



UNIVERSITI PUTRA MALAYSIA

***HEALTH RISK ASSESSMENT OF NITRATE EXPOSURE IN GROUND
WATER AMONG RESIDENTS AT THREE VILLAGES IN BACHOK,
KELANTAN***

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AMONG RESIDENTS AT THREE VILLAGES IN BACHOK, KELANTAN**

BY

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**Thesis submitted in fulfillment of the requirement for the degree of Bachelor Science
(Environmental and Occupational Health) from the Faculty of Medicine and Health
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1307170031

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ABSTRAK

KAJIAN PENILAIAN RISIKO KESIHATAN TERHADAP TAHAP NITRAT DI DALAM AIR PERIGI DI TIGA KAMPUNG DI BACHOK, KELANTAN

NORAZIAH JAMALUDIN

Pengenalan: Pendedahan nitrat dalam air perigi di kawasan pertanian merupakan isu penting dalam aspek kesihatan. Pendedahan manusia kepada nitrat membawa kepada banyak risiko kesihatan termasuk penyakit methaemoglobinemia. **Objektif:** Objektif kaji selidik ini adalah bagi mengkaji pendedahan nitrat dalam air perigi dan menjalankan penilaian risiko di tiga buah kampung di daerah Bachok, Kelantan. **Methodologi:** Sejumlah 70 orang responden telah dipilih berdasarkan kriteria yang telah ditetapkan. Manakala, sampel air perigi diambil dari setiap rumah responden dan analisis sampel dijalankan menggunakan DR 2500 Spectrophotometer. Borang soal selidik digunakan untuk mendapatkan maklumat sosio-demografik, maklumat perigi dan pengambilan air minuman harian responden. Berat badan responden diukur menggunakan penimbang berat Seca. Penilaian risiko kesihatan dijalankan melalui pengiraan rumus yang sedia ada. **Keputusan:** Nilai min \pm SP bagi kepekatan nitrat dalam sampel air adalah 1.66 ± 2.11 mg/L. Kepekatan nitrat tertinggi adalah di kawasan Kampung Aman iaitu nilai min \pm SP (3.34 ± 4.07 mg/L), diikuti Kampung Kandis (1.45 ± 1.32 mg/L) dan Kampung Telong (1.43 ± 1.95 mg/L). Ujian hubungkait Kruskal-Wallis menunjukkan tiada hubungkait antara kepekatan nitrat dengan jenis kampung ($p > 0.05$). Manakala ujian hubungkait antara nilai kepekatan nitrat dengan setiap lokasi pengambilan sampel menunjukkan ada hubungkait ($p < 0.05$). Nilai min \pm SP bagi pengambilan kronik harian ialah 0.051 ± 0.086 dan bagi indeks hazad pula 0.032 ± 0.054 . Keseluruhan, nilai kepekatan nitrat dalam sampel air adalah di bawah piawaian kualiti air Malaysia (< 10 mg/L). **Kesimpulan:** Penilaian risiko kesihatan setiap responden adalah diterima dan selamat.

Kata Kunci: Nitrat, air perigi, piawaian kualiti air Malaysia, pengambilan kronik harian, indeks hazad, Bachok Kelantan

ABSTRACT

HEALTH RISK ASSESSMENT OF NITRATE EXPOSURE IN GROUNDWATER
AMONG RESIDENTS AT THREE VILLAGES IN BACHOK, KELANTAN

NORAZIAH JAMALUDIN

Introduction: The nitrate exposure in groundwater especially in agricultural areas has become a major public health issue. Methaemoglobinemia is the most common disease that related to nitrate exposure. **Objective:** This cross-sectional study was conducted in Bachok Kelantan with an aim to determine the nitrate exposure level in groundwater and to perform health risk assessment among respondents at respective areas. **Methodology:** Seventy (70) respondents were selected in this study based on the inclusive and exclusive criteria. The groundwater samples were taken from each respondent well, and were analysed with DR 2500 Spectrophotometer to determine the nitrate levels. Questionnaires were used to determine the respondents water daily intake, socio-demographic background and status of water quality supply. The body weight of respondent was measured using a Seca Body Weight Scale. The health risk assessment was calculated through Chronic Daily Intake (CDI) and Hazard Index (HI). **Result:** Nitrate level in this study was below the Maximum Concentration Limit of National Standard for Drinking Water Quality of Malaysia (NSDWQ) (< 10 mg/L). The value of mean \pm SD for nitrate levels in all water samples were 1.66 ± 2.11 mg/L. The highest mean \pm S.D of nitrate level was in Kampung Aman (3.34 ± 4.07 mg/L) followed by Kampung Kandis (1.45 ± 1.32 mg/L) and Kampung Telong (1.43 ± 1.95 mg/L). There was a significance difference of nitrate level between each house location, ($p < 0.05$) and Kruskal-Wallis test showed no significant difference of nitrate levels between villages ($p > 0.05$). The mean \pm S.D for Chronic Daily Intake (CDI) and Hazard Index (HI) was 0.051 ± 0.086 and 0.032 ± 0.054 respectively **Conclusion:** The health risk of nitrate exposure in groundwater in respective areas was acceptable.

Keywords: Nitrate, groundwater, maximum concentration limit, chronic daily intake, hazard index, Bachok Kelantan

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LIST OF ACRONYMS AND ABBREVIATIONS

ATDSR	Agency for Toxic Substances and Disease Registry
WHO	World Health Organization
mg / L	milligram per litre
RfD	Reference Dose
USEPA	United States Environmental Protection Agency
CEPA	California Environmental Protection Agency
USGS	United States of America Geological Survey
NJDEP	New Jersey Department of Environmental Protection Division of Air Quality
NSDWQ	National Standard for Drinking Water Quality for Malaysia
MoH	Ministry of Health
CWC	Community Water Center's Health & Drinking Water Series
ANL	Argonne National Laboratory



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CHAPTER 1

INTRODUCTION

1.1 Introduction

Agriculture is very important to the Malaysian economy. There has been a rapid growth in agricultural activities. These developments of agriculture have also resulted in increasing of chemicals usage such as fertilisers, herbicides and insecticides (*Mohd Kamil et al., 1990*).

The increasing in consumption of chemicals such as fertilisers in agricultural activities has raised many issues on chemical pollution of groundwater

such as nitrate, arsenic and other chemicals (Kevin et al., 2005; Rosen and Kropf, 2009).

Nitrate in the environment accumulating from both natural and anthropogenic sources. Naturally, soil mineralization and atmospheric deposition of nitrogen are major contributors of nitrate existence. Meanwhile, the examples of anthropogenic (man-made) sources are from agricultural, industrial residue, septic tanks and so on. Yet, agricultural activities are more important sources of nitrate to the environment (Weyer et al., 2001).

Today, the intensive of agricultural practices present a threat to the world's clean water supply. The excess application of nitrogen fertiliser in crop production has led to the major nitrate pollution in groundwater (Reyes, 2007).

The excess consumption of nitrogen fertiliser will cause problem to health and environment as well. Regarding to WHO (2006), groundwater is a vital water source for human needs such as for drinking water. The problem is, drinking water with high levels of nitrate can contribute to the serious health problems, especially in children and infants (Reyes, 2007).

1.2 Problem Statement

Poor water quality remains an important issue throughout developing nations nowadays (*Wan Ruslan et al., 2004*). Nowadays, the degradation of quality of water supply has arisen due to anthropogenic factors such as agricultural practices, industrial activities and so on (*Mohamed Azwan et al., 2010*).

According to *Mohd Kamil et al. (1990)*, agriculture is important sector to the Malaysian economy in which there has been substantial development in the cultivation of rubber, oil palm, cocoa, fruits and vegetables. The developments of agriculture activities have also resulted in increased use of commercial fertilisers.

The increase in fertiliser usage in agricultural activities has raised chemical pollution of groundwater, especially by plant nutrients such as nitrate. Previous studies have indicated that most of the nitrate in groundwater is associated with the use of fertilisers (*Mahvi et al., 2005*).

According to the previous study in Iowa, nitrate was found in 94% of samples taken from aquifers (groundwater) in agricultural areas compared to samples taken in urban areas (*Weyer et al., 2001*).

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 (CWC, 2011). In addition, the increasing contamination of groundwater and surface water supplies by nitrate, primarily from commercial fertilisers usage has been documented (*Weyer et al., 2001*).

Nitrate in low levels is a necessary nutrient for plants, but at high levels it can impact human health and environment (*Rosen and Kropf, 2009*). It will infiltrate to the groundwater, degrade the water quality, and potentially cause a public health risk since groundwater is the source of drinking water for most of the population (*Dubrovsky et al., 1998*).

1.3 Study justification

This study is carried out in order to assess nitrate concentration level in groundwater at Kampung Kandis, Kampung Telong and Kampung Aman in Bachok, Kelantan since majority of people in Bachok practice agriculture activities. The common crops are tobacco, watermelon, sweet potato and vegetables. Their main activity of agricultural practices is expected to cause high application of urea and NPK fertiliser for supporting plant with the nutrients. As being referred to the many issues, contamination of groundwater has strong relationship with fertiliser consumption in agricultural field.

In Kelantan, Malaysia, groundwater plays a very important role in the public water supply system. About 70% of the total water supply in the state including Bachok derived from groundwater (*Mohamed Azwan et al., 2010*). Bachok is one of the districts in Kelantan and it is also labelled as an agricultural area. As referred to *Mohd Kamil et al. (1990)*, nitrate levels in groundwater located in agricultural areas are significantly different from urban and forested areas. The increasing consumptions of fertiliser resulting in increased nitrate content in the groundwater source.

Another aspect of concern is, most of people that staying in this area lack knowledge and awareness in terms of how to manage the water system properly and do not take into account the maintenance of groundwater system which can contribute to the degradation of water quality. They are not concern to groundwater maintenance and its treatment system. Groundwater system that are not be maintained properly can cause nitrate accumulation in groundwater.

Furthermore, little attention has been given to the research aspects of nutrient pollution to water in Malaysia. That is why this study is conducted in order to seek a better understanding and awareness of nutrient pollution in groundwater.

Last but not least, these findings of study may be used to generate hypotheses will be able to provide baseline data for further research.

1.4 Conceptual framework

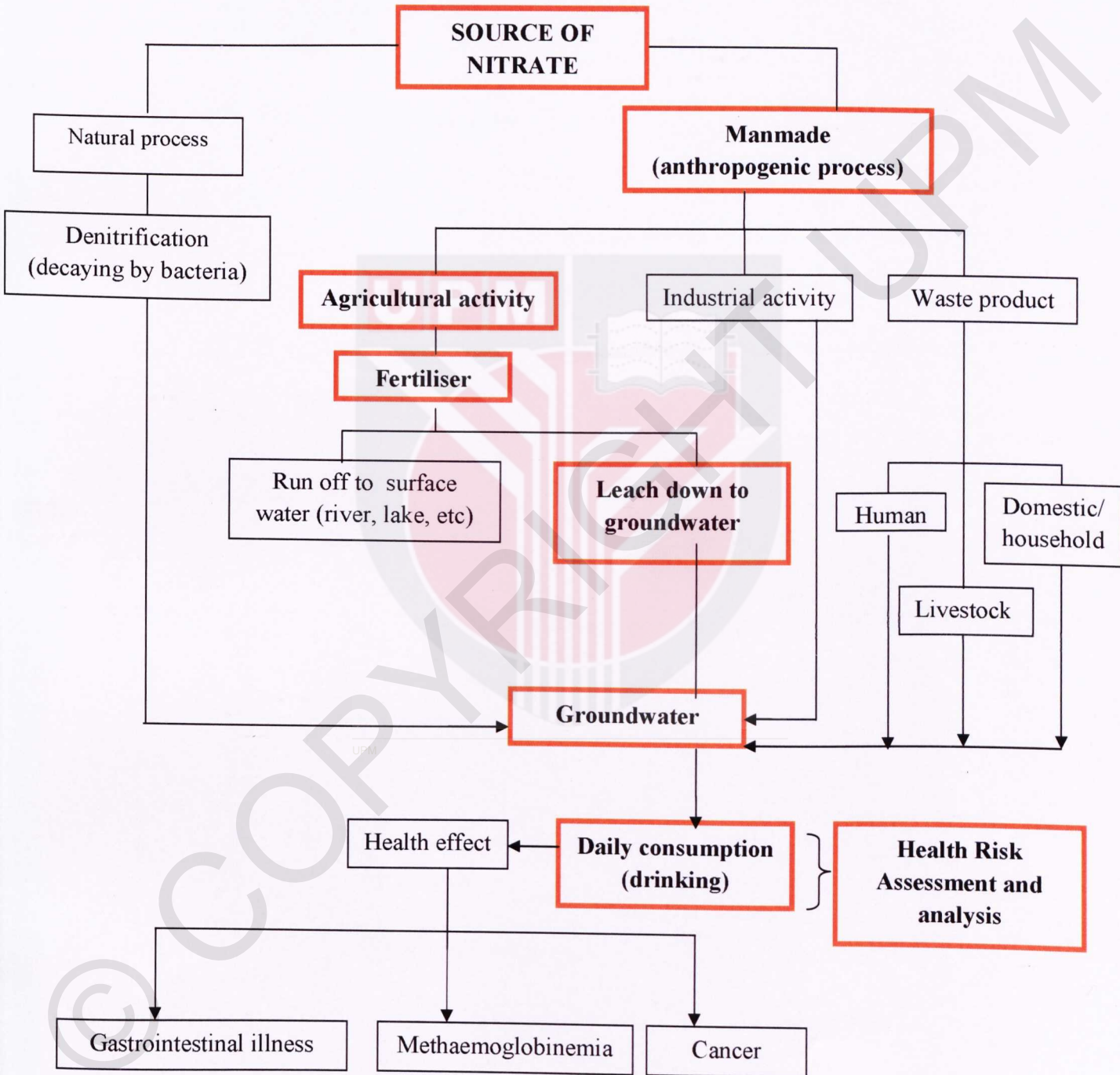


Figure 1.1 : Conceptual framework (CWC, 2011 ; Rosen and Kropf, 2009).

1.5 Definition

1.5.1 Conceptual Definition

1.5.1.1 Drinking water

Drinking water or potable water is water pure enough to be consumed or used with low risk of immediate or long term harm. The drinking water quality is a powerful environmental determinant of health (*WHO, 2012*).

1.5.1.2 Nitrate level

According to Interim National Standard for Drinking Water Quality for Malaysia (*NSDWQ, 2000*), the maximum allowable nitrate concentration in drinking water is 10 mg/L.

1.5.1.3 Health Risk Assessment

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

Four basic steps of risk assessment process (OEHHA, 2001) :

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

1.5.2 Operational Definition

1.5.2.1 Drinking water

The drinking water samples are collected direct from each respondent's groundwater source. Then, the water is poured into pre-cleaned 250ml high density polyethylene (HDPE) bottles.

1.5.2.2 Nitrate level

Nitrate level in groundwater sample is analysed singly for nitrate using DR 2500 MR of cadmium reduction method with electronic spectrophotometer (method 8171) (HACH Company, 2003; Patton *et al.* 2002 cited by Campbell, 2006).

1.5.2.3 Health Risk Assessment

According to *USEPA (1992)*, to estimate the daily exposure of individuals for nitrate exposure through ingestion is by calculating the chronic daily intake (CDI) as the exposure metric. Then, to estimate the non-carcinogenic risk of nitrate, the hazard index (HI) is calculated using the equation in Chapter 3.



1.6 Objective

1.6.1 General Objective

To determine the exposure of nitrate in groundwater and to perform health risk assessment among respondents at Kampung Kandis, Kampung Telong and Kampung Aman in Bachok, Kelantan.

1.6.2 Specific objective

1. To determine socio-demographic data of respondent
2. To determine nitrate level in groundwater in study areas
3. To determine the distribution of nitrate level in study locations using Geographical Information System (GIS)
4. To compare nitrate level between each study location
5. To compare nitrate level between the three villages
6. To compare the nitrate level of groundwater with Malaysia national standard
7. To estimate the chronic daily intake (CDI) and Hazard Index (HI) among respondents

1.6.3 Hypothesis

1. There is a significant different of nitrate level of groundwater among each house location
2. There is a significant different of nitrate level of groundwater between three villages in Bachok
3. Nitrate concentration of groundwater in Kampung Kandis, Kampung Telong and Lampung Aman is higher than national standard
4. Hazard index of respondents in Kampung Kandis, Kampung Telong and Kampung Aman is higher than 1 ($HI > 1$)

CHAPTER 2

LITERATURE REVIEW

2.1 Nitrates in Environment

The majority of Earth's atmosphere; approximately 78% is nitrogen, making it as the largest pool and occurs in many different gaseous forms such as elemental nitrogen, nitrate, nitrite and ammonia (*Absolute Astronomy, 2011*). Natural reactions of atmospheric forms of nitrogen with rainwater result in the formation of nitrate and ammonium ions. Nitrate is also an inorganic ion and common nitrogenous compound that occur from nitrogen cycle and anthropogenic (man-made) sources (*Haller et al.; ATSDR, 2011*).

2.2 Source of Nitrate

Nitrate accumulates from both natural and anthropogenic sources. Nitrates occur in soil, in water, and in some foods (*ATSDR, 2011*).

2.2.1 Natural source

The nitrogen cycle represents one of the most important nutrient cycles found in terrestrial ecosystems (*Pidwirny, 2006*). The nitrogen cycle is the natural process by which nitrogen is converted between its various chemical forms and this transformation can be carried out via both biological and non-biological processes. Important processes in the nitrogen cycle include fixation, mineralization, nitrification, and denitrification. The nitrogen cycle is of particular interest to ecologists because nitrogen availability can affect the rate of key ecosystem processes, including primary production and decomposition (*Astronomy Absolute, 2011*).

Microbes break down animal and human organic wastes in soil and water. The breakdown process converts waste into ammonia, then oxide to nitrite and nitrate (*ATSDR, 2011*).

2.2.2 Anthropogenic source

Anthropogenic activities or man-made source such as use of fertilisers, fossil fuel combustion and release of nitrogen in wastewater have also dramatically altered the global nitrogen cycle (*Absolute Astronomy, 2011*).

The activities of humans have severely altered the nitrogen cycle. Some of the major processes involved in this alteration including of the application of nitrogen fertilisers to crops has caused increased rates of denitrification and leaching of nitrate into groundwater. The additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes, and estuaries. In these systems, the added nitrogen can lead to eutrophication. Secondly is due to the increasing of deposition of nitrogen from atmospheric sources because of fossil fuel combustion and forest burning. Both of these processes release a variety of solid forms of nitrogen through combustion. Thirdly, livestock release a large amounts of ammonia into the environment from their wastes. This nitrogen enters the soil system and then the hydrologic system through leaching, groundwater flow, and runoff. Moreover, the sewage waste and septic tank leaching also cause nitrogen alteration (*Pidwirny, 2006*).

2.3 Exposure to nitrate

Nitrate is an inorganic compound produced when nitrogen is introduced into the environment. Although nitrate occurs naturally at low levels, human activities including the usage or improper disposal of fertilisers for agriculture, animal manure, or human waste, can elevate levels of nitrates in sources of drinking water (CWC, 2011).

Human exposure to nitrates and nitrites can occur via exogenous sources such as diet, drinking water, occupation or environmental exposures (Griensenbeck, 2009).

Some vegetables (lettuce, spinach, celery, greens, etc), cigarette smoking, and certain medications all contribute to daily nitrate intake in the U.S. population. In addition, drinking water consumption can account for a substantial portion of that intake (Weyer *et al.*, 2001).

2.4 Issue of agricultural activity and nitrate in groundwater

Nitrate is also a common nitrogenous compound due to natural nitrogen cycle and anthropogenic (man-made) sources which have greatly increased the nitrate concentration level particularly in groundwater (Haller *et al.*, 2010).

As mentioned by Walter *et al.* (2009) and Tredoux *et al.* (2009), groundwater can be a significant source of nitrate which can come from runoff and leach down of fertiliser residue as major factor.

Today, nitrogen fertilisers are used in large quantity in most agricultural settings as one of nitrate level contribution factor in groundwater (Ryker and Jones, 1998).

The high agricultural activities are achieved by using plant nutrients such as nitrogen fertilisers. When nutrients are applied in excess of plant needs, they have a potential to pollute surface and groundwater (Mahvi *et al.* 2005).

For more elaboration, nitrate-containing compounds from fertilisers in the soil are generally soluble, which means they dissolve easily in water and it leach down easily into groundwater and contaminate it (Rosen and Kropf, 2009).

2.5 Exposure and risk assessment

Exposure to nitrates can cause immediate or acute health problems. Exposure over long periods of time can lead to many other dangerous health conditions (CWC, 2011).

Therefore, health risk assessments are used to determine if a particular chemical poses a significant risk to human health and if so, under what circumstances (OEHHA, 2001).

Risk assessment method can also be used to estimate the risk of adverse ecological effects due to pollutant in the environment which are consist of four steps; hazard identification, doe-response assessment, exposure assessment and risk characterization (Boguski, 2010).

2.6 Health Effects

2.6.1 Methaemoglobin or “Blue Baby Syndrome”

Simply about methaemoglobinemia, it disturbs the blood cells' ability to carry oxygen (*Haller et al., 2011; CWC, 2011*). The excessive nitrates or nitrites can alter the iron in haemoglobin to the ferric state. Nitrite oxidizes easily into nitrate. Thus, nitrate will form methaemoglobin; an abnormal form of haemoglobin (*ATSDR, 2011*).

Greer and Shannon (2005) mentioned that infants for whom formula may be prepared with well water contain high nitrate can lead to nitrate poisoning and methaemoglobinemia in infant called as “Blue Baby Syndrome”. Therefore, the clinical report reinforces the need for testing of groundwater for nitrate content.

Referring to standard guideline by USEPA, the standard for nitrate is 10mg/L. This limit is utilised to prevent the occurrence of methaemoglobinemia in infants or what is called ‘Blue Baby Syndrome’ (*Clesceri et al. 1998*).

It has been supported by *Weyer et al (2001)* that mention the exposure of infant whose less than 6 months of age to nitrite has been linked to development of methaemoglobinemia.

Other than that, infants are the most vulnerable group of methaemoglobinemia, children are also be classified as high risk group to the following health impacts of nitrates (*ANL, 2005*).

2.6.2 Gastrointestinal (GIT) complications

Many gastrointestinal illnesses are related to nitrates. The consumption of nitrate contaminated water causes multiple digestive tract impairment (*Rao, 2006*).

In a study of rural households using well water, it show that the prevalence of a child younger than 10 years having an episode of gastrointestinal illness. There is some evidences that long-term effects, such as gastric cancer, might result from exposure to even smaller amounts of nitrate if they expose to the N-nitroso compounds; the form when nitrate react with certain conditions and in which it is potent carcinogens in many species (*Walter et al., 2009*).

Children may also drink water at child care or when travelling. Illness resulting from children's ingestion of nitrate contaminated water can be severe. Other complications are indigestion and inflammation of the stomach and gastrointestinal tract (gastroenteritis), with abdominal pain, diarrhea and blood in the urine and faeces (CWC, 2011; Walter et. al, 2009).

2.6.3 Carcinogenic disease and problem

Peter Weyer who hold Ph.D. and also as an associate director of the University of Iowa, Center for Health Effects of Environmental Contamination (CHEEC) mentioned that even low level exposures to nitrate over many years could be problematic in terms of certain types of cancer (Pedersen, 2001).

According to Weyer et al (2001), the additional studies are needed to look at possible links between nitrate levels in drinking water and cancer, particularly with respect to refining exposure assessments. From a public health perspective, source water protection is a main concern. Sources of nitrate which can impact water supplies include fertilisers, human waste and animal waste should be concern of too.

Nitrate can be reduced endogenously within the human body to nitrite through bacterial and other reactions. Nitrite can be further reduced to N-

nitroso compounds (NOCs). NOCs are some of the strongest known as carcinogen can act systemically and have been found to induce cancer in a variety of organs (*Weyer et al., 2001; Rao, 2006*).

Cancers of the digestive system, stomach, esophagus, lungs, colon, bladder and ovaries, testicles, uro-genital tract and non-Hodgkins lymphoma is reported to relate to nitrate intake (*CWC, 2011; Rao, 2006*).

By using cancer incidence data from the Iowa Cancer Registry for 1986 to 1998, the researchers found a greater risk for bladder cancer as the nitrate levels in the communities' water supplies increased. Women whose average drinking water nitrate exposure level was greater than 2.46 milligrams (mg) per liter (nitrate-nitrogen) were 2.83 times more likely to develop bladder cancer than women in the lowest nitrate exposure level that less than 0.36 mg/L (*Pedersen, 2001*).

The few epidemiologic studies have also observed elevated risks for colon cancer and neural tube defects associated with drinking water nitrate (*CWC, 2011*).

2.6.4 Others related health problem

The scientific and medical studies have linked nitrates to multiple digestive tract impairment, dyspepsia, depression, headache and weakness (CWC, 2011).

Besides that, miscarriage, stillbirths or premature birth and Sudden Infant Death Syndrome (SIDS) can occur. It also can cause the mutagenicity (DNA damage), teratogenicity and also impaired growth of foetuses in utero, which by leading to neural tube disabilities and other birth-related disabilities (Kevin *et. al*, 2005).

Another complications due to chronic nitrates exposure reported are nervous system disabilities, diuresis (increased urination), increased starchy deposits and hemorrhagic of the spleen, active ulcerative colitis and Crohn's disease, pancreatitis which is highly associated with pancreatic cancer and thyroid disruption in which including of hypertrophy and increased risk of thyroid cancer. Other than that, children are also vulnerable to inflammatory bowel disease and acute respiratory tract infections as well. Moreover, diabetes may be indirectly linked because impaired pancreas functioning can lead to diabetes mellitus, and nitrates are associated with chronic pancreatitis. In fact, nitrate levels in blood have been recommended as a marker for diabetes (CWC, 2011).

2.7 Extra information about nitrate

For extra information, nitrosamines and nitrosamides are the two groups of chemicals that comprise N-nitroso compounds. N-nitroso compounds can be formed by the reaction of a nitrite compound with amines or amides. This process is known as N-nitrosation of nitrates and nitrites. Both of them are known to be precursors to N-nitroso compound formation in the presence of amines or amides in which under normal gastric conditions. Approximately 5% of ingested nitrates in food and water are converted to nitrite in the saliva, further promoting endogenous nitrosamine formation. N-nitroso compounds are known to be potent carcinogens and are known to cause congenital malformations (*Griesenbeck, 2009*).

All the health impact of nitrate can be exacerbated if a person is consuming nitrate-contaminated water and that person has a pre-existing gastrointestinal problem, such as inflammation. Health impacts can also be existed if nitrate contamination is accompanied by bacterial contamination. Studies have shown that drinking water contaminated with both bacteria and nitrates can make methaemoglobinemia more likely. Nitrates also have indirect health impacts. High nitrate levels can also be harmful to vulnerable or high risk populations, such as pregnant women and children (*Tredoux et.al, 2009*).

CHAPTER 3

METHODOLOGY

3.1 Introduction

For the methodology, it was divided into few subsections which were study design, study location, sampling, data collection method and instrumentation, risk assessment, quality control, ethic committee approval and data analysis.

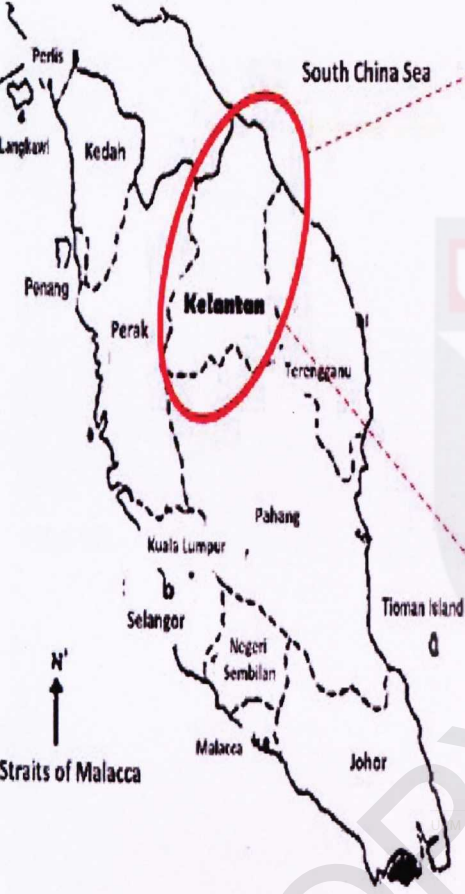
3.2 Study design

This cross sectional study was conducted in Bachok Kelantan. This study received an ethical approval from the Research and Ethical Committee, Faculty Medicine and Health Sciences of Universiti Putra Malaysia (UPM).

3.3 Study location

The study locations were Kampung Kandis, Kampung Telong and Kampung Aman in Bachok, Kelantan (Figure 6). These locations had been chosen due to its agricultural activities as main activity and most of residents still relied on groundwater for daily needs. This place was believed to have nitrate in groundwater with regards to usage of inorganic fertilizer for their crops. Thus, these areas were at high risk for nitrate residue to leach down into the groundwater.

MAP OF PENINSULAR MALAYSIA



MAP OF KELANTAN

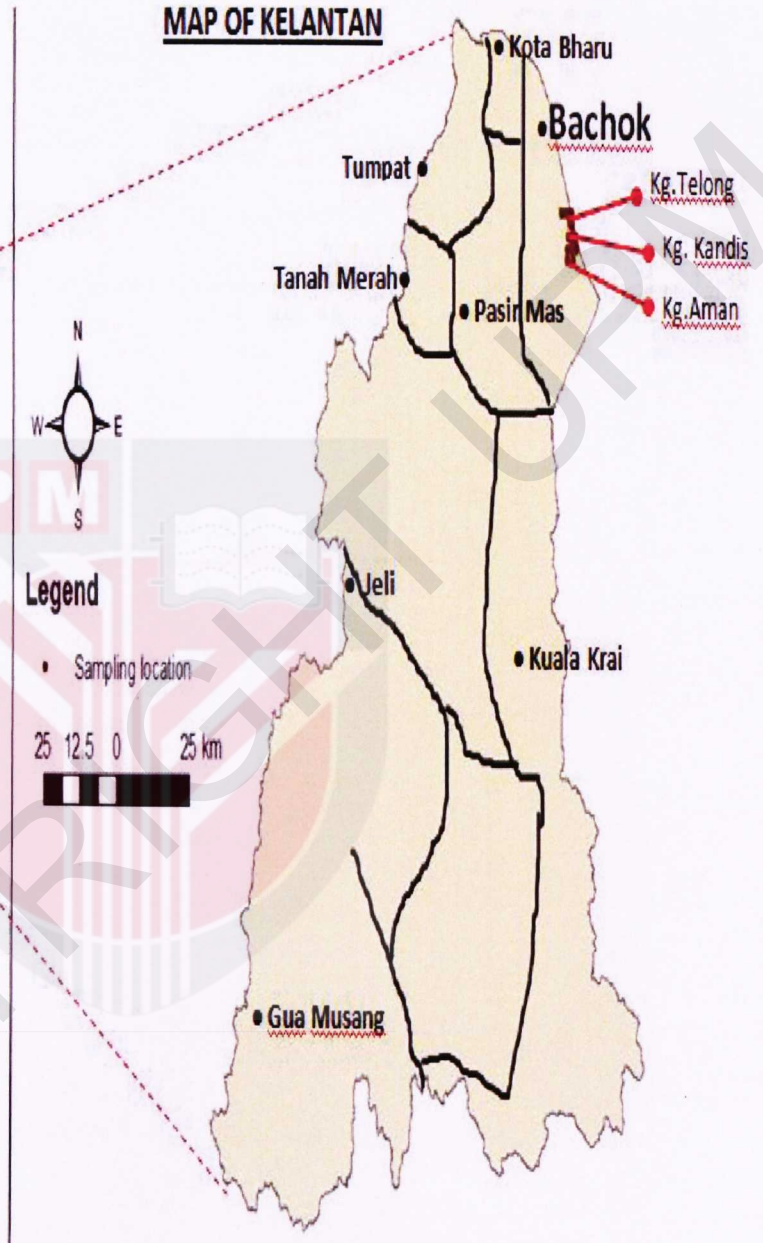


Figure 3.1: Map of study location

3.4 Study population

The study population were residents at Kampung Kandis, Kampung Telong and Kampung Aman in Bachok, Kelantan, whom used groundwater as the main source for drinking water and for other daily consumption.

3.5 Sampling

3.5.1 Study sample

The assessment was conducted only to resident or respondent who meet the inclusion criteria only and all the exclusion criteria will be exclude from this study.

3.5.2 Sample size

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

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

Where,
N = Sample size
P = Prevalence
e = Probability error

According to *Reyes (2007)*, the prevalence of nitrate level of groundwater from wells sampled which was above of 50 mg/L is 30% (0.3). So, the sample size was calculated as below.

$$\begin{aligned} N &= \frac{0.3(1-0.3)}{(0.05)^2} \\ &= 84 \end{aligned}$$

Based on the calculation above, the value of 84 was considered as minimum sample size needed. To ensure that the study was statistical significant and to take into consideration damaged data and non-response survey, the sample size was added to 20% from actual sample size. So, the sample final sample size was 100.

3.5.3 Sampling method

The sampling method that used in this study was purposive sampling. The respondent was selected based on inclusive and exclusive criteria.

3.5.4 Sampling unit

The sampling unit for this study were resident living at Kampung Kandis, Kampung Telong and Kampung Aman, who fulfill the inclusive criteria.

Inclusion criteria:

- I. Age 18 years old and above which was considered as adult.
- II. The respondent should be a lifelong resident at Kampung Kandis, Kampung Telong and Kampung Aman in Bachok, Kelantan.
- III. The respondent use groundwater as his/her main source of water supply for his daily consumption.

Exclusion criteria:

- I. Respondent who used water filtered system.
- II. Respondent who used other than groundwater as his/her main water supply for daily consumption.

3.6 Study instrumentation and data collection

3.6.1 Questionnaire

A set of questionnaire comprising of three sections were administered to each respondent. Part A of the questionnaire contained questions regarding the socio-demographic information, Part B contained questions related to duration of residence. Part C contained questions about the information of daily intake of drinking water. The questionnaire was adapted from the Baseline, Descriptive and Time Activity Questionnaires used in the National Human Exposure Assessment Survey (NHEXAS) Arizona study (*Qaiyum et al., 2011*).

3.6.2 Body weight

The body weight of the respondents was measured using a Seca Weight Scales. The readings were taken three times and then averaged. The unit was in kilogram (kg).



Figure 3.2: Seca Weight Scale

3.6.3 Drinking water daily intake

The daily intake rate of water among respondents was measured by using a standard cup of 200 ml, and every respondent need to recall back their water consumption amount in a day based on that standard cup in order to calculate the Chronic Daily Intake (CDI) and Hazard Index (HI).

3.6.4 Water sampling

3.6.4.1 Water sampling

Water samples were collected and stored into pre-cleaned HDPE bottles (250 mL). The samples were taken directly from respondent's groundwater source by both manually and pump.

3.6.4.2 Storage and preservation of water sample

Then, the water samples were stored in an ice box at 4°C prior to analysis. The maximum holding time of the nitrate water samples was up to 24 - 48 hours (*HACH Company, 2003*).

3.6.4.3 Water analysis

Sample analysis was carried out within 48 hours by using the Cadmium Reduction Method (Method 8171) with a HACH brand DR/2500 spectrophotometer. This method was for analysing nitrate in water, wastewater and also seawater (HACH Company, 2003).

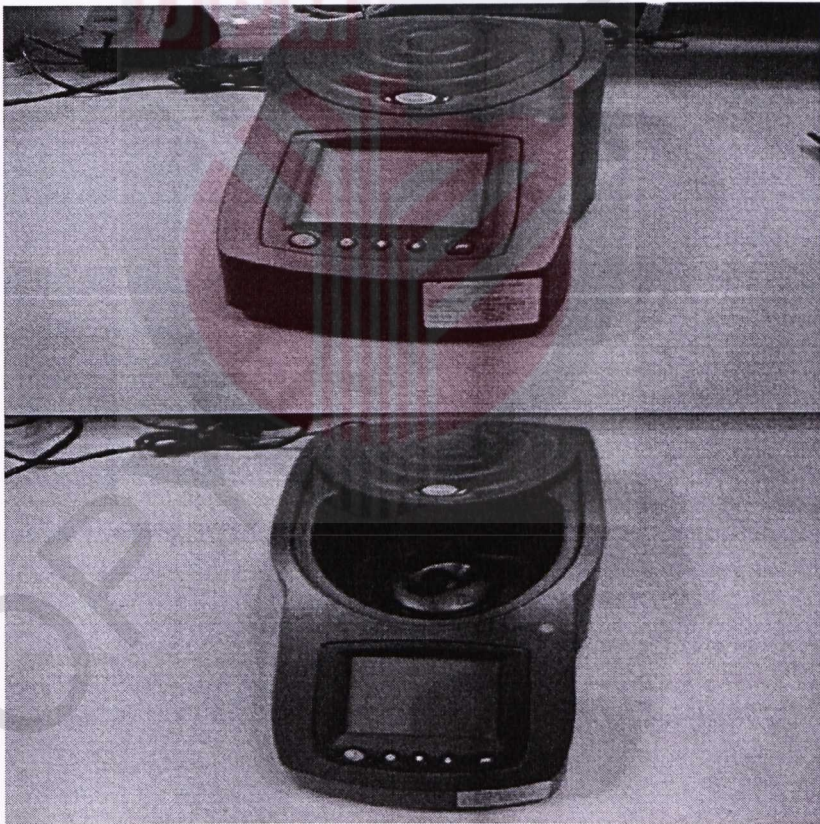


Figure 3.3: DR/2500 spectrophotometer

3.6.5 Geographical Information System (GIS) Software

A Geographical Information System (GIS) was used to capture, store, analyse and display geographically reference information which related to location. It also used to view, interpret, and visualize the data that reveal the patterns, and distributions of nitrate level in groundwater at the study area in the form of maps.

3.7 Risk Assessment (Calculation)

In order to determine exposure of nitrate in drinking water, chronic daily intake (CDI) was first calculated using the following equation.

$$CDI = \frac{C \times DI}{BW} \quad \text{(Equation 2)}$$

Where,

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

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

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

BW = Body weight (kg).

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

$$HI = \frac{CDI}{RfD} \quad \text{(Equation 3)}$$

Where,

HI = Hazard Index,

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

Rfd = Reference dose (mg/kg/day)

HI value more than 1 ($HI > 1$) will show a significant risk level, the higher the value, the greater the likelihood of adverse non-carcinogenic health impact. Rfd value that will be used in this study was 1.6 mg/kg/day (USEPA, 2000).

3.8 Quality control

3.8.1 Standard Operating Procedures (SOPs)

The analysis of water samples using Cadmium Reduction Method (Method 8171) with a HACH brand DR/2500 spectrophotometer followed the standard operating procedure that was given by the manufacturer, HACH Company (USA). By following the standard operating procedure, it will minimise any analytical error that might occur during analysis.

3.8.2 Calibration

DR/2500 spectrophotometer was calibrated first before conducting the analysis.

3.8.3 Pre test of questionnaire

Pre testing of questionnaire was conducted on 10% of sample size before the actual data collection. The reason was to conduct the pre test is to ensure that the questionnaire was easily understood and could be easily answered by the respondent.

3.8.4 Pre test of equipment

Pre testing of equipment (DR/2500 spectrophotometer) was conducted before the actual sample analysis. The pre-testing of equipment done followed the standard operating procedure of HACH Method. The pre-testing of equipment was to ensure that the equipment in good condition.

3.8.5 Water sampling

The water sample will be stored in cool box at 4°C to prevent any nitrate loss or disruption from water samples (*Mohd Kamil et al., 2003*).

3.9 Data analysis

Data analysis was performed using the Statistical Program for Social Science software (SPSS for Windows) version 17.

For descriptive data, univariate analysis was used to determine socio demographic information of respondents, water consumption and results of water analysis in percentage, mean, standard deviation, range, percentiles, maximum and minimum values.

Then, the normality test in this study was performed by using Kolmogorov-Smirnov Test where $p > 0.05$ indicated a normal distributed data. The parametric test was used if data was parametric or normal distribution. While, if it was not normally distributed, non-parametric test was used to analyse the data.

One sample t-test was used to compare nitrate level in groundwater between each respondent's house locations, while, Kruskal-Wallis test was used to compare nitrate levels between the three villages in Bachok.

Besides, the nitrate level in groundwater was compared to the Interim National Drinking Water Quality Standards for Malaysia (*NDWQS, 2011*).

3.10 Ethical issues

Ethical approved to carry out this study was requested from the ethical committee, Faculty Medicine and Health Sciences of Universiti Putra Malaysia.

3.11 Study limitation

1. The information given from respondents could not be sure to be 100% valid but in term of this limitation, we assumed the answer and data given was met the validity. The recall bias can contribute to this study.
2. This study was a cross-sectional study that only measure nitrate for specific period only. The data collected from this study might be insufficient to support the argument on groundwater contamination issue in Kampung Kandis, Kampung Telong and Kampung Aman in Bachok.
3. This study probably be conducted during the planting season, in which indirectly affect the outcome of study. If the usage of fertiliser was high, nitrate level will also increase.

CHAPTER 4

RESULT

4.1 Background of respondent

4.1.1 Socio-demographic information

The data collection was carried out within one week started from 19 January 2012 to 25 January 2012 at the respective areas.

The total respondents who had participated in this study were 70. All of the 70 respondents were Malay (100%). There were more female participated in this study (45 respondents-64.3%) compared to male (25 respondents-35.7%).

The mean and standard deviation (mean \pm S.D) for age of respondents was 47.23 \pm 16.29. The median was 46 years old. The range was between 21-90 years old.

This study was conducted at three villages namely Kampung Kandis (31 respondents-44.3%), Kampung Telong (31 respondents-44.3%) and Kampung Aman (8 respondents-11.4%).

For information on education level, the highest percentage was respondent who never attend school (17 respondents-24.3%), followed by primary school level, Penilaian Menengah Rendah (PMR) which was 15 (21.4%) respondents and Sijil Pelajaran Malaysia (SPM) which was also 15 (21.4%) respondents. For Sijil Tinggi Pelajaran Malaysia (STPM), there were only 5 (7.1%) respondents. Lastly, only 3 (4.3%) respondents had higher education background.

Information on occupation of respondents, the highest number was farmers (31 respondents-44.3%). The second highest was unemployed (24 respondents-34.3%), followed by others job and self-employment which was 9 (12.9%) respondents and 6 (8.6%) respondents respectively.

On information regarding income of respondents, those were salary less than RM500 was 31 (44.3%) respondents. Then, income between RM500 to RM1000 was 32 (45.7%) respondents. While, only 5 (7.1%) respondents was within RM1001-RM1500. Income of RM 1501-RM2000 and more than RM2000 was only 1 (1.4%) respondent respectively.

Table 4.1 shows the information of period of residency, 47 (67%) respondents stayed more than 20 years at the respective areas. Then, 10 (14.3%) respondents stayed from 1- 10 years, followed by 11-20 years (7 respondents-10%) and only 6 (8.6%) respondents stayed less than 1 year.

Table 4.1 Socio-demographic information

Variable	No. of respondents	%	Mean ± S.D	Median (IQR)	Range
Gender:					
Male	25	35.7			
Female	45	64.3			
Age:					
< 25	6	8.6			
25-35	12	17.1			
36-45	16	22.9	47.23 ±	46.00 (23)	21-90
46-55	15	21.4	16.29		
>55	21	30.0			

Village:		
Kg.Kandis	31	44.3
Kg.Telong	31	44.3
Kg.Aman	8	11.4

Race:		
Malay	70	100
Chinese	0	0
Indian	0	0
Other	0	0

Education Level:		
No education	17	24.3
Primary school	15	21.4
PMR	15	21.4
SPM	15	21.4
STPM	5	7.1
Higher Education	3	4.3

Occupation:		
Non-employment	24	34.3
Self-employment	6	8.6
Farmer	31	44.3
Others	9	12.9

Income (RM):		
<500	31	44.3
500-1000	32	45.7
1001-1500	5	7.1
1501-2000	1	1.4
>2000	1	1.4

Period of residency:		
< 1 year	6	8.6
1-10 years	10	14.3
11-20 years	7	10
>20 years	47	67.1

N=70

4.1.2 Well information

Table 4.2 shows all 70 respondents (100%) at Kampung Kandise, Kampung Telong and Kampung Aman used electric pump well rather than manual hand pump.

For age of well, 49 (70%) wells were more than 15 years old. There were 7 (10%) wells were used just less than 1 year and within 11-15 years old (Please refer to Table 4.2).

Table 4.2 Well information

Variable	No. of respondents	%
Type of well:		
Pump well	70	100
Manual well	0	0
Age of well:		
< 1 year	7	10
1-5 years	4	5.7
6-10 years	3	4.3
11-15 years	7	10
>15 years	49	70

N=70

4.1.3 Drinking water information

All respondents used groundwater for drinking purposes. Table 4.3 shows information about daily water intake (L/day) and complaints on detection of water odour and colour change.

For daily water intake, the mean \pm S.D (L/day) was 1.80 ± 0.87 .

While, median was 1.5 L/day. The range was between 0.5- 4.5 L/day.

Furthermore, only 23 (32.9%) respondents complained about the colour and odour change of groundwater source (Table 4.3).

Table 4.3 Drinking water information

Variable	No. of respondents	%	Mean \pm S.D (L/day)	Median (IQR) (L/day)	Range (L/day)
Daily water drink (L)/day			1.80 ± 0.87	1.5 (0.75)	0.5 – 4.5
Colour and odour change:					
Yes	23	32.9			
No	47	67.1			

N=70

4.2 Nitrate level in groundwater

Table 4.4 shows the mean \pm S.D for nitrate level (mg/L) was 1.66 ± 2.11 . The range was 0 – 9.60 mg/L (Table 4.4). Figure 4.1 illustrate the nitrate level distribution with Inverse Distance Weight (IDW) interpolation technique with GIS. High level of nitrate was detected at the South of the study area in Kampung Aman.

Table 4.4 Nitrate level in groundwater samples

Variable	Mean \pm S.D (mg/L)	Range (mg/L)
Nitrate level (mg/L)	1.66 ± 2.11	0.00 - 9.60

N=70

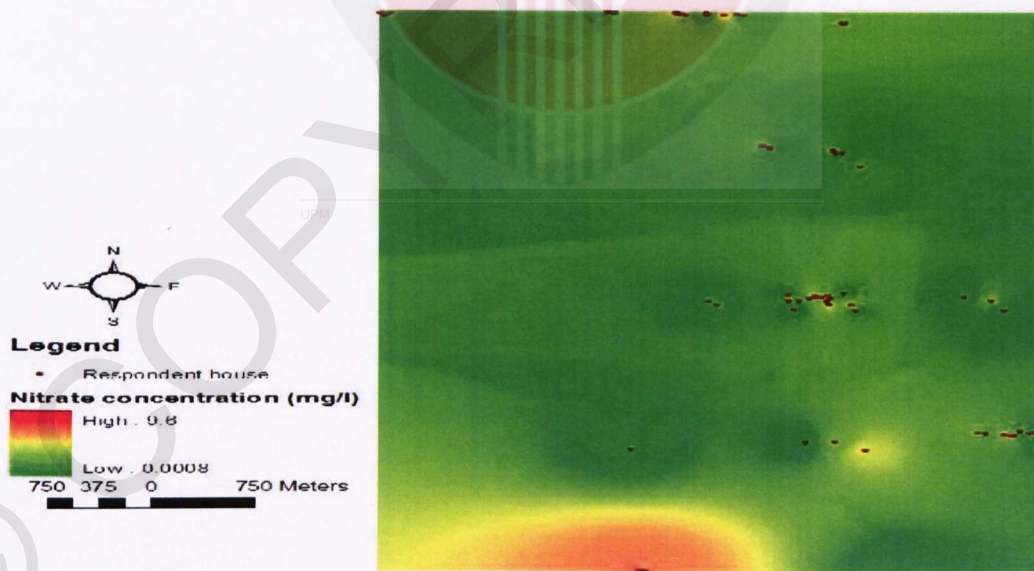


Figure 4.1: Geographical Information System (GIS) of nitrate concentration level

4.3 Comparison of nitrate level between each study location (one sample t-test)

Table 4.5 shows the comparison of nitrate level of groundwater between each study location. The mean \pm S.D (mg/L) was 1.66 ± 2.11 . One sample t-test was used to compare the difference of nitrate level between each house.

P-value for this comparison was 0.00. Therefore, there is a strong significant difference of nitrate level between each house in the study areas since p-value was less than 0.05 ($p < 0.05$) (Table 4.5).

Table 4.5 Comparison of nitrate level of groundwater between each study location

Variable	Mean \pm S.D (mg/L)	Range (mg/L)	p-value
Nitrate level (mg/L)	1.66 ± 2.11	0.00 - 9.60	0.00

N=70

4.4 Comparison of nitrate levels between villages (Kruskal-Wallis test)

Kruskal-Wallis test was used to compare nitrate levels between three (3) villages in Bachok. The highest mean \pm S.D of nitrate level (mg/L) was Kampung Aman which was 3.34 ± 4.07 . The mean \pm S.D (mg/L) for Kampung Kandis was 1.45 ± 1.32 . Lastly, mean \pm S.D (mg/L) for Kampung Telong was 1.43 ± 1.95 .

According to p-value (0.749), there is no significant difference of nitrate level between these 3 villages, since p-value is more than 0.05 ($p > 0.05$) (Table 4.6).

Table 4.6 Comparison of nitrate level between the 3 villages

VILLAGE	No. of respondents	Mean \pm S.D (mg/L)	Range (mg/L)	P-value
Kg Kandis	31	1.45 \pm 1.32	0.00-5.30	0.749
Kg. Telong	31	1.43 \pm 1.95	0.00-9.10	
Kg. Aman	8	3.34 \pm 4.07	0.10-9.60	

N=70

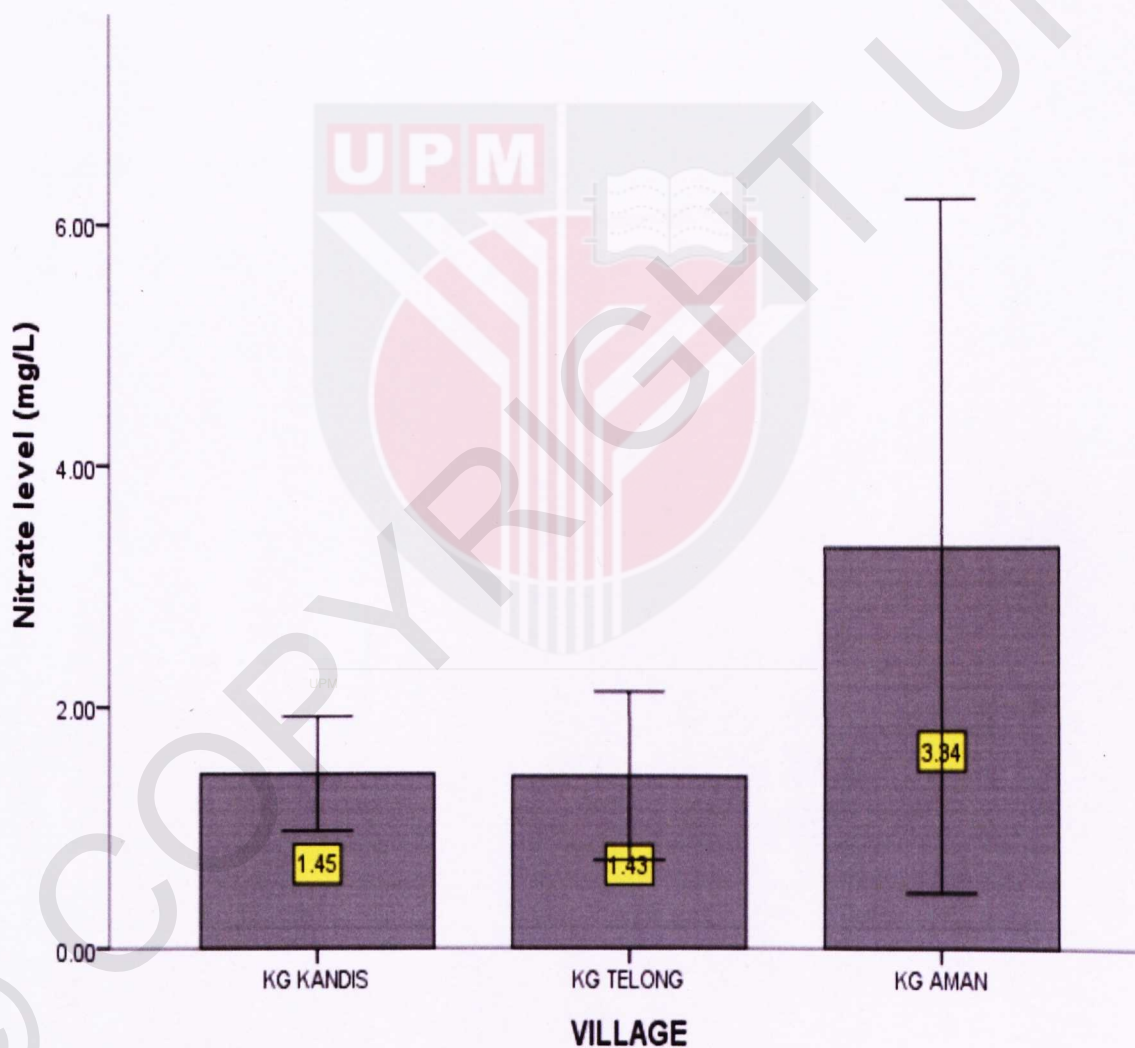


Figure 4.2: Comparison of nitrate level among 3 villages in Bachok

4.5 Comparison nitrate level of each house with national standard

With regards to Malaysian National Standard of Drinking Water Quality Standard (NSDWQ), the maximum concentration limit (MCL) for nitrate is 10mg/L (MOH, 2012). Figure 4.2 indicated that nitrate level of all respondents were below the 10mg/L, which was below the maximum limit of NSDWQ.

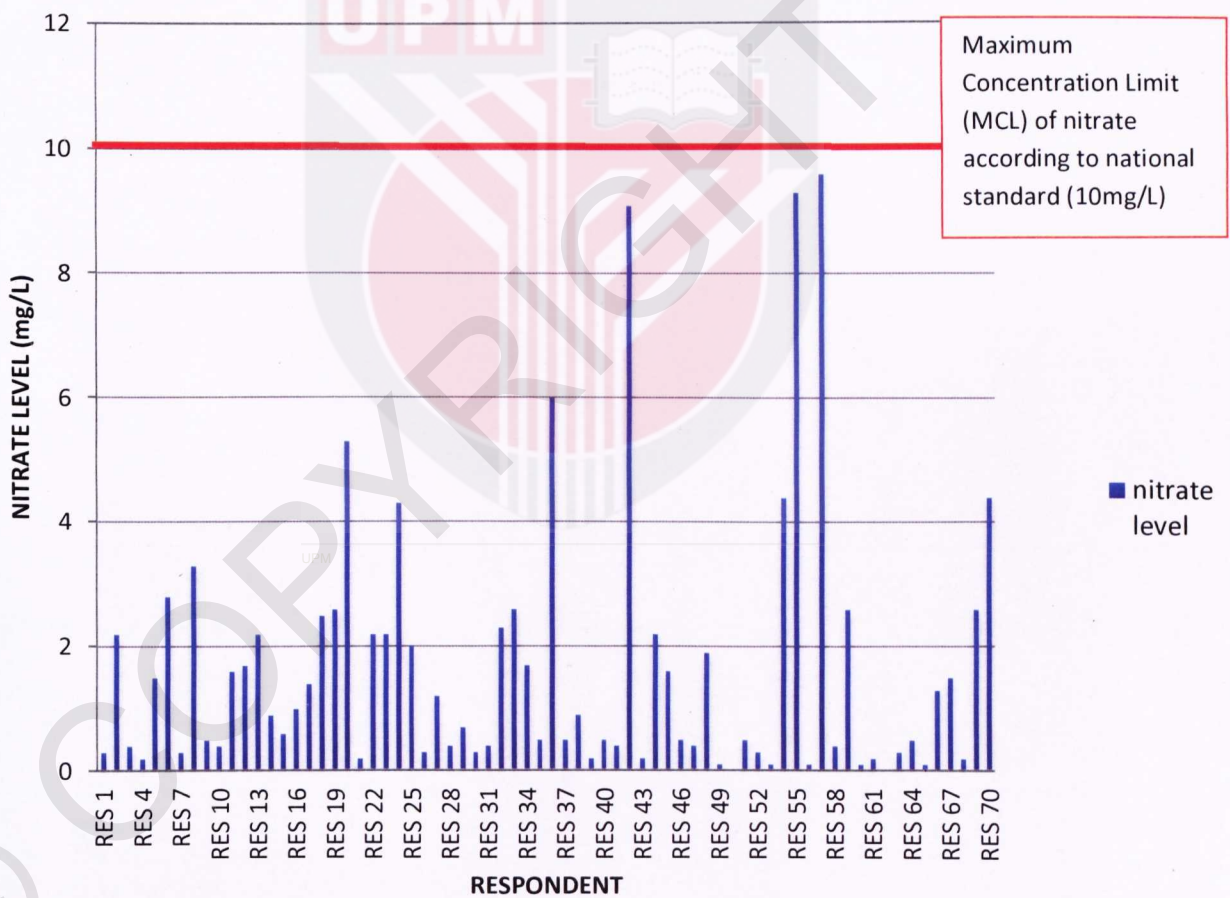


Figure 4.3: Comparison of nitrate level among study locations with national standard

4.6 Exposure information (Chronic Daily Intake)

Table 4.7 shows the mean \pm S.D for respondents' body weight as 59.95 \pm 10.47 kg. The range for respondents' body weight was between 36 - 81 kg.

Based on the table below, the exposure of nitrate on respondent was estimated as Chronic Daily Intake (CDI). The CDI value was calculated using an equation that was stated earlier in Chapter 3. Table 4.6 shows the mean \pm S.D for CDI (mg/kg/day) was 0.051 \pm 0.086. The range for CDI was between 0.00 - 0.48 mg/kg/day (Table 4.7).

Table 4.7 Chronic daily intake (CDI) estimation

	Nitrate level (mg/L)	*DI (L/day)	*W (kg)	*CDI (mg/kg/day)
Mean	1.66	1.80	59.95	0.051
Median (IQR)	0.8 (1.9)	1.5 (0.75)	59.50 (15)	0.024 (0.05)
Standard deviation	2.11	0.87	10.47	0.086
Range	0.00-9.60	0.5-4.5	36-81	0.00-0.48

N=70

* W=weight (kg)

*DI= water daily intake (L)

*CDI=Chronic daily intake (mg/kg/day)

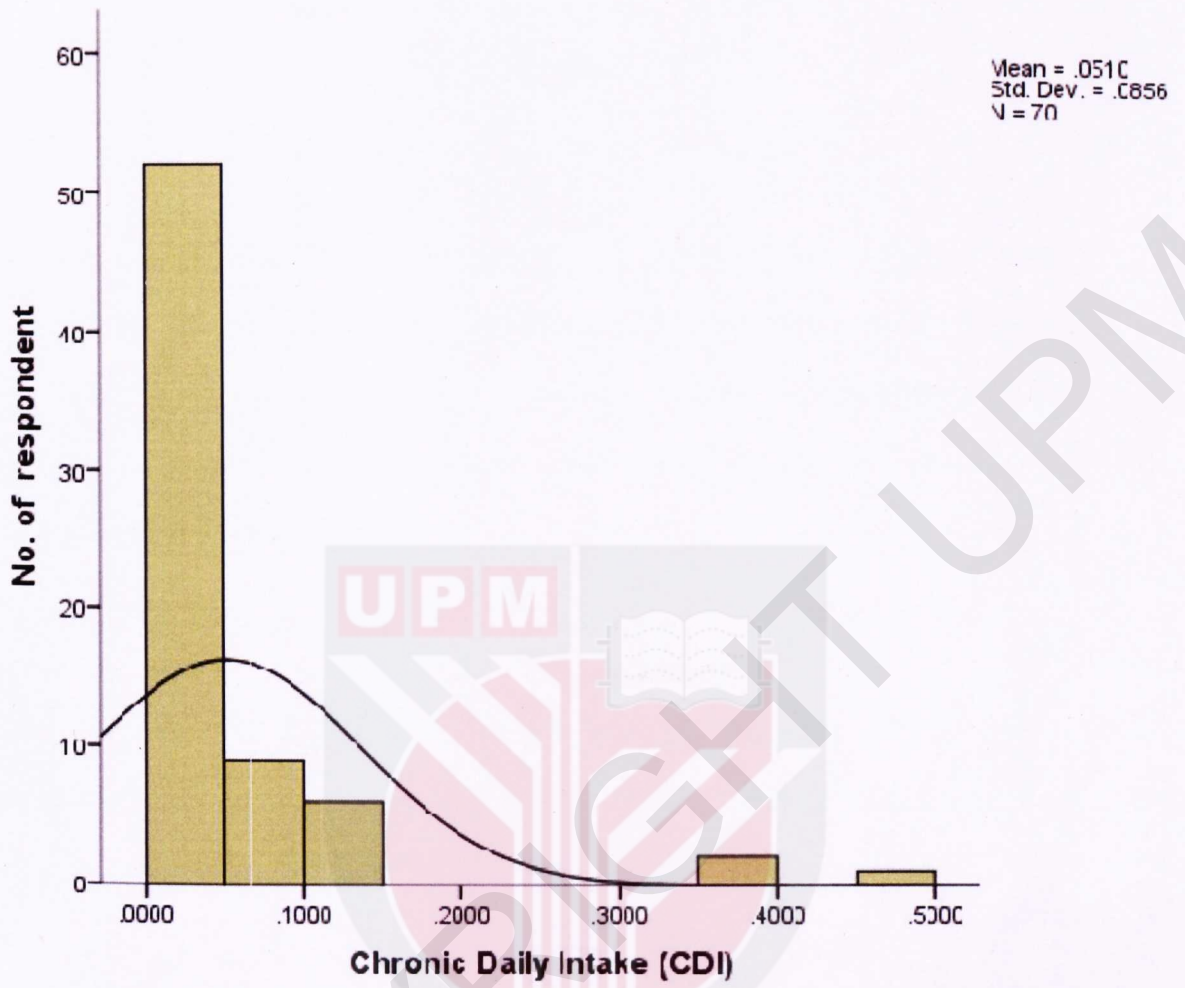


Figure 4.4: Chronic Daily Intake (CDI) distribution

4.7 Health risk assessment information (Hazard Index)

To estimate non-carcinogenic risk, Hazard Index (HI) was calculated by dividing the CDI value with reference dose (RfD) as shown in Chapter 3. Referring to United State Environmental Protection Agency (USEPA), reference dose (RfD) for nitrate is 1.6 mg/kg. A HI reading greater than 1 indicates potential for an adverse effect to occur (NJDEP, 2007).

Table 4.8 shows the result of HI. The range of HI was between 0.00-0.3. The mean \pm S.D was 0.032 ± 0.054 . As shown in Table 4.7, HI value for all respondents were less than 1 (70 respondents-100%).

Table 4.8 Hazard Index (HI) estimation among respondents

Hazard Index (HI)	No. of respondent	Percentage (%)	Mean \pm S.D	Range
HI < 1	70	100	0.032 ± 0.054	0.00 – 0.3
HI > 1	0	0		

N=70

Chapter 5

Discussion, Conclusion and Recommendation

5.1 Discussion

5.1.1 Socio-demographic data

Based on the finding in Table 4.1.1, all respondents in this study were Malay, comprised of 45 female (64.3%) and 25 male (35.7%), age between 21 to 90 years old (Table 1). The mean \pm S.D for respondent age was 47.23 ± 16.29 . Majority of respondents were age more than 55 years old (21 respondents). Majority of the respondent never get formal education (17 respondents). Most of respondents work as agricultural workers (31 respondents). Most of respondents' income was less than RM1000. Majority of respondents live in the study area for more than 20 years, used electric-pump well. Majority of wells were more than 15 years old (49 wells).

5.1.2 Nitrate level in groundwater

The mean \pm S.D of nitrate was 1.66 ± 2.11 mg/L and range between 0.00 - 9.60 mg/L. This was considered as normal, as indicated by WHO (2007); the normal concentration of nitrate in surface water or groundwater is between 0-18 mg/L. However, nitrate can reach high levels as a result from agricultural run-off, refuse dump run-off, or contamination of human and animal wastes. Grover (2006) study also indicated that nitrate was found at level greater than 1 mg/L in groundwater. Study by Mahmoud *et al.* (2009) indicated the mean of nitrate level in drinking water networks in Tabas, Iran was range between 2.9 to 3.25 mg/L; slightly higher than this study.

In addition, results of nitrate analysis in Sumas-Blaine aquifer, USA for the period of 1990 to 2000 showed a mean of 5.7 mg/L (Mohammad and Kaluarachchi, 2004). Environment Canada (2003) also reported that nitrate concentration in groundwater in Canada often exceeding the Canadian Drinking Water Quality of 10 mg/L.

Low level of nitrate determined in this study was probably influenced by the rainfall event; as sampling was conducted after rainy season in January 2012. According to Environment Canada (2003) and Ahmad *et al.*, (1992), rainfall

influenced the concentration of nitrate, as it entering the groundwater at high rate at the beginning of rainy season, decrease throughout the rainy season and remain at constant low level during dry season. During the rainy season, water table rises and nitrate in unsaturated zone such as soil to become mobilised into groundwater. Therefore, nitrate level is high at this condition. In contrast, nitrate will accumulate in soil during dry season, decrease of mobilisation into stream and groundwater, thus resulted to lower nitrate concentration in the groundwater.

Another factor that caused low nitrate level in this study could be due to sampling time. Sample was collected during pre-fertilisation period, where applications of fertiliser to the crops not yet started and no excessive fertiliser leaching to groundwater.

Nitrate concentration in groundwater was also depending on crop system. *Randall et. al., (1997)* indicated that different cropping system caused different concentration of nitrate in groundwater. The continuous crop system increased the tendency for nitrate to leach downwards compared to mixed crop system. Farmers in this study practiced mixed crop system that maybe caused low concentration level of nitrate.

5.1.3 Comparison of nitrate level between each study location

Result of this study indicated a significant difference of nitrate level between each study location. This was consistent with *Rajmohan and Elango, (2005)* study whom indicated nitrate level of groundwater were varied between each sampling location. The different of well depth is possibly caused the significant difference in nitrate level between each location. A survey of Ontario domestic well illustrated that nitrate in groundwater typically decrease with the increase of well depth (*Environment Canada, 2003*). The variation in well depth of each location may contribute to the different in concentration level of nitrate.

Furthermore, the distance of septic tank to the well may be one of the possible factors influenced nitrate concentration as well that closed to septic tank may cause high nitrate level (*Mohamed Azwan et. al., 2010*).

The distance of agricultural land to the well also plays an important role in determining the nitrate level in groundwater. Many studies have shown agricultural activities contribute to high nitrate level (*Wan Ruslan et.al, 2004; Weyer, 2001*).

5.1.4 Comparison of nitrate levels between villages

The highest nitrate level (mean \pm SD) was detected in Kampung Aman (3.34 ± 4.07 mg/L) followed by Kampung Kandis (1.45 ± 1.32 mg/L) and Kampung Telong (1.43 ± 1.95 mg/L). High level of nitrate in Kampung Aman was possibly due to the fertiliser application. Most probably, groundwater samples of Kampung Aman were collected right after application of fertiliser. Besides that, the quantity or rate of fertiliser application to crop may be another factor. This may cause leaching process of excess nitrate to the groundwater in this area. Excessive fertiliser application will lead to nitrate pollution in groundwater (Roy *et al.*, 2000). However, there were no significant differences of nitrate level between these three (3) villages.

5.1.5 Comparison of nitrate level to the national standard

Nitrate level in this study were below the maximum concentration limit (MCL) of Malaysian National Standard of Drinking Water Quality (*NSDWQ, 2011*) and the International standard of *USEPA (2000)* ; 10 mg/L.

In most countries, nitrate levels in drinking water normally not exceeded 10 mg/l. However, in some areas, the nitrate level can be high as a result of agriculture activities, discharge of sewage effluent and certain industrial wastes (*WHO, 2007*).

Besides that, the uptake of nitrate as nutrient by crops is responsible for the nitrate level in water source. Low level of nitrate possibly due to quantity of nitrate fertiliser application to crops was reasonable or insufficient, in which reduce the leaching of excess nitrate into water streams or aquifers. In addition, sampling was conducted after rainy season, thus this may disrupts nitrate concentration level. Chemical concentration such as nitrate in groundwater is primarily linked to the bedrock sources within the aquifer and also influenced by hydrological factors such as the frequency of rainfall and duration of rainfall (*Neal et. al 2000; Grover, 2006*).

Many studies showed nitrate level in groundwater increase when increase the water table during the raining season. Meanwhile, during post-raining or during dry

and warm weather, nitrate level seems to decrease (*Rajmohan and Elango, 2005; Mohammad and Kaluarachchi, 2004*). Similar with study from *Mahmoud S. (2009)*, stated that weather conditions should be considered as it may influence the concentration level of chemical such as nitrate in water source.

Previous study in Kelantan, also indicated nitrate contamination was found to be prominent and persistent in groundwater. On average, 15 % of groundwater samples were found to have nitrate levels above the MCL level of 10 mg/L with the highest concentration level was 30 mg/L (*Aminuddin et.al, 1994*).

5.1.6 Exposure and Health Risk Assessment

Chronic Daily Intake (CDI) was used to estimate the individual daily exposure of nitrate USEPA (2005). The mean \pm S.D for CDI (mg/kg/day) in this study was 0.051 ± 0.086 and range between 0.00 - 0.48 mg/kg/day.

Hazard index (HI) value greater than 1 indicates potential for an adverse effect to occur (NJDEP, 2007). HI value in this study was range between 0.00-0.3 and the mean \pm S.D was 0.032 ± 0.054 . HI values for all respondents were less than 1 and this indicated the risk of adverse effect of nitrate pollution in groundwater in respective areas was acceptable.

5.2 Conclusion

Water is a critical resource which life depends. Loading of contamination to drinking water sources occurs through many paths, natural and anthropogenic including via agricultural activities. Water contamination also can cause many health problems. Thus, quality of water source including groundwater should be concern of.

This study also showed a strong significant difference of nitrate level between each location as nitrate level may differ according to different location and geographical areas. Thus, the hypothesis failed to reject.

However, there is no significant difference of nitrate level between Kampung Kandis, Kampung Telong and Kampung Aman. Thus, the hypothesis was rejected.

Based on this study, the quality of groundwater in these three villages in Bachok is considered safe since the nitrate level of each house was below national and international standard and Hazard Index (HI) was below 1 that indicated no adverse effect due to nitrate exposure. In short, the hypothesis was rejected.

Although there was no nitrate level that exceeded the MCL, concern should be put as vital concern in order to minimize any further exposure of nitrate towards human as well as ecosystem and environment.

5.3 Recommendation

Human health risk requires further study. Furthermore, monitoring programmes should be in place in areas where drinking water has a high probability of nitrate contamination such as at agricultural areas.

The wells are required to be regularly tested to ensure that the water being supplied meets all the drinking water standards for public water supply systems. If water quality problems do exist, the water is required to be treated before it is consumed by the individual. Besides that, people should be recommended to use water filter system in order to minimise the contamination.

In order to build the new wells, wells must be drilled deep enough to extend past the water table into the groundwater aquifer below. Due to nitrate concentration in the groundwater or aquifer will decrease as depth of well increase.

Moreover, as many local factors influence groundwater, it is important that local governments realise the role they have in managing this resource for the future. The emphasis of groundwater management should be placed on conservation and prevention, not remediation after groundwater becomes contaminated.

Coordination and cooperation between state agencies, local government, and citizens is a vital thing. Educate community members about the local groundwater resource, current and potential problems, how to manage the pollution, how to apply fertilizers at the reasonable amount and correct time as well as possible solutions.

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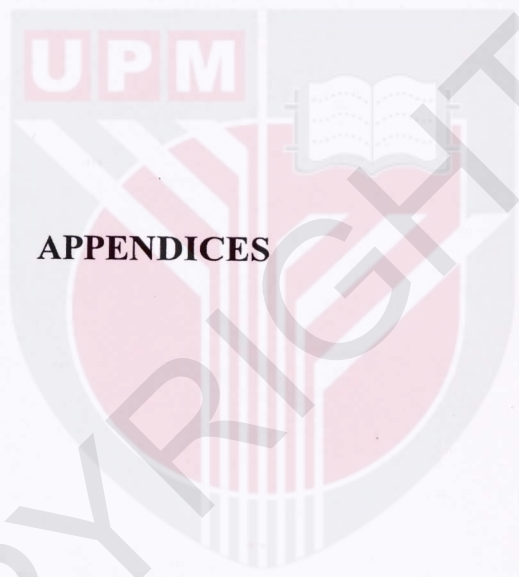
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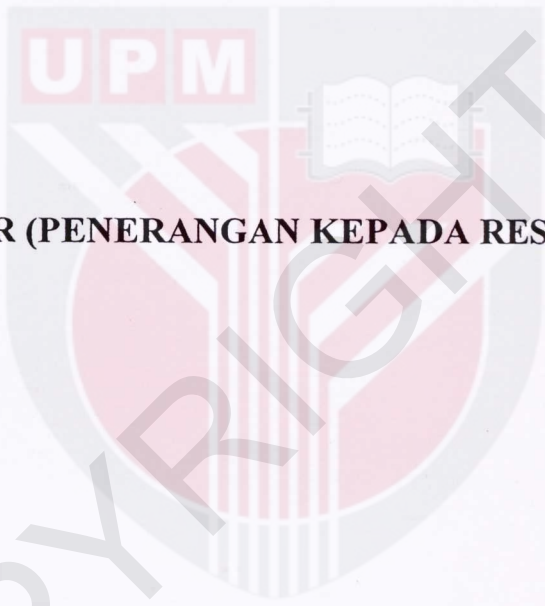
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APPENDICES



COVER LETTER (PENERANGAN KEPADA RESPONDEN)

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PENERANGAN KEPADA PESERTA

TAJUK KAJIAN:

Kajian risiko kesihatan mengenai kepekatan nitrat dalam air telaga di kawasan pertanian di Bachok, Kelantan.

Terima kasih kerana membantu kami di dalam kajian ini.

1. Apakah kajian ini?

Kajian ini adalah berkaitan dengan risiko kesihatan mengenai kepekatan nitrat dalam air telaga di kalangan responden.

2. Apakah tujuan kajian ini?

Kajian ini dijalankan bertujuan untuk mengkaji risiko kesihatan disebabkan oleh pendedahan kepekatan nitrat dalam air telaga dengan melibatkan pengiraan kadar pengambilan air minuman dalam sehari serta pengiraan indeks hazard setiap responden yang terlibat.

3. Berapa ramai responden yang terpilih?

Responden akan dipilih dari kalangan penduduk Kampung Kandis, Bachok, Kelantan. Ciri-ciri responden yang dipilih adalah penduduk yang menggunakan air telaga sebagai sumber air utama untuk kegunaan harian. Seramai 102 orang responden akan dipilih untuk terlibat di dalam penyelidikan ini.

4. Apakah jenis ujian yang akan dijalankan?

Semua responden akan diberikan borang soal selidik untuk diisi sendiri oleh responden. Selain itu, berat setiap responden akan ditimbang menggunakan penimbang tanta dalam unit kilogram (kg).

5. Adakah bayaran dikenakan?

Pengkaji akan menanggung segala pembiayaan ujian yang akan dijalankan dan tiada sebarang bayaran dikenakan terhadap setiap responden.

6. Adakah maklumat dijamin sulit?

Semua maklumat yang diberikan oleh responden di dalam borang kaji selidik adalah dijamin sulit. Tiada huraian individu akan dibuat pada mana-mana bahagian di dalam kajian atau penerbitan.



7. Adakah hak anda?

Kajian ini melibatkan anda secara sukarela. Oleh itu, peserta mempunyai hak untuk menarik diri dari penyertaan dalam kajian ini pada bila-bila masa sekiranya peserta merasa tidak selesa untuk memberikan maklumat kepada pengkaji.

8. Apakah yang harus anda lakukan?

Anda dikehendaki menandatangani borang penyertaan responden yang menyatakan minat anda untuk menyertai kajian ini. Ianya boleh dilakukan setelah anda membaca dan memahami isi kandungan penerangan ini. Borang penyertaan responden haruslah dikembalikan kepada penyelidik sebelum ujian dijalankan. Sekiranya anda mempunyai sebarang kemasykulan, penyelidik akan membantu untuk memberi maklumat yang selanjutnya.

Terima kasih atas kerjasama dan bantuan anda.

NORAZIAH JAMALUDIN

Penyelidik

B. Sc. Kesihatan Persekitaran dan Pekerjaan

Unit Kesihatan Persekitaran dan Pekerjaan

Jabatan Kesihatan komuniti

Fakulti Perubatan dan Sains Kesihatan

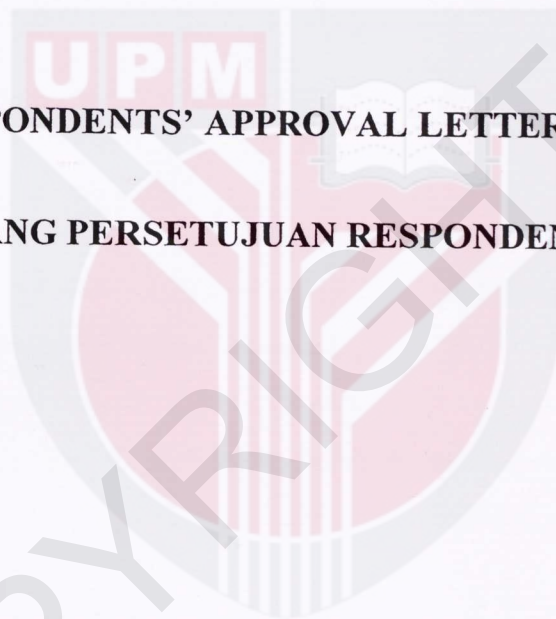
Universti Putra Malaysia.

013-2192123

aziahjamaludin@gmail.com

RESPONDENTS' APPROVAL LETTER

(BORANG PERSETUJUAN RESPONDEN)



BORANG PERSETUJUAN RESPONDEN

RESEARCH TITLE :

Kajian Risiko Kesihatan Terhadap Pendedahan Nitrat dalam Air Telaga di Kawasan Pertanian di Bachok, Kelantan

RESEARCHER : NORAZIAH JAMALUDIN

Saya.....No.K/P.....

Alamat.....

bersetuju untuk menyertai kajian bertajuk seperti di atas.

Saya telah membaca dan memahami isi kandungan kajian berdasarkan apa yang telah dinyatakan di dalam 'PENERANGAN KEPADA PESERTA' yang telah dilampirkan bersama surat kebenaran ini dan penerangan tambahan daripada penyelidik.

Saya faham bahawa kajian ini dijalankan untuk mengenalpasti kesan pendedahan kepekatan nitrat dalam air telaga di kalangan penduduk di Kampung Kandis, Bachok, Kelantan.

Saya juga faham bahawa segala maklumat yang diberikan dan segala keputusan yang saya perolehi adalah sulit dan hanya akan digunakan untuk tujuan penyelidikan dan rujukan penyelidik.

Saya juga faham bahawa maklumat ini boleh digunakan untuk penerbitan tetapi setiap individu tidak akan dinyatakan identitinya.

Saya faham bahawa saya mempunyai hak untuk menarik diri dan juga mempunyai hak untuk menarik semula keizinan pada bila-bila masa sekiranya perlu apabila merasa tidak selesa pada mana-mana ujian atau aktiviti yang dijalankan oleh penyelidik semasa kajian dijalankan dan tiada sebarang tindakan boleh dikenakan ke atas saya atas tindakan tersebut.



Tandatangan
(Responden)

Tandatangan.....
(Saksi)

Tarikh :.....

Nama.....

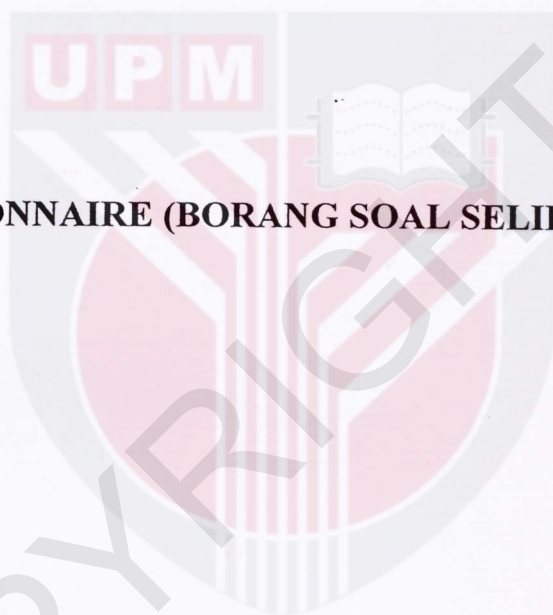
No. K/P :.....

Saya mengesahkan bahawa saya telah menjelaskan kepada responden sifat dan tujuan penyelidikan klinikal yang tersebut di atas.

Tarikh

Tandatangan
(Penyelidik)

QUESTIONNAIRE (BORANG SOAL SELIDIK)



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

Arahan: Sila jawab semua soalan pada bahagian yang disediakan

BAHAGIAN A (MAKLUMAT RESPONDEN)

Nama: _____

Alamat: _____

1. Umur: _____

2. Jantina:

P	L
---	---

3. Bangsa:

Melayu Cina
 India Lain-lain (Nyatakan): _____

4. Berapakah berat badan anda?

5. Tahap pendidikan tertinggi anda?

Tidak bersekolah Sekolah rendah SRP/PMR
 SPM STPM/Diploma Lain-lain (Nyatakan): _____

6. Apakah pekerjaan anda?

Tidak bekerja Peniaga
 Petani Lain-lain (Nyatakan): _____

7. Berapakah jumlah pendapatan seisi rumah sebulan?

< RM500

RM501-1000

Rm1001-1500

Rm1501-RM2000

>RM2000

8. Berapa lamakah tempoh anda tinggal di kawasan penempatan ini?

< 1 tahun

1-5 tahun

6-10 tahun

11-15 tahun

16-20 tahun

>20 tahun

BAHAGIAN B (MAKLUMAT PERSEKITARAN)

9. Status kawasan perumahan:

Bandar

Separa Bandar/pekan

Luar bandar

10. Adakah kawasan pertanian anda berdekatan dengan tempat kediaman anda?

Ya

Tidak

11. Berapakah jarak kawasan pertanian dengan kediaman anda?

12. Apakah jenis telaga yang digunakan?

Telaga pam

Telaga gelung

Telaga tanah

Lain-lain (Nyatakan): _____

13. Berapa lamakah tempoh telaga ini digunakan?

< 1 tahun

1-5 tahun

6-10 tahun

10-15 tahun

>15 tahun (Nyatakan): _____

14. Adakah air telaga dirawat?

Ya (Nyatakan : _____) Tidak

15. Adakah telaga ini pernah diselenggara?

Tidak pernah < 1 tahun sekali
 1-5 tahun sekali > 5 tahun sekali

BAHAGIAN C (MAKLUMAT PENDEDAHAN AIR MINUMAN)

16. Berapa gelaskah air yang diminum sehari?

< 3 gelas 3-5 gelas
 6-8 gelas > 8 gelas

17. Adakah air telaga dimasak terlebih dahulu sebelum diminum?

Ya Tidak

18. Penggunaan air telaga untuk: _____

Air minum dan memasak Mandi sahaja
 Membasuh pakaian sahaja Pertanian

19. Adakan anda berpuas-hati dengan kualiti air telaga?

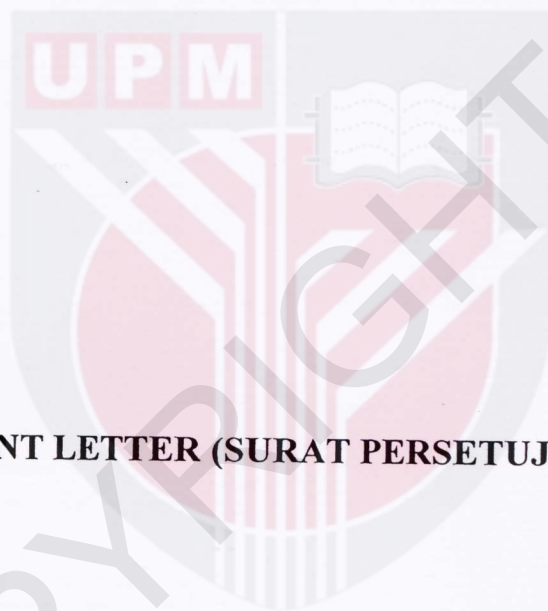
Ya Tidak Tidak pasti

20. Pernahkah air telaga yang digunakan keruh/berbau?

Ya Tidak

21. Adakah anda pernah mengalami gejala sampingan selepas mengambil air minuman tersebut?

Ya Tidak



ETHIC CONSENT LETTER (SURAT PERSETUJUAN ETHIC)





MEDICAL RESEARCH ETHICS COMMITTEE

Application for Ethical Clearance to Involve Human Subjects in Research

New Applicant Reviewer Resubmission Revision

TITLE OF RESEARCH PROJECT:
Nitrate Level of Groundwater at Agricultural Area in Bachok, Kelantan

Date: 25/10/2011 Applicant's status: Lecturer Student Master
PhD

Investigators	Name	Dept & Address	H.P/Office/Fax	E-mail:
Chief Investigator				

Human Subject Involvement

Tick appropriate (/)

1.	Questionnaires / Interviews	/
2.	Physiological Measurements	/
3.	Clinical Trials of drugs / formulations	
4.	Clinical Trials of devices	
5.	Use of Human tissue samples	
6.	Use of Body fluids (e.g. blood)	
7.	Human genetic research	
8.	Others (please specify:)	

Information should be provided by applicant (11 points checklist): Indicate with a √ if provided and X if not (if not please provide the reasons)

		Check list √ or X	Remarks (Please Describe)
1.	Protocol of research proposal	/	
	<i>a) Summary of proposal</i>	/	
	<i>i) Purpose</i>	/	
	<i>ii) Background rationale</i>	/	
	<i>iii) Hypothesis (e.g. / research questions to be examined</i>	/	
	<i>b) Methodology / Procedures</i>	/	
	<i>i) Procedures involve invasion of the body (e.g. touching, contact, attachment of instruments, withdrawal of specimens)</i>	X	

	ii) Description of all procedures to be conducted in a sequential order in which research subjects will be involved (e.g. paper and pencil tasks, interviews, surveys, questionnaires, physical assessment, psychological tests, doses and methods of administration of drugs, time requirement)	/	
	iii) A copy of questionnaires attached	/	
	iv) A copy of <i>permission/approval</i> letter to carrying out the project study attached	/	
2.	Study population (Subjects involved in the study)		
	a) Description of how subjects are recruited into study (selection criteria)	/	
	b) Number of subjects	/	
	c) Gender	X	
	d) Age range	/	
	e) Any special characteristics		
	i) Inclusion criteria	/	
	ii) Exclusion criteria	/	
	f) Relationship between investigator and subjects	X	
	g) Emolument or compensation for participation (to subject)	X	
3.	Feedback to subjects		
	Provision made for arrangements to inform subjects of the outcome of the result	/	
4.	Potential benefits of the study		
	a) Direct benefits to subject from involvement in the study	/	
	b) Potential / benefits to the scientific community / society that would justify involvement of human subjects in the study	/	
5.	Potential risks of the study		
	a) Psychological risks / harm (might make subject demeaned, embarrassed worried or upset)	/	
	b) Physical risks	X	
	c) Social risks / harm. Loss of status, privacy and or reputation	X	
	d) Pharmaceutical details and known safety of formulations used	X	
6.	Competency of Investigators in carrying out project study / procedures		
	b) CVs of all research participants/supervisors	/	
	c) Investigators have conducted a similar research		
7	Subject information sheet. Information of a-k available to subjects (letter of information separate from consent form): describing disease / condition to be evaluated in the research study		
	Letter of information		
	a) Language and proper translations	/	
	b) Disease evaluated	X	
	c) Drug evaluated	X	
	d) Others		
	e) Aim of study	/	

	f) Why the subject is being chosen for study?	/	
	g) Expected outcome	/	
	h) Alternative treatment available	x	
	i) Side effects of participating in the study	x	
	j) Organization and funding of research		
	k) Emolument of subjects		
8	Study Insurance for subjects		
9	Informed consent form		
	a) Appropriate language	/	
	b) Criteria should include reading and understanding of subject information sheet	/	
10	Funding of Project study and approval status (please identify)		
	a) University		
	b) Government		
	c) Private/Company		
	d) Others		
11	Vetting from other committees **		
	a) Has the proposal been vetted by other committees? (e.g. supervisory committees, research committees)	/	Supervisor Signature:
	b) If yes, please specify committee.		Name:
	Supervisor Committees.....		Date:
		

**Student's proposal must be presented to the Supervisory Committee and be certified by the Supervisor before applying for Medical Research Ethics approval.

Check list for Applicant Enclose the following documents in relation to format above. Indicate with a [√] if enclosed.				Comments of Medical Research Ethics Committee:	
		<u>Check list for Applicants</u>	√	Remarks: (from Medical Research Ethics Committee)	√
(i)	Item 1 (iii)	Questionnaire	/		
(ii)	Item 1 (iv)	Evidence of approval institutional to conduct study		Acceptable	
(iii)	Item 6 (b)	CVs of research participants	/	Not acceptable	
(iv)	Item 7 (a-k)	Subject information sheet	/	Require further clarification	
(v)	Item 9	Informed consent	/		
Signature: Name: NORAZIAH JAMALUDIN Date: 25/10/2011				Signature: Name: Date:	