural land on which legumes are grown and nitrogen-containing fertilisers. Nitrate will contaminate the groundwater due to the fertiliser leaches into the soil and migrate to the level where most of the groundwater is present. This leaching process will induce the groundwater contamination due to the excessive use of fertiliser (Kamaludin et al., 2013) High nitrate was identified in wells less than 50 meters away from the livestock area. Shallow and old wells typically have higher nitrate contents rather than deep and new wells (Juntakut et al., 2019).

2.5) Drinking Water Quality Standard

Malaysia developed the National Drinking Water Quality Standards in 2000 after a series of amendments to the previous standard. The new standard reviewing was based on new scientific information as well as new chemical found in drinking water as available in the WHO Guidelines for Drinking Water, 1993-1998 and by

comparing drinking water guidelines of other countries. Thus, the maximum acceptable value of nitrate-nitrogen (NO₃-N) is 10mg/L nitrate - N, or 44.3-ppm nitrate-NO₃ (NDWQS, 2000).

2.6) Health Risk Assessment

Exposure of nitrates in groundwater can lead to acute health problems. Long-term exposure can lead to many other adverse health conditions (CWC, 2011). The risk assessment method could also be used to quantify the risk of adverse environmental effects due to environmental pollution in four stages; hazard identification, dose-response assessment, exposure assessment and risk characterisation (US EPA, 2016).

Hazard Quotient (HQ) might be used to determine the likelihood of adverse non-carcinogenic health impact. A hazard quotient (HQ) of 1 or greater signifies a hazardous condition, while for HQ of less than 1 is categorised as an acceptable risk for a non-carcinogenic health effect (US EPA, 2016).

2.7) Health Effect due to Nitrate

2.7.1) Methemoglobinemia

Methemoglobinemia or “Blue Baby Syndrome” disturbs the blood cells ability to carry oxygen (Haller et al, 2011). Greer & Shannon (2005) mentioned that infants for whom formula may be prepared with well water containing high levels of nitrate can lead to nitrate poisoning and the methemoglobinemia in infants. Methemoglobinemia is a life threatening disease when the levels of methemoglobin reach and go beyond 10% (Ward et al., 2018). The most susceptible group to methemoglobinemia in infants under six months of age due to the enzyme in body inadequately change methemoglobin (nitrite oxidises the iron in the hemoglobin of red blood cells to form methemoglobin and lack the ability of blood to carry oxygen) to oxyhemoglobin and thus, lead to methemoglobinemia or ‘blue baby syndrome’. Another study by Sadeq et al. (2008) also mentioned that older children (1-7 years) are significantly affected by blue baby syndrome (methemoglobinemia) if drinking water contaminated with nitrate (more than 50 mg/L).

2.7.2) Gastrointestinal (GIT) Complications

Many gastrointestinal illness are related to nitrates. The consumption of nitrate-contaminated water causes multiple digestive tract impairment (Rao, 2006). There is some evidence that the long-term consequences, such as gastric cancer, may result

from even less nitrate exposure when they are exposed to N-nitroso compounds; the form when nitrate reacts with certain conditions and in which it is a potent carcinogen in many species (Walter et al, 2009).

2.7.3) Cancer

An ecological study from Slovakia found a positive association between Colorectal Cancer (CRC) and cancers in all digestive systems with nitrate levels in drinking water (Schullehner et al., 2018). Another case-control study in Iowa reported that higher nitrate levels in drinking water consumed among susceptible subgroups (high red meat and low vitamin C intake) with elevated endogenous nitrosation showed an increased colon cancer risk. Jones et al. (2018) reported that increased risk of bladder cancer among postmenopausal women was associated with long-term ingestion of nitrate in drinking water.

2.7.4) Others Health Related Problems

Nitrates have been connected to multiple digestive tract impairment, dyspepsia, depression, headaches and weaknesses according to scientific and medical studies. (CWC, 2011).

For fact, there may be miscarriage, stillbirths or premature birth and Sudden Infant Death Syndrome (SIDS). It can also cause mutagenicity (DNA damage), teratogenicity and even disrupted fetal development in utero, resulting in defects in the neural tube and other birth-related disorders (Kevin et al, 2005). Moreover, recent results from the Framingham Offspring Study indicated that decreased risk of mortality was correlated with plasma nitrate when corrected for glomerular activity but no correlation for cardiovascular disease events was found (Maas et al., 2017).



CHAPTER 3

METHODOLOGY

3.1) Study Design

The study design used in this project was a cross-sectional study as in for measuring contamination of nitrate in groundwater and health risk assessment in Tanah Merah, Kelantan.

3.2) Study Population

The study population involved the residents from Buloh, Pasir Besar and Bukit Merbau Villages in Tanah Merah, Kelantan who still depended on groundwater for their daily use and drinking water.

3.3) Study Sample

The study conducted on the residents that fall in the inclusion criteria only and all exclusion criteria had been excluded from this study.

Inclusion criteria:

- I. Long-life residents (at least 6 years)
- II. Age 18 years and above
- III. Use groundwater as their main source of drinking supply

Exclusion criteria:

- I. Using water filter system
- II. Having drinking water sources other than groundwater

3.4) Study Location

The study location was selected at Buloh, Pasir Besar and Bukit Merbau Villages. These locations were chosen due to its agricultural activities as the main economic activity and most of the residents still rely on groundwater for their daily needs.

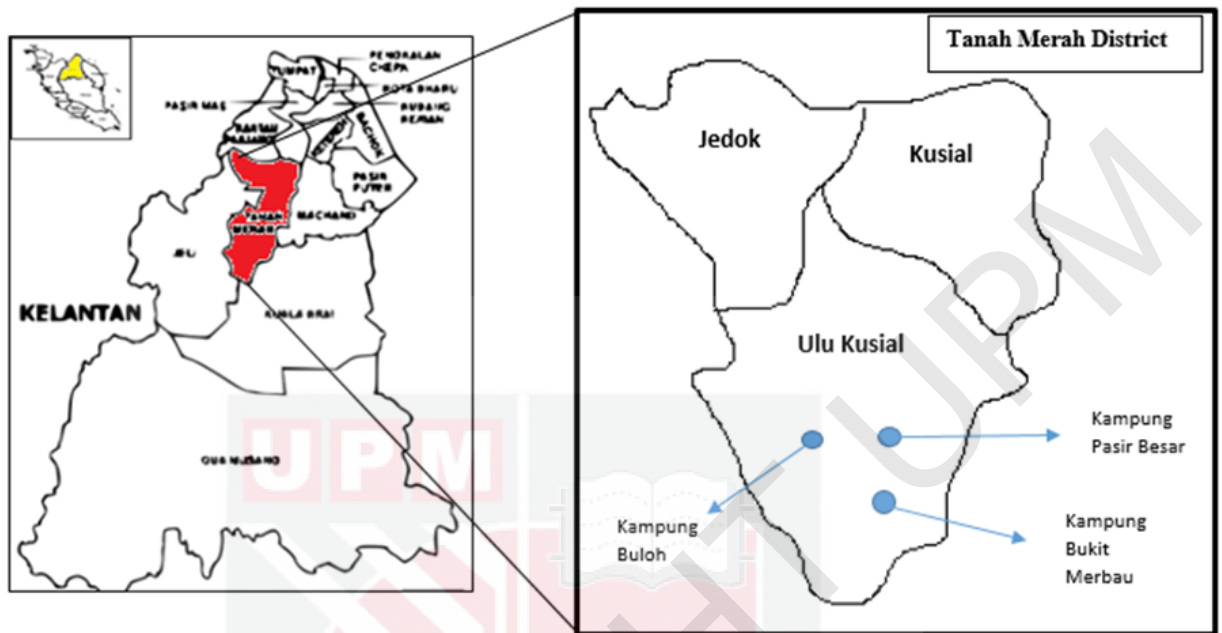


Figure 3.1 Study Location

3.5) Sample Size

The sample size was determined by using a formula established by Kirkwood and Sterne (2003):

$$N = p(1-p) / e^2$$

Where,

N = sample size

P = Prevalence

e = sampling error

Calculation:

$$N = \frac{0.087(1-0.087)}{0.05^2}$$

$$N = 32$$

The prevalence of nitrate level in groundwater which above 10 mg/L is 8.7% was determined by a previous study (Adham, 2014). The number of sample size required is 32. To ensure the study is statistically significant and taken into consideration damaged, the sample size taken was 52 samples.

3.6) Sampling Method

Purposive sampling was used as the sampling method in this study. The respondents had been selected based on inclusive and exclusive criteria.

3.7) Study Instrument

3.7.1) Questionnaire

A set of questionnaire consist of four sections were given to the respondents. Part A of the questionnaire contained questions regarding the socio-demographic information. Part B focus on information about water usage. Next, part C assesses the

house living environment information. Lastly, health information was asked in Part D. This questionnaire was adapted from the Baseline, Descriptive and Time Activity used in the National Human Exposure Assessment Survey (NHEXAS).

3.7.2) GPS Mobile Application

GPS mobile application was used to measure the distance of the well from the plantation area. It is more convenient to use this application rather than using measuring tape.

3.8) Water Sampling

3.8.1) Water Analysis

Water samples from the house of each respondent were taken directly from the well using a container of high density polyethylene (HDPE) and replicated twice. Then, the nitrate level in the water samples were analysed by using the Portable PH/ORP/ISE Meter model HI98191 and Probe Model HI4113.



Figure 3.2 Portable PH/ORP/ISE Meter Model HI98191

Source HANNA Instrument Website



Figure 3.3 Probe Model HI4113

Source HANNA Instrument Website

3.8.2) Analysis of Nitrate

Nitrate level in groundwater was analysed by using the Portable PH/ORP/ISE Meter Model HI98191 and probe Model HI4113. The probe was mounted and connected to the portable meter. Then, the portable meter was calibrated using 10 ppm, 100ppm and 1000ppm buffer solution. After that, 50ml of the water sample was poured into the beaker. In order to elevate the nitrate level, 1ml of ISA (Ionic Strength Adjuster

) reagent was added into the beaker. The steps were repeated for other water samples that represent different well.

3.9) Risk Assessment

Due to inadequate human evidence of nitrate carcinogenicity in drinking water, only the non-carcinogenic health consequences of long-term nitrate consumption in drinking water have been quantified using the US EPA environmental risk evaluation model in terms of the hazard quotient (HQ) (U.S. EPA Region 6 2005) as shown in Eq. (1).

$$HQ = ADD/RfD \quad (1)$$

where ADD is the sum of nitrate intake via drinking water as shown in Eq. (2) (US EPA, 2018)), and RfD is a reference dose for nitrate which is 1.6 mg/kg/day (IRIS 2012).

$$ADD = C \times IR \times EF \times ED / (BW \times AT) \quad (2)$$

Where,

C Nitrate concentration (mg/L)

- IR Intake rate (1 L/day for children and 2 L/day for adults)
- EF Exposure frequency (365 days/year)
- ED Exposure duration (6 years for children and 30 years for adults)
- BW Body weight (15 kg for children and 60 kg for adults)
- AT Averaging time (365 days/year×6 years for children and 365 days/year×30 years for adults)

An HQ value >1 showed a significant non-carcinogenic risk level (U.S. EPA Region 6 2005).

3.10) Data Analysis

The data obtained through data collection were analysed using IBM SPSS (Statistical Program for Social Sciences) Version 22.

The normality testing in this study was calculated by using the Kolmogorov-Smirnov test as the sample size was larger than 50. The non-parametric test was used to analyse the data as the data was not normally distributed.

| Objectives | Type of Analysis |
|---|---|
| To determine the nitrate level in groundwater and compare the nitrate level between each study location. | Descriptive Analysis |
| To compare the nitrate level in ground water with the National Drinking Water Quality Standards (NDWQS) | Descriptive Analysis |
| To determine the association between age of well, depth of well, and distance of well from paddy field area with nitrate level. | Parametric: Pearson Correlation Non-Parametric: Spearman Correlation |
| To determine the health risk associated with nitrate level in groundwater | Descriptive Analysis |

3.11) Ethical Consideration

- I. The respondents were given a brief explanation about the whole study activities involved
- II. Permission was obtained to do the data collection around the respondent's house and well water
- III. Approval letter was given to the village representatives and respondents to obtain their consent to participate in this study

CHAPTER 4

RESULTS AND DATA ANALYSIS

4.1) Number of Respondents

Table 4.1 shows the total respondents who participated in this study were 52 persons. The number of male respondents was 20 (38.5%), while the number of female respondents was 32 (61.5%) as tabulated in Figure 4.1.

Table 4.1 Number of Male and Female Respondents

| Variables | Respondents (%) |
|------------------|------------------------|
| Respondents | |
| Male | 20 (38.5%) |
| Female | 32 (61.5) |

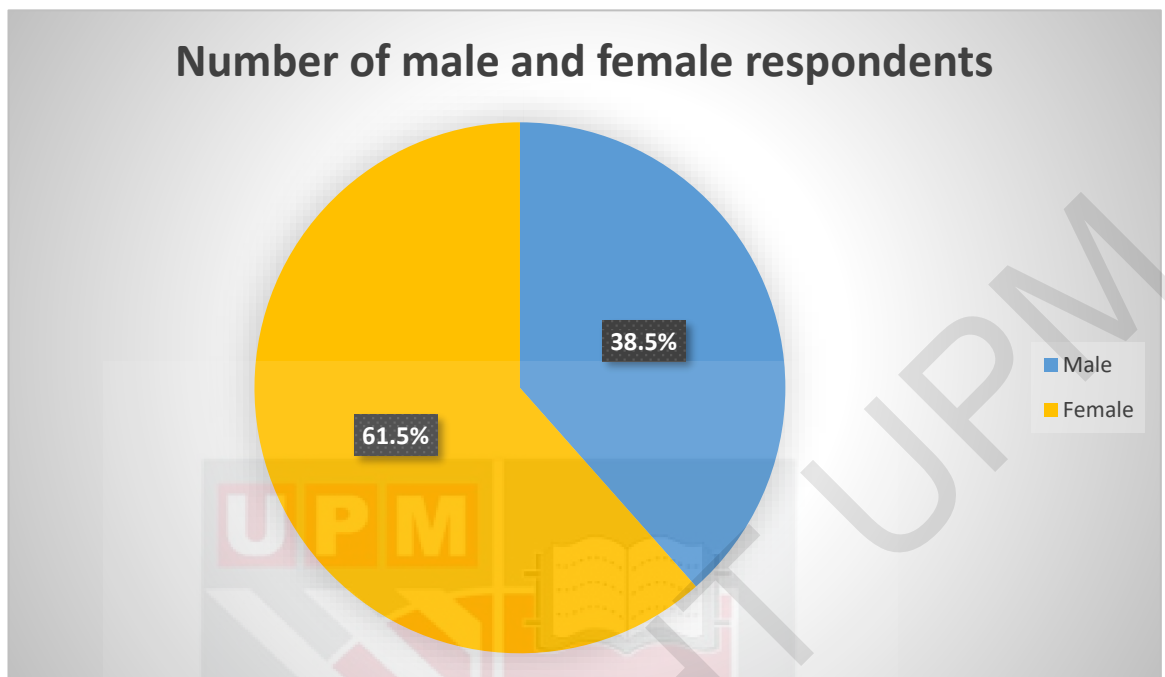


Figure 4.1 Percentage of Respondents

4.2) Weight of The Respondents

From table 4.2, it displays that the Mean \pm SD of the weight of the respondents was 63.54 ± 14.27 (Kg), whereas the respondent's weight range between 40.0 – 100.0 (Kg).

Table 4.2 Weight of The Respondents

| Variable | Mean \pm SD (Kg) | Range (Kg) |
|----------|--------------------|--------------|
| Weight | 63.54 ± 14.27 | 40.0 - 100.0 |

N = 52

4.3) Characteristics of The Well

Table 4.3 below displays the characteristics of respondents' wells which cover the information regarding age, depth and distance of well from the agriculture area. As illustrated in Figure 4.2, the samples collected from the well age below 5 years (< 5) are 6 (11.5%). While, the sample taken from age of well 5 – 10 years, 11 – 15 years, 16 – 20 years and above 20 years (> 20) was as much as 10 (19.2%), 5 (9.6%), 1 (1.9%) and 30 (57.7%) respectively.

The information regard the depth of well was tabulated in Figure 4.3. The most sample was collected from the depth above 15 meters which is 20 (38.5%). Followed by 5 – 10 meters, 11 – 15 meters and below 5 meters (< 5) which was 13 (25.0%), 11 (21.2%) and 8 (15.4%) respectively.

Besides, the result showing the distance of well from the agriculture area was 64.06 ± 36.39 meters for Mean \pm SD, while the range was from 5.0 – 176.0 meters.

Table 4.3 Characteristics of Respondents' Wells

| Variables | Frequency (%) | Mean ± SD (meters) | Range (meters) |
|-------------------------|----------------------|-------------------------------------|-----------------------|
| Age of Well | | | |
| < 5 Years | 6 (11.5%) | | |
| 5 – 10 Years | 10 (19.2%) | | |
| 11 – 15 Years | 5 (9.6%) | | |
| 16 -20 Years | 1 (1.9%) | | |
| > 20 Years | 30 (57.7%) | | |
| Depth of Well | | | |
| < 5 meters | 8 (15.4%) | | |
| 5 – 10 meters | 13 (25.0%) | | |
| 11 – 15 meters | 11 (21.2%) | | |
| > 15 meters | 20 (38.5%) | | |
| Distance of Well | 52 (100%) | 64.06 ± 36.39 | 5.0 – 176.0 |
| From The | | | (meters) |
| Agriculture Area | | | |
| (meters) | | | |

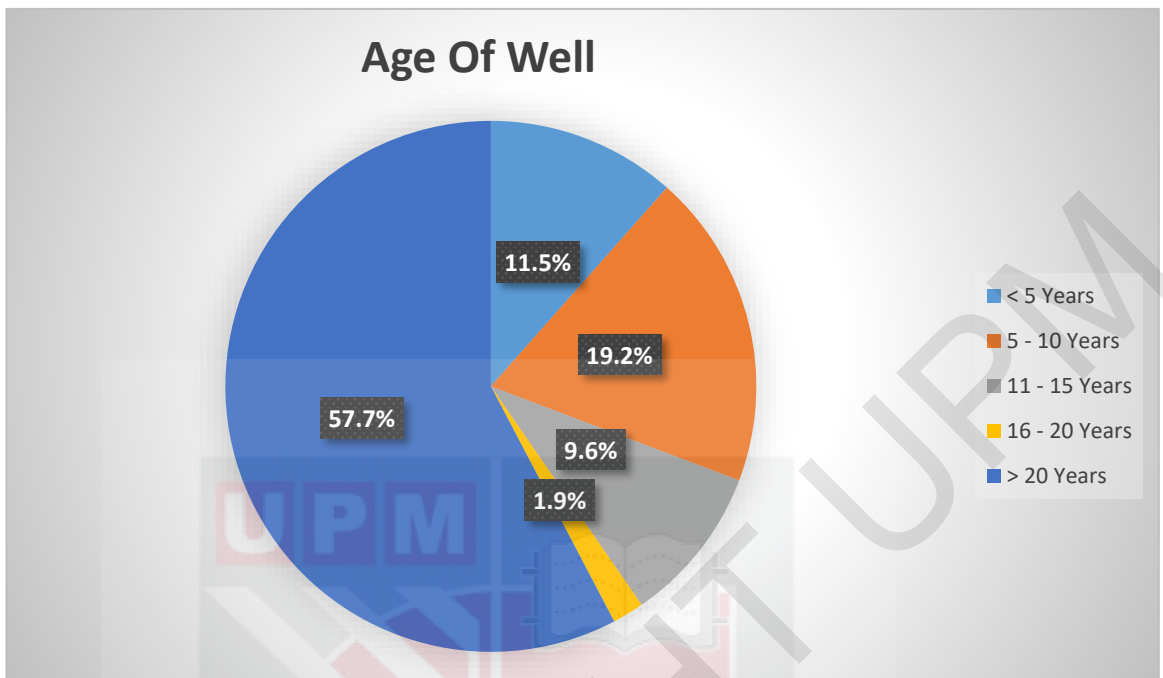


Figure 4.2 Percentage of Age of Well

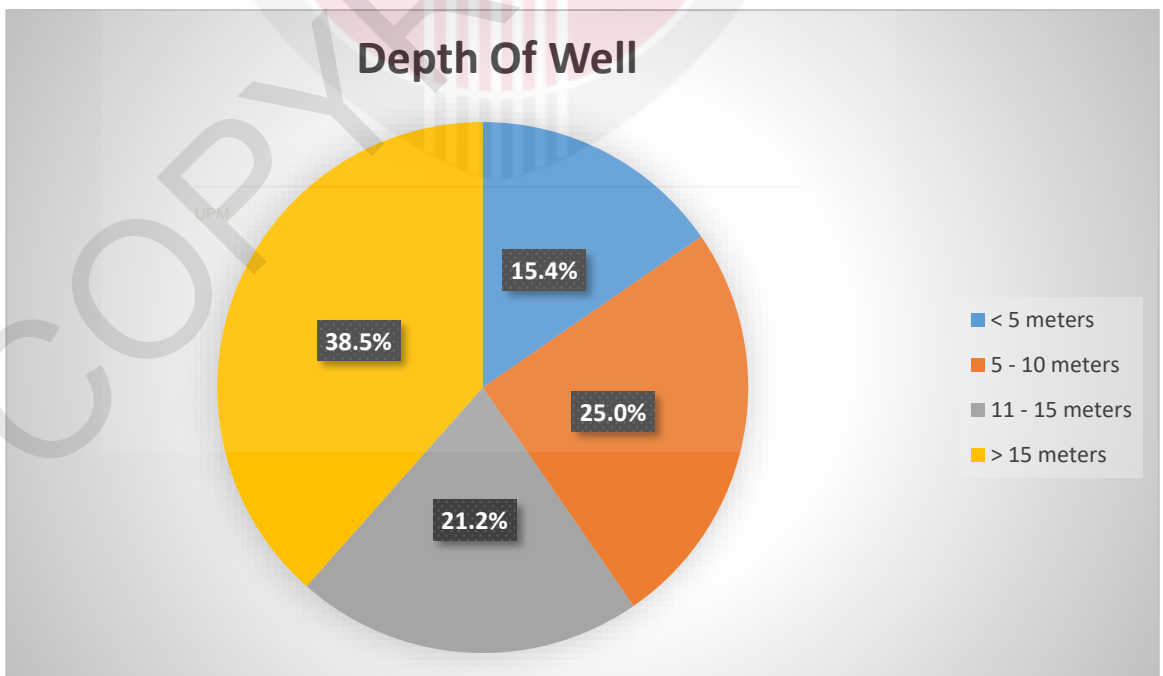


Figure 4.3 Percentage of Depth of well

4.4) Nitrate Level In Groundwater

From Table 4.4 below, it shows the range of nitrate level in groundwater was from 0.22 to 8.81 ppm, while the Mean \pm SD was 2.94 ± 2.27 ppm. The data obtained was below the maximum acceptable limit, which is 10 ppm.

Table 4.4 Nitrate Level in Groundwater

| Variable | Mean \pm SD (ppm) | Range (ppm) |
|----------|---------------------|-------------|
| Nitrate | 2.94 ± 2.27 | 0.22 – 8.81 |

4.5) Comparison of Nitrate Level For Each Samples With Standard.

Based on Figure 4.5, it presented that the nitrate level from all the sampling points was below the maximum acceptable limit, which is 10 ppm according to National Drinking Water Quality Standard. The highest reading recorded was 8.8 ppm.

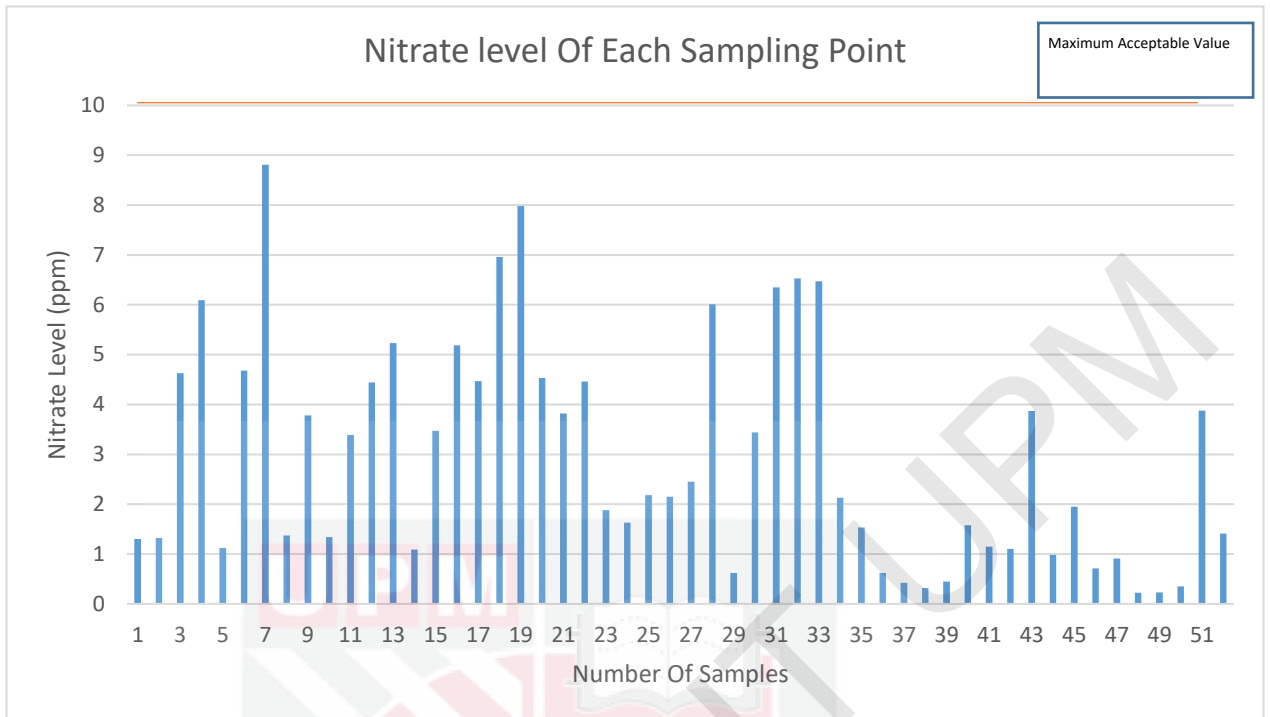


Figure 4.4 Comparison of Nitrate Level of Each Sampling Points With National Drinking Water Quality Standard (NDWQS)

4.6) The Association Between Age of Well, Depth of Well and Distance of Well From Agriculture Area With Nitrate Level. (Spearmen Correlation Test)

Spearmen Rho Correlation has been used to find the association between age of well, depth of well and distance of well from agriculture area with nitrate level. This was because of the non-parametric value of nitrate level. The result shows there was a significant difference between the age of well and the nitrate level ($p < 0.05$) with the correlation coefficient, $r = -0.310$. However, the depth of well and distance of well from the agriculture area show there was no significant difference with the nitrate level ($p > 0.05$) (Table 4.6).

Table 4.5 Spearmen Rho Correlation Test

| Variable | Nitrate Level | |
|---|---------------|---------|
| | r | p-value |
| Age of Well (Year) | -0.310 | 0.025 |
| Depth of Well (Meter) | 0.188 | 0.183 |
| Distance of Well From Agriculture Area (Meter) | -0.045 | 0.751 |

4.7) Average Daily Dose (ADD) Estimation.

Table 4.7 shows the Average Daily Dose (ADD) estimation of the respondents. ADD value was calculated as per the formula mentioned in chapter 3. The result showed that Mean \pm SD obtained was 0.10 ± 0.08 (mg/kg/day) and the range was 0.01 – 0.29 (mg/kg/day).

Table 4.6 Average Daily Dose (ADD) Estimation

| Variable | N = 52 | | |
|------------------------|-----------------|--------|-------------|
| | Mean \pm SD | Median | Range |
| Nitrate Level (ppm) | 2.94 ± 2.27 | 2.14 | 0.22 – 8.81 |
| ADD (mg/kg/day) | 0.10 ± 0.08 | 0.07 | 0.01 – 0.29 |

4.8) Hazard Quotient (HQ) Estimation.

Hazard Quotient for all respondents has been calculated based on the formula in chapter 3. The result indicates that all respondents have the Hazard Quotient (HQ) below 1, which means the respondents does not pose a significant health risk due to exposure of nitrate in drinking water.

Table 4.7 Hazard Quotient (HQ) Estimation Value

| Hazard Quotient | No. of Respondents | Percentage (%) |
|-----------------|--------------------|----------------|
| HQ < 1 | 52 | 100 |
| HQ > 1 | 0 | 0 |

CHAPTER 5

DISCUSSION

5.1) Characteristics of Wells.

The three characteristics of the wells collected were age, depth and distance from the agriculture area. The data collected for the age of wells was presented in Figure 4.2. The highest age of the wells recorded was above 20 years (> 20) which were 30 wells (55.7%), followed by 5-10 years, below 5 years (< 5), 11-15 years and 16-20 years with the frequency of 10 (19.2%), 6 (11.5%), 5 (9.6%) and 1 (1.9%) respectively.

Next, the data obtained for the depth of wells was shown in Figure 4.3. Most of the wells had a depth more than 15 meters (> 15) which was 20 (38.5%) wells from 47, while followed by 5-10 meters, 11-15 meters and below 5 meters (< 5) with the frequency of 13 (25.0%), 11 (21.2%) and 8 (15.4%) respectively. Moreover, the distance of the wells from the agriculture area was measured by using GPS. The Mean \pm SD obtained was 64.06 ± 36.39 mg/L and ranged from 5.0 -176.0 meters. These three characteristics mentioned above were identified in this study because they are potentially contributed to elevate nitrate level in groundwater (Swistock et al., 2009).

5.2) Nitrate Level In Groundwater

The Mean \pm SD of nitrate obtained in this study (2.94 ± 2.27 ppm) was considered as in normal value. This study was in line with the study conducted by Jamaludin et al. (2013) the Mean \pm SD of nitrate level in well water of the study was 1.66 ± 2.11 ppm.

This study was conducted during rainy seasons and pre-planting phase for paddy plantation. This occurrence may be the reasons of low nitrate level measured in groundwater. According to Wang et al (2015) rainfall has affected the nitrate concentration as it reaches the groundwater, the nitrate concentration increases at the beginning of the rainy season, decreases throughout the rainy season and stays at a constant low level during the dry season. During the pre-planting phase, the nitrate level was low because the farmers have not yet started the application of fertilisers to the crops. The nitrate level is likely to increase during the planting phase as compared to pre-planting and harvest phase (Amirah et al., 2014).

5.3) Comparison with National Drinking Water Quality Standard (NDWQS)

Different countries have different standards for nitrate level in groundwater in order to make sure that groundwater is safe for users to drink and consume. Malaysia has set its own standard under National Drinking Water Quality Standard (NDWQS) for the nitrate level in groundwater which is 10 ppm. Nevertheless, Jamaludin et al

(2013) indicated in his study that the nitrate levels in the intensive agriculture region in Bachok were below the maximum concentration limit of the Malaysia's National Drinking Water Quality Standards, with mean value 1.66 ± 2.11 ppm and range between 0 to 9.6 ppm. The same goes for this study, the Mean \pm SD value was 2.94 ± 2.27 ppm and range between 0.22 to 8.81 ppm.

5.4) The Association Between Age of Well, Depth of Well And Distance of Well From Agricultural Area With Nitrate Level (Spearman Rho Correlation Test).

Based on the analysis, there was a significant association between the age of wells and the nitrate levels in groundwater. This indicates the age of the wells did contribute to the nitrate contamination in this study. Swistock et al. (2009) state the age of well was statistically important in relation with nitrate level in groundwater. Generally, older wells were more susceptible to nitrate contamination (USEPA, 2002). However, this study showed the age of well had fair negative correlations with nitrate levels in groundwater. This occurrence may be because of small numbers for age of wells that below than 20 years included in this study. Another factor such as wells with leaking or damaged fittings or casings and dug wells with casings that are not watertight also may contribute to this result (Minnesota Department of Health, 2020).

Next, nitrate levels in groundwater samples were not associated with the depth and distance of well from the agricultural area. This can be related to varying levels of difference in the depth and distance of wells from the nitrate source. These results were partially in line from a study done by Shaharuddin et al. (2019) who stated that the

age, depth and distance of well from the source of nitrate did not play a significant role in the concentration of nitrates in the wells studied. However, Shamsuddin et al. (2016) stated that the high nitrate was detected in the well < 50 m to the agricultural area. Plus, groundwater flow direction also should be taken into account, which is an essential factor in nitrate contamination (Ki et al., 2015).

5.5) Health Risk Assessment (Hazard Quotient)

Based on the result obtained, Average Daily Dose (ADD) estimation for all respondents had 0.10 ± 0.08 (mg/kg/day) for Mean \pm SD and acquired a range between 0.01 – 0.29 (mg/kg/day). After that, this result was used to calculate Hazard Quotient (HQ) by using the equation stated in Chapter 3. Hazard Quotient (HQ) for all respondents in this study was less than 1. This indicates the risk of an adverse effect of nitrate pollution in groundwater in respective areas were within the acceptable limit.

This study was in line with Jamaludin et al. (2013) as there is no result obtained for HI were more than 1. Su et al. (2013) acquired a health hazard index, R, reflecting a level of non-carcinogenic safety risk. An $R < 1$ demonstrates fairly safe conditions. The average risk in the area was not too high for adults and the town has reasonable nitrate levels.

CHAPTER 6

CONCLUSION, LIMITATION AND RECOMMENDATION

6.1 CONCLUSION

For thousands of years, water has been beneficial to humans. There will be no life on earth without water. We use water to drink, eat, bath and for domestic use in our homes. So it is essential to make sure the quality of the water at its best and free from contamination that can cause many health problems to humans.

This study shows that the nitrate level from all the sampling points was below the maximum acceptable limit, which is 10 ppm according to National Drinking Water Quality Standard. The highest reading recorded was 8.8 ppm. The result indicates that all respondents have the Hazard Quotient (HQ) below 1, which means the respondents does not pose a significant health risk due to exposure of nitrate in drinking water. However, the nitrate level in groundwater may vary from time to time. Hence, efforts should be made as essential to reduce the exposure of nitrate to human in the future.

6.2 LIMITATION

The sample size of this study was 52 respondents and involved the three villages in the district of Tanah Merah. Hence, this result from this study cannot represent the whole district of Tanah Merah, but it can act as baseline data for future studies.

Next, this study only obtained data of nitrate level during the pre-planting session due to time constraints. This was because the data collection was only managed to carry out during January 2020 (during semester break).

Last but not least, the information obtained from the respondents could not be determined to be 100% valid as the recall bias may occur during the interviews.

6.3 RECOMMENDATION

This study suggests future research to widen the sampling area in Tanah Merah and increase the sample size of the population, so that the results of the study can be generalised to the whole district Tanah Merah.

This study was a cross-sectional study. The data was collected at one point of time only, which was during pre-planting phase. Further studies are recommended to collect the data at different points of time which cover during the pre-planting phase, planting phase and harvesting phase, in order to observe significantly different from the nitrate level between each phases.

The continuous monitoring from health authority is very important, so that the contamination of nitrate in groundwater can be prevented in the future as the nitrate level may vary from time to time. Lastly, the villagers are recommended to use water filtration system in order to minimise the exposure to water contamination.

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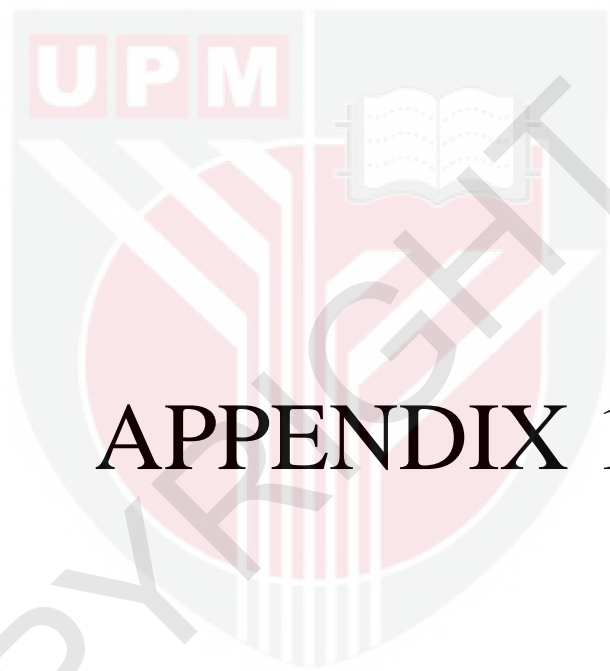
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APPENDIX 1



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UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE :

Contamination Of Nitrate In Groundwater And Health Risk Assessment In Tanah Merah, Kelantan: A Cross-Sectional Study

2. INTRODUCTION:

The study will be conducted to access the level of nitrate concentration in groundwater at Tanah Merah, Kelantan since most people in Tanah Merah are engaged in farming activities. The most common crops are Paddy, tobacco, watermelon and vegetables. Their agricultural practises are expected to cause high application of urea and Nitrogen, Phosphorus and kalium (NPK) fertilizer to support plant growth. Thus, can lead nitrate to leaching into groundwater, especially near the paddy field. Thus it is important to measure the concentration of nitrate level among residents in two village involving 47 respondents because it is very much linked to health consumers. The research also will compare nitrate levels in groundwater with the national Standard for Drinking Water Quality (NDSWQ) in Malaysia. The study will be conducted for 1-2 weeks in February. Expected duration of participation is 1-2 hours.

3. WHAT WILL YOU HAVE TO DO?

The respondents will need to answer and provide all the information, water usage, living environment and health information required in the questionnaire given.

The respondents in this study is voluntary, respondents can refuse or withdraw without any fine or complaint to higher authorities.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

The respondents that does not include in inclusion criteria and fall under exclusion criteria; respondents with age range below 18 years old, use another water source other than groundwater and use filtration system in their house.

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

The study can determine the level of nitrate in respondent's location and identify whether the level of nitrate in groundwater is in safe level or in dangerous level. The knowledge about the danger of exposure to nitrate also will be disseminate to the respondents.

(b) TO THE INVESTIGATOR?

Enrich existing nitrate data and may give more explanation regarding all issues about nitrate in groundwater and its effects. It will provide the information of the new baseline nitrate level in groundwater.

6. WHAT ARE THE POSSIBLE RISKS?

There is no possible risks will happen to the respondents.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

Yes, all the information about the respondents will be kept internally and confidentially.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

Dr Shaharuddin Bin Mohd Sham,

Department Of Environment and Occupational Health,

Faculty of Medicine and Health Sciences,

Universiti Putra Malaysia,

Phone no: 012-338 7305

Office no tel: 03 97692407

Email: shaha@upm.edu.my

Please initial here if you have read and understood the contents of this page_____

9. CONSENT

I Identity Card No.
address.....
.....hereby voluntarily agree to take part in
the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/
questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible
adverse
effects and complications (as written in the Respondent's Information Sheet). I understand
that I have the right to withdraw from this research at any time without giving any reason
whatsoever. I also understand that this study is confidential and all information provided with
regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me
be used in any form of publication or presentation (if applicable)

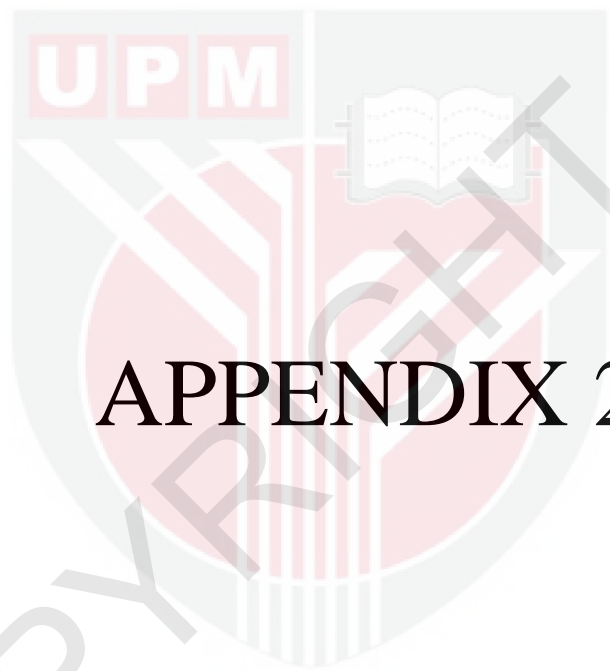
* delete where necessary

Signature Signature
(Respondent) (Witness)

Date : Name :
I/C No. :

I confirm that I have explained to the respondent the nature and purpose of the above-
mentioned research.

Date Signature
(Researcher)



APPENDIX 2

Ref. no: UPM/TNCPI/RMC/JKEUPM/1.4.18.2 (JKEUPM)

Date: 2 January 2020

Dear Prof./Dr./Mr./Ms.,

APPLICATION FOR JKEUPM ETHICAL CLEARANCE: APPROVED

With reference to the above, I am pleased to inform you that your application for ethical clearance for the research project entitled '**Contamination on nitrate in groundwater and health risk assessment in Tanah Merah, Kelantan: a cross-sectional study**' has been approved.

Please note that the official letter of approval will be issued as soon as possible. However, the ethical clearance is considered effective from the date of this email, and you may now proceed with your research.

Kindly remind the ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.

Researchers should also complete a Study Final Report upon study completion. The form can be obtained from the Ethics Committee for Research Involving Human Subjects (JKEUPM) website (<http://www.tncpi.upm.edu.my/faildokumen>).

If you have any enquiries, please contact Ms. Nurulhasanah Ishak (03-97691605) or Ms. Nor Ellia Abd Ajis (03-97691244).

Note: Please use this reference number for any transaction.

- JKEUPM-2019-454

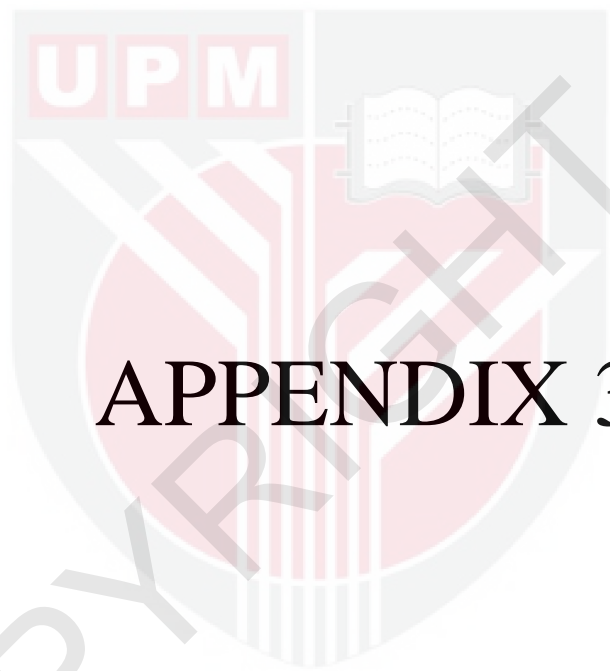
Thank you.

Yours faithfully,

Prof. Dr. Zamberi Sekawi

Chair

Ethics Committee for Research Involving Human Subjects
Universiti Putra Malaysia



APPENDIX 3

Bahagian C: Maklumat persekitaran tempat tinggal

Adakah terdapat kawasan pertanian berdekatan dengan tempat tinggal anda?

Ya Tidak Tidak pasti

Apakah jenis perpaipan air di rumah? Logam PVC Tidak pasti

Umur Telaga < 5 Tahun 5-10 Tahun 10-15 Tahun 16-20 Tahun
 > 20 Tahun

Kedalaman telaga (m) < 5 m 5-10 m 11-15 m >15 m

Jenis telaga Terbuka Tertutup Boring Lain-lain, sila nyatakan

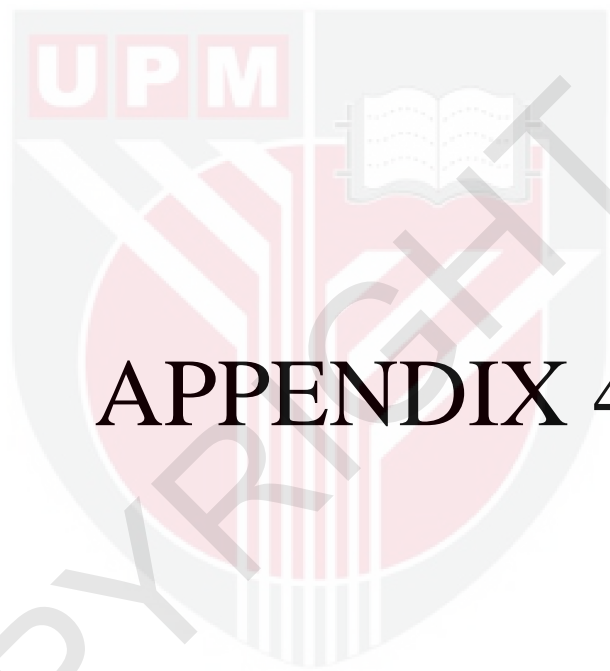
Bagaimana air diambil daripada telaga? Menggunakan baldi Pam elektrik
 Lain-lain, sila nyatakan.....

Bahagian D: Maklumat Kesihatan

Adakah anda mempunyai masalah kesihatan serius: Ya Tidak

TERIMA KASIH ATAS KERJASAMA ANDA
-TAMAT-

| | |
|--|--|
| NAMA PENUH RESPONDEN | |
| NOMBOR RUMAH | |
| NAMA JALAN | |
| NAMA KAMPUNG | |
| JARAK DARIPADA SAWAH/SISTEM SEPTIK (M) | |
| KOORDINAT GEOGRAFI | |
| MAKLUMAT TAMBAHAN | |
| TANDATANGAN ENUMERATOR & TARIKH | |



APPENDIX 4

On-Site Work Picture

