



UNIVERSITI PUTRA MALAYSIA

***A CROSS SECTIONAL STUDY ON CONTAMINATION OF NITRATE IN
GROUNDWATER AND HEALTH RISK ASSESSMENT AMONG
RURAL RESIDENTIAL IN BACHOK, KELANTAN***

MOHD AKMAL ASYIQ ZOLKIFLEE

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GROUNDWATER AND HEALTH RISK ASSESSMENT AMONG RURAL
RESIDENTIAL IN BACHOK, KELANTAN**

BY

MOHD AKMAL ASYIQ BIN ZOLKIFLEE

**This 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

A CROSS SECTIONAL STUDY ON CONTAMINATION OF NITRATE IN GROUNDWATER AND HEALTH RISK ASSESSMENT AMONG RURAL RESIDENTIAL IN BACHOK, KELANTAN

Mohd Akmal Asyiq Zolkiflee

Introduction: Nitrate is the most commonly found contaminant in the world's aquifers. The main concern on concentration of nitrate had increased globally due to application of inorganic fertilizer and manure in agricultural sector. Human activities have interfered in many ways with natural water cycle and affect the society-water relationship. Thus, it increased demand on food in agricultural product, and had raised future risks from high usage fertilizer to boost up the yield. Nitrates used in fertilizers are commonly found in drinking water sources, particularly in agricultural areas where nitrogen fertilizer is used and raise risk factor such as methamoglonbinemia and colon cancer. Private Wells nearby agricultural activities are more at risk of contamination as most of rural area in Kelantan still depends on well water as their main source of water. Therefore, probability of harmful effect can be quantified to assess the health risk in the selected population area. **Objectives:** To determine the health risk and concentration of nitrate in groundwater at rural area in Telaga Ara Village, Bachok, Kelantan. **Methodology:** This study was conducted among residents at Telaga Ara Village, Bachok, Kelantan. A total of 56 respondents are chosen based on inclusive and exclusive criteria. Groundwater samples are going to be taken from each of the respondent's houses. Then, it be analysed by using Portable PH/ORP/ISE Meter model HI98191 and Probe Model HI4113, while a set of questionnaires was distributed among respondents for health risk assessment of the exposure. **Result:** The groundwater at Telaga Ara Village, Bachok, and Kelantan was considered safe for drinking and cooking purposes; however, nitrate concentrations in drinking water should be monitored as a precaution to avoid any side effect towards Health. **Conclusion:** The groundwater level in Telaga Ara village was considered safe for human consumption and usage purposes. There was no significant in health index that can contribute towards non-carcinogenic risk. However, level of nitrate in drinking water should be concerned as it will affect human's quality of life in a long run exposure.

Keywords: Nitrate, Well Water, Bachok, Paddy, Groundwater

ABSTRAK

KAJIAN KERATAN RENTAS MENGENAI PENINGKATAN NITRAT DENGAN PENILAIAN RISIKO KESIHATAN PENDUDUK LUAR BANDAR TERHADAP AIR BAWAH TANAH DI BACHOK, KELANTAN

Mohd Akmal Asyiq Zolkiflee

Pengenalan: Nitrat adalah bahan pencemar yang paling biasa dijumpai di akuifer dunia. Kebimbangan utama mengenai kepekatan nitrat telah meningkat secara global disebabkan penggunaan baja anorganik dan baja di sektor pertanian. Aktiviti manusia telah mengganggu banyak cara dengan kitaran air semula jadi dan mempengaruhi hubungan masyarakat-air. Oleh itu, ia meningkatkan permintaan terhadap makanan dalam produk pertanian, dan telah meningkatkan risiko masa depan dari baja penggunaan yang tinggi untuk menaikkan hasil. Nitrat yang digunakan dalam baja biasanya dijumpai dalam sumber air minuman, terutamanya di kawasan pertanian di mana baja nitrogen digunakan dan meningkatkan risiko seperti metamoglonbinemia dan kanser kolon. Perladangan persendirian berdekatan aktiviti pertanian lebih berisiko mencemari kerana kebanyakan kawasan luar bandar di Kelantan masih bergantung kepada air telaga sebagai sumber air utama mereka. Oleh itu, kebarangkalian kesan berbahaya boleh diukur untuk menilai risiko kesihatan di kawasan penduduk terpilih. **Objektif:** Untuk menentukan risiko kesihatan dan kepekatan nitrat dalam air bawah tanah di kawasan luar bandar di Kampung Telaga Ara, Bachok, Kelantan. **Kaedah:** Kajian ini dilakukan di kalangan penduduk di Kampung Telaga Ara, Bachok, Kelantan. Sebanyak 56 responden dipilih berdasarkan kriteria inklusif dan eksklusif. Sampel air tanah akan diambil dari setiap rumah responden. Kemudian, ia akan dianalisis menggunakan model Meter Port PH / ORP / ISE HI98191 dan Probe Model HI4113, manakala satu set soal selidik diedarkan di kalangan responden untuk penilaian risiko kesihatan pendedahan. **Hasil:** Air bawah tanah di Kampung Telaga Ara, Bachok, dan Kelantan dianggap selamat untuk tujuan meminum dan memasak; Walau bagaimanapun, kepekatan nitrat dalam air minuman perlu dipantau sebagai langkah berjaga-jaga untuk mengelakkan sebarang kesan sampingan terhadap Kesihatan. **Kesimpulan:** Tahap air bawah tanah di kampung Telaga Ara dianggap selamat untuk minuman serta penggunaan manusia. Tiada indeks kesihatan yang signifikan yang boleh menyumbang kepada risiko bukan karsinogenik. Walau bagaimanapun, tahap nitrat dalam air minuman haruslah diambil berat kerana ia akan menjejaskan kualiti hidup manusia dalam pendedahan yang panjang

Kata kunci: Nitrat, Air Telaga, Bachok, Padi, Air Bawah Tanah

TABLE OF CONTENT

	Page
DECLARATION	iii
SIGNATURE OF SUPERVISOR / INTERNAL EXAMINER	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vi
TABLE OF CONTENT	vii
LIST OF TABLES	xv
LIST OF FIGURES	xvi
LIST OF ABBREVIATIONS	

CHAPTER 1: INTRODUCTION

1.1	Background	1
1.2	Problem Statement	2
1.3	Research Question	3
1.4	Study Justification	3
1.5	Objectives	4
1.6	Hypothesis	4
1.7	Variables	5
1.8	Definition of terms	5
1.9	Conceptual Framework	7

CHAPTER 2: LITERATURE REVIEW

2.1	Nitrate	8
2.2	Major Process Of Nitrate Cycle	9
2.3	Source Of Nitrogen	11
2.4	Nitrate In Groundwater	12
2.5	Health Effect	13
2.6	Drinking Water Quality Standard	14
2.7	Age, Depth, And Distance Of Well	15

CHAPTER 3: METHODOLOGY

3.1	Study Design	16
3.2	Study Location	16
3.3	Study Population	17
3.4	Subject Criteria	18
3.5	Sample Size	18
3.6	Sampling Method	19
3.7	Study Instrument	20
	3.7.1 Questionnaire	20
	3.7.2 Body Weight	20
	3.7.3 Drinking Water Intake	20
	3.7.4 Graphic Positioning System	21
	3.7.5 Water Sampling	21
	3.7.5.1 Water Analysis	21
	3.7.5.2 Analysis of Nitrate	22

	3.7.5.3 Quality Assurance & Quality Control	22
	3.7.5.4 Personal Protective Equipment	23
3.8	Risk Assessment	24
3.9	Data Analysis	26
3.10	Ethical Consideration	27



CHAPTER 4: RESULT & DATA ANALYSIS

4.1	Socio Demographic Data	28
4.2	The Concentration Of Nitrate In Groundwater.	30
4.3	Determine The Association Between Well Characteristic With Nitrate Concentration In Groundwater.	31
4.4	Chronic Daily Intake (CDI) Estimation	34
4.5	Health Risk (Weight) Of The Respondents Due To Exposure To Nitrate.	35

CHAPTER 5: DISCUSSION & CONCLUSION

5.1	Socio-Demography Background	36
5.2	Concentration Of Nitrate In Groundwater	37
5.3	Association Between Well Characteristic With Nitrate Concentration In Groundwater.	38
5.4	Association Health Risk (Weight) Of The Respondents Due To Exposure To Nitrate.	39

CONCLUSION	41
LIMITATION	42
RECOMMENDATION	43
REFERENCES	44
APPENDIX 1	51
APPENDIX II	56

LIST OF TABLE

		Page
Table 3.1	Criteria for research study	17
Table 4.1	Distribution of respondents	28
Table 4.2	Weight of respondent	29
Table 4.3	Nitrate concentration in groundwater	30
Table 4.4	Association between well characteristic (age, depth of well and distance of well from paddy field) with nitrate concentration in groundwater	31
Table 4.5	Well characteristic with nitrate concentration in groundwater	32
Table 4.6	Chronic daily intake estimation	34
Table 4.7	Health risks of the respondent	35

LIST OF FIGURES

		Page
Figure 1.1	Conceptual framework	7
Figure 2.1	Nitrogen cycle	9
Figure 3.1	Location of the study area	16
Figure 3.2	Hi98191 professional waterproof portable	21
Figure 3.3	Hi4113 nitrate combination ion selective electrode	21
Figure 4.1	Distribution of respondents based on gender	28
Figure 4.2	Comparison of nitrate concentration in groundwater with national standard	30
Figure 4.3	Age of well	33
Figure 4.4	Depth of well	33

LIST OF ABBREVIATIONS

CDI	Chronic Daily Intake
CRC	Colorectal Cancer
DWQS	Drinking Water Quality Standard
EIA	Environmental Impact Assessment
GPS	Global Positioning System
HI	Hazard Index
HIA	Health Impact Assessment
HQ	Hazard Quotient
INWQS	Interim Water Quality Standard of Malaysia
ISA	Ionic Strength Adjuster
MAV	Maximum Acceptable Value
NADH	Nicotinamide Adenine Dinucleotide
NOC	N-Nitroso Compounds
RfD	Reference Dose
US EPA	United States Environmental Protection Agency



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INTRODUCTION

1.1 Research Background

Nitrate was used in fertilizers and was commonly found in sources of drinking water, particularly in agricultural areas where nitrogen fertilizer was used. The risk of contamination was greater for shallow private wells. It was hard to alter such factors as redox conditions when it comes to mitigating nitrate pollution. Food was the main source of exposure to nitrates if the drinking water level was not exceeded (Chowdhury, 2013). Increasing demand for food, the requirement for a more environmentally friendly agriculture and future risks arising from climate change are all associated with the urgent need to improve nitrate use efficiency in plants (Zhang, 2015). We focus our analysis on nitrate because it was one of the most widespread contaminants in groundwater systems and one of the primary components of fertilizer applied to croplands (Minnesota Pollution Control Agency, 2013).

In a local research study conducted by Abdul Rashid (2010), 35% have been identified as having Nitrate concentration above the limit value, 10mg/L, while 2.0% are above the threshold value of 45mg/L or the authorized World Health Organization (WHO) value. Nitrogen fertilizer has efficiently improved production of crop in more than 5 decades. Due to increase human population, agricultural sector need to increase its production to meet the population demands. Tremendous amount of fertilizer have been used worldwide, that's equally same as natural global nitrate atmospheric fixation in the bio-lithosphere. Thus, it can cause an affect anthropogenically out of control bio-geochemical N cycle. (Steffen, 2015).

1.2 Problem Statement

Accumulations of nitrate in ground water are easily leached through soil because it was a soluble compound. (Wongsanit, 2015). Nitrate contamination in groundwater poses a threat for human health, due to exposure of nitrate in water supply. The contamination happens from intensive use of nitrogenous fertilizer that seeps into soil and pollute nearby groundwater. (Jamaludin, 2013). Paddy farming was the main agriculture activity in Bachok (Aida Soraya et al., 2016) and residential area located nearby to paddy field. (Muhammad et al., 2017). According to study by Noor (2014), agricultural activity such as tobacco planting and paddy field industries in Bachok, Kelantan are the main contributor to high concentration of nitrate compared to other districts.

1.3 Research Question

- 1.3.1 What is the concentration of nitrate among rural residential area in Bachok, Kelantan?
- 1.3.2 Is there any significant association between nitrate concentration in groundwater and the distance of agricultural activity?
- 1.3.3 Is the concentration of nitrate in groundwater is higher than the recommended concentration?

1.4 Study Justification

Bachok is a district in Kelantan that covered an area of 280km² (Kelantan department of statistic ,2014). It was located at eastern part of Peninsular Malaysia and 70% of public mainly rely on groundwater(Nazaruddin et al.,2017).This state poses a significant potential for contamination of groundwater because it was covered primarily by the agricultural area (Aida Soraya et al.,2017). High usage of nitrate fertilizer in agricultural activity such as tobacco, paddy, and orchard to catalyst high yield and growth of crops which are located near the wells (Noor, 2014) had caused leaching of nitrate (Borneff and Adabe,1973). Furthermore, limitation of piped water had caused the area to depend on groundwater (well water) as their water supply, which strengthen up the possibilities of the risks (Muhammad, 2017)

1.5 Objectives

1.5.1 General Objective

To determine the concentration of nitrate in groundwater and health risk among villagers in Telaga Ara Village, Bachok, Kelantan.

1.5.2 Specific objectives

- a) To determine descriptive data of the respondent's.**
- b) To determine the concentration of nitrate in groundwater.**
- c) To identify the age, depth, distance, and source of nitrate in well water.**
- d) To determine the health risk of the respondents due to exposure to nitrate.**

1.6 Hypothesis

There is a significant difference between nitrate concentration and the distance of well from nitrate source.

1.7 Variables

Independent variable

Distance of nitrate source from ground water.

Dependent variable

Concentration of nitrate in groundwater.

1.8 Definition of Terms

1.8.1 Conceptual Definition

Nitrate

Nitrite and nitrate are inorganic compounds which occur naturally in the environment, such as water and soil (Chan & Zhu, 2013). It can be formed in organic and inorganic matters that entered subsurface depending on the source (Reddy and Patrick, 1981). In plant roots, nitrogen (N) is available in many forms including ammonium (NH_4^+), organic forms NO_3 and chiefly amino acids. Abundant source of nitrogen are in nitrate form yet, it can dissolve easily in soil water and move freely in soil profile (Miller et al., 2007). Therefore, Nitrate was considered as the most common pollutant in groundwater. In addition to natural sources of nitrogen, it can also enter water and soil through raw human and industrial wastewater, agricultural wastewater, solid municipal and industrial waste, and destruction of forests and pastures (Abu-Jabal, 2014).

Drinking water

In year 1998 to 2010, there was a respectively increment from 10.4 billion m³/year to 12.1 billion m³/year of Malaysia water demand, projected to cover 97% of water supply taken from surface water sources especially river (Pauzi, 2018). There are 189 lakes in Malaysia (22 in Sarawak, 78 in Sabah, 89 in Peninsular Malaysia) however; the resources have been fully exploited especially in highly developed and population area such as Selangor, Putrajaya, and Federal Territory of Kuala Lumpur (Abdullah, 2018). Therefore, The Safe Drinking Water Act was enacted for the protection of drinking water sources, except private well water which was unregulated as opposed to regulated public water systems. For some target population groups (vegetarians, infants and elderly) the risk of developing cancer may be higher when exposed to excessive nitrate dietary intakes (Cavaiuolo and Ferrante, 2014).

Groundwater

© Agricultural region that uses groundwater as their main source of water, commonly affected with nitrate contamination at their water source as it had contributed towards worldwide environmental problem. Study shows that in china, serious amount of nitrate groundwater pollution was reported due to nitrate fertilizer irrigation and intensive use exceeding the national safe drinking water limit of 45 mg / L (Zhou et al., 2011).

1.9 Conceptual Framework

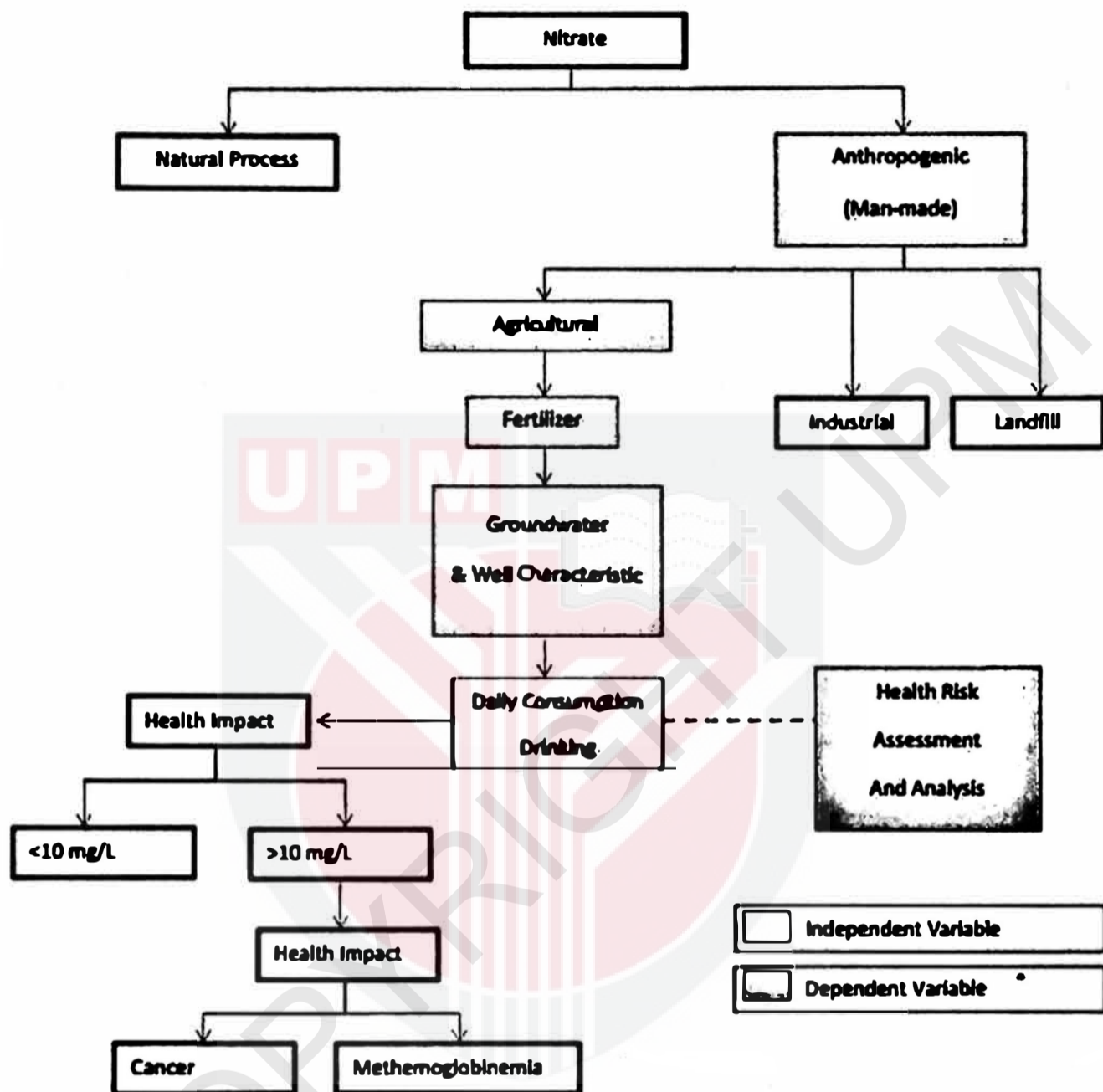


Figure 1.1: Conceptual Framework

2.0 Literature Review

LITERATURE REVIEW

2.1 Nitrate

Nitrate was the contaminant most frequently found in aquifers around the world (Exner et al., 2014). Nitrate fertilizers were also commonly used in maize production, and nitrate contamination of drinking water was major concern in the Midwestern United States. (Spalding et al., 2014) It's important as Nitrate (NO_3) it was the main available nitrogen source for plants (Shitan, 2013). Previous study in indonesia the Mati River estuary acquired nitrate and phosphate usually exceeded quality requirements (Suteja Y and Dirgayusa,2015).

Nitrate was commonly used in fertilizer and found in sources of drinking water, especially in agricultural areas. The risk of contamination was greater for shallow private wells. It was hard to alter such factors as redox conditions when it comes to mitigating nitrate pollution. Food was the main source of exposure to nitrates if the drinking water level not exceeded (Anna, 2014).

The movement of nitrates dissolved through the soil was controlled by convection including measurement of chemical flow with moving soil solution, diffusion of the chemical within the solution and diffusion of the chemical within the solution and hydrodynamic dispersion (Rosenstock, 2013).

2.2 Major Process of the Nitrogen Cycle

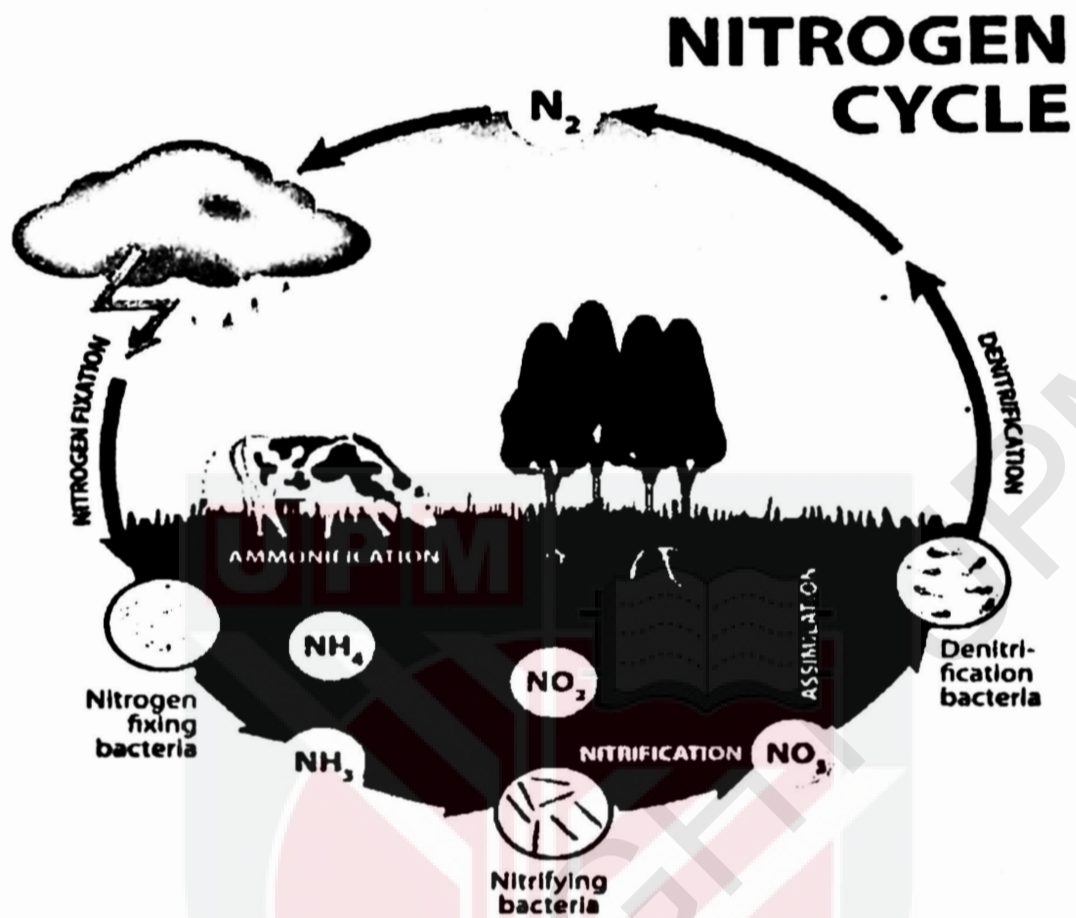


Figure 2.1: Nitrogen Cycle Adapted from Corwin, 2017

For all organisms, nitrogen was important because it is part of the biological protein and nucleic acid molecules. Atmospheric gas (N_2) accounts for 78 percent. Nitrogen was stable in the atmosphere and must be separated to form proteins and nucleic acids in order for the nitrogen atoms to combine with other elements. Nitrogen fixation, nitrification, assimilation, ammonification and denitrification are the five main steps in the nitrogen cycle (Environment, 2004).

The ammonification process consisted of nitrogen fixation, which converts ammonium into continuous nitrification process and then nitrate through nitrification bacteria activities (Dudley, 1990). The source of the nitrate gas which was, a compound of nitrogen and oxygen that was commonly used in fertilizers and from agricultural runoff finds its way into waterways (Sherwood, 2014). Nitrate undergoes assimilation and is being used by plants to fulfill their nutrient needs. It can be found in leaves and stem of a plant and can leech into groundwater because compounds in nitrate are soluble and migrate easily in groundwater (Self and Waskom, 2014).

In soils with finer texture, such as clay and silt, nitrate levels are higher than in soils with rough textures, such as sand. The soil profile with alluvial deposit (consist of gravel, sand, silt and clay) become fragile and porous due to overuse of groundwater and man-made activities at the surface thus make Bachok as a potential district in this study. (Hussin, 2016)

Climate conditions can directly affect the amount of nitrate in soil. Excessive rainfall or standing water on soil can lead to leaching and denitrification, particularly in warm weather. Heavy rains after nitrogen applications can create considerable loss of soil nitrates, and create a source of pollution. Soil nitrate levels are increased through rapid nitrification in well-aerated soils with pH of 6 to 8 and temperatures greater than 50 degrees. Wet, cold or acidic soils do not contain high levels of nitrate. (Leigh, 2019)

2.3 Source of Nitrate

Agriculture has been impacting land-use and water quality especially nearby lake (US National Park Service, 2017). Nitrate was leached to the aquatic environment, mainly from human activities, particularly fertilizer use in intensive farming, and was a frequent pollutant to drinking water (WHO, 2011).

In many parts of the world, high concentrations of nitrate in groundwater may pose a risk to human health and pollution of the environment. Approximately half of all agricultural waste leached cause contaminating water surface, groundwater, and the concentrations of nitrate in our water resources has risen tremendously. (Davidson et al., 2012). Nitrate threats are dependent on scales that can be chronic or acute (Sousa et al., 2013). Agriculture has been the greatest polluter of the waters introducing mineral and organic fertilizers into the soils. Its applications were important for yields produced however the excessive use ends up in irreparable harms to the groundwater and it can accumulated at the water surface (Dimitar,2014).

A recent study of trends in nitrate violations across the U.S. conducted by the USEPA concluded that when surface water systems have improved throughout the past decades, the amount of groundwater systems in violation and also the average period of violations are increasing, pointing to persistent nitrate pollution in drinking water (Pennino et al., 2017).

On the other hand, groundwater quality in Shandong China, shows excess threshold safety concentration in groundwater. This was reported due to close vegetation planting with higher load of nitrogen fertilizer (Zhang, 2018).

2.4 Nitrates in Groundwater

Nitrate groundwater contamination was wide spread throughout the world, due to the use of fertilizers, to leaking from sewage network, and to the presence of old septic systems (Ducci, 2017). According to Lockhart et al., 2013 area of large amount of livestock and berry production were expected on elevation nitrate concentration in groundwater. Agricultural activities contribute towards directly leaching of nitrate groundwater from agrochemical that affect either the process and increase of concentration from the soil (Nemčić-Jurec, 2017). Groundwater acted as world 's most extracted raw natural with intake rates in the range of 982 km³/year (Margat and Gun,2013).

The variant nitrate concentration determined different factor because of different anthropogenic activities, such as the agriculture, which help to increase wastewater and nitrate disposal. (Devic et al., 2014) (i) Anthropogenic and (ii) geogenic (Lapworth et al. 2017) mechanisms are widely associated with deteriorating ground-water quality. Nitrate, nitrite (NO₃), ammonia (NH₄), and organically bound forms of nitrogen (Org-N) are the species of concern for water resource management (Pradesh, 2016) around the globe.

2.5 Health Effects

The consumption of nitrate contaminated groundwater in areas where the main source of potable, domestic and agricultural water poses considerable health risks (Fazlzadeh et al., 2017) Human health risks associated with high nitrate concentrations in drinking water include dysfunction of the thyroid gland, gastric cancer, and decreased blood capacity to carry oxygen (known as methemoglobinemia) in infants under the age of six months. (WHO,2011).

Bacteria in the mouth and in the infant stomach, which were less acidic than adults, reduce the ingested nitrate to nitrite. Nitrite binds to methemoglobin in order to form methemoglobin, interfering with the blood's oxygen carrying capacity. Methemoglobinemia is a life-threatening condition occurring when concentrations of methemoglobin exceed about 10% (Ward et al., 2005)

2.6 Drinking Water Quality Standard

In a study of the Central Valley aquifer, observed increasing trends in the proportion of the aquifer with nitrate concentration > 5 mg/L in both shallow and deep zones of the eastern fans sub region from the 1950s through the 2000s (Burow et al., 2013).Central Valley found between 40 and 50% of wells sampled for nitrate exceeded the drinking water MCL (Lockhart et al., 2013).

The International Agency for Research on Cancer classified nitrate and nitrite as probably carcinogenic to humans (group 2A) under conditions that result in endogenous nitrosation (IARC,2010).The background nitrate concentration in groundwater shall not exceed 10 mg/L as nitrate or 2 mg/L as nitrate-nitrogen, NO₃-N (Mueller and Helsel 1996). The concentrations exceeding background limit are an indicator of nitrate contamination, primarily through various anthropogenic activities (Wongsanit et al. 2015).

While the mean nitrate concentrations in Europe's groundwaters are above background levels(< 10 mg / l as NO₃) according to European surface freshwaters, they do not exceed 50 mg / l as NO₃(EEA,2000). After contamination of groundwater, processing was difficult and costly, so contamination preventions were primary water quality management strategy (Corniello et al., 2014)

2.7 Age, depth and distance of well

Most wells display a trend of increasing apparent age with depth, while a correlation between apparent age and horizontal position was not well-defined (Stefania, 2018). Nitrate values in deep and shallow wells conjointly shows considerably higher concentrations within the shallow wells. A large part of the study area was irrigated cropland. More water and, in general, more fertilizer are applied to

irrigated than to non-irrigated land, thus increasing the potential for nitrate leaching (Margaret, 2013).

High water conductivity in the non-farming region could be due to the area near the coastal zone. Conductivity is greatly increased by adding salt water from the coast that is frequently blended with groundwater (Yan et al, 2015). Also considered have been the potential factors affecting nitrate contamination in the study area (Yang et al., 2007; Kuo, et al., 2007; Khademikia et al., 2013) soil characteristics and hydrogeological variables such as well thickness, under-water depth, aggregate tone thickening, and saturating thicknesses for the unsaturated and saturated areas.

CHAPTER 3

METHODOLOGY

3.1 Study Design

This study design was a cross-sectional study on nitrate contamination in groundwater and health risk assessment.

3.2 Study Location

This study was located at Telaga Ara Village, Bachok, Kelantan because it have possibility risk factor such as usage of groundwater and populated nearby agricultural area (source of nitrate).

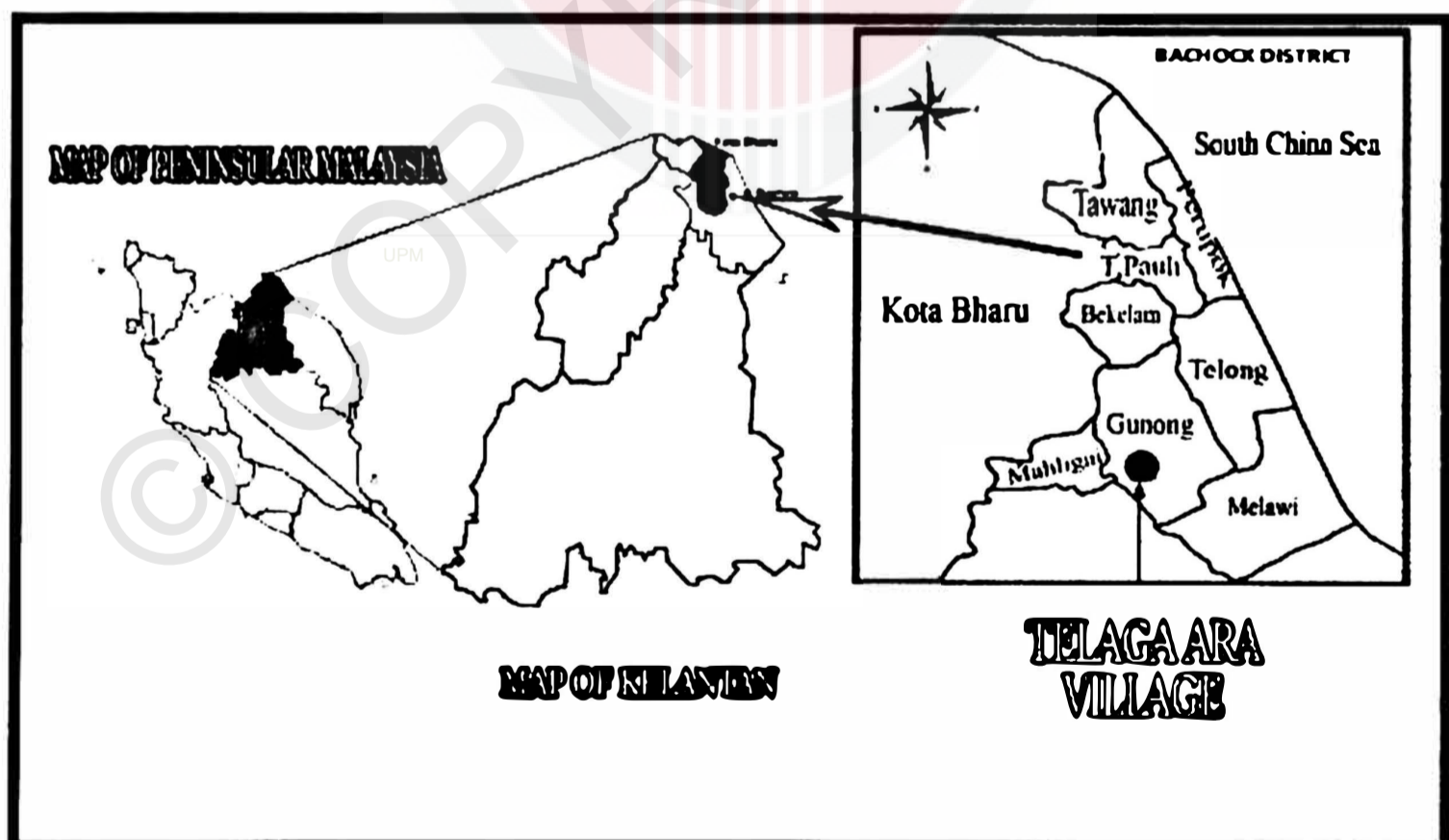


Figure 3.1 : Location of the study area

3.3 Study Population

The populations were villagers that live in Telaga Ara Village in Bachok, Kelantan.

3.4 Subject Criteria

The subject criteria were selected above 18 years because had mature and met respondent's age consent to participate in the research project.

Table 3.4.1: Respondent's criteria for research study

Inclusive Criteria	Exclusive Criteria
<ol style="list-style-type: none">1. Age 18 years and above2. Long life residents3. Use groundwater as their main source of water supply	<ol style="list-style-type: none">1. Having water source other than groundwater2. Using water filtration system.

3.5 Sample Size

The sample size was determined 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 number of sample size required was 32. In order to ensure the study was statistically significant and taken into consideration for the damaged sample therefore, the sample size was intended to 56 samples. The prevalence of nitrate concentration in groundwater (above than 10 mg/L) was 8.7% as determined by previous study (Alif, 2014).

3.6 Sampling Method

Purposive selective sampling was used in this study. The respondents were selected based on a number of inclusive and exclusive criteria.



3.7 Study Instrument

3.7.1 Questionnaire

Selected respondent was given a set of questionnaires to gather information from the area of study. The questionnaire consists of health status of the respondent, socio-demographic data, types of water supply, and residential area information (Appendix 1). The questionnaire was important to ensure the respondents comply with the inclusive criteria of this study.

3.7.2 Body Weight

The body weight of the respondents was measured with a digital weight machine, and measured in the kilogram unit (Kg).

3.7.3 Drinking Water Daily Intake

Respondents were asked about their water consumption amount per day to calculate the Chronic Daily Intake (CDI) and Hazard Index (HI). We used standard cup of 250 ml to measure daily water intake rate of water among respondents.

3.7.4 Global Positioning System (GPS)

GPS was used in this study to measure the distance of well from source of nitrate at the area of study.

3.7.5 Water Sampling

3.7.5.1 Device for Water Analysis

Nitrate in groundwater was analyzed using HI98191 Professional Waterproof Portable pH / ORP / ISE Meter and Ion Selective Electrode (ISE) HI4113 Nitrate Combination.



Figure 3.2: HI98191 Professional Waterproof Portable pH/ORP/ISE Meter

Source HANNA Instrument Website

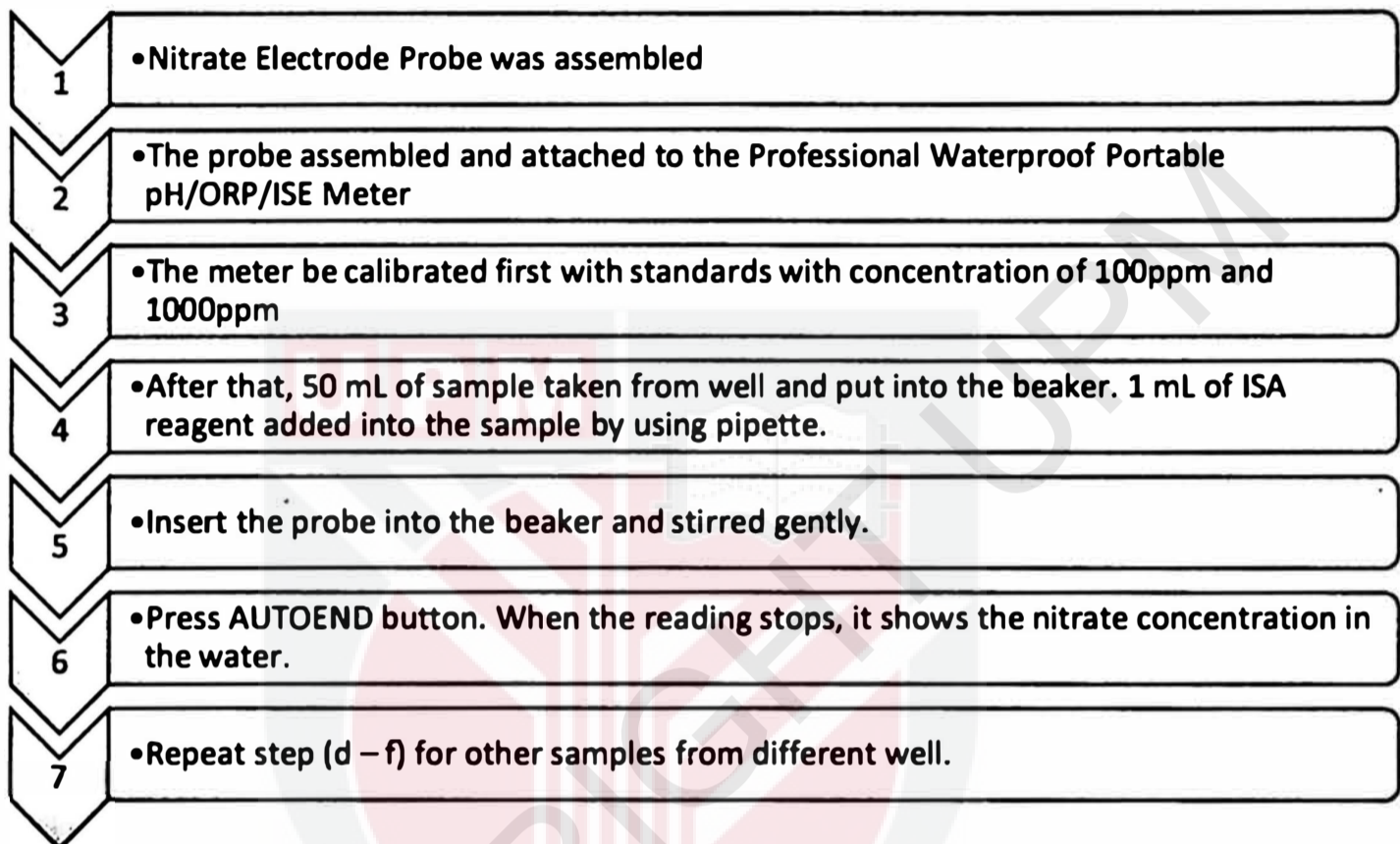


Figure 3.3: HI4113 Nitrate Combination Ion Selective Electrode (ISE) Source

HANNA Instrument Website

3.7.5.2 Analysis of Nitrate

Nitrate in groundwater was analyzed by using nitrate electrode (HI4113) and HI98191 professional waterproof portable pH/ORP/ISE Meter. The Ionic Strength Adjuster (ISA) reagent was used according to the following steps:



3.7.5.3 Quality Assurance and Quality Control

There were several aspects taken when collecting groundwater samples. During sample collection, two samples were collected at the same time in duplicate and latex glove been worn to protect contamination of water sample. High density polyethylene (HDPE) bottle was used to store the sample then analyzed within time period of 24 hour to protect the quality of sample.

3.7.5.4 Personal Protective Equipment

The person responsible and involved in sample handling should wear latex glove and laboratory coat to avoid splash or contact accident with chemical use in the analysis. It also to prevent contamination of samples testing that might affect the result.



3.8 Risk assessment

Chronic Daily Intake (CDI) was used to calculate population health risk due to exposure of groundwater nitrate contamination using the following equation:

$$CDI = \frac{C \times DI}{BW} \quad (\text{US EPA, 2000})$$

[Equation 1]

Where,

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

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

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

BW = body weight (kg)

The Hazard Index (HI) has been calculated using the following equation for non-carcinogenic health effects posed by nitrate in drinking water:

$$HI = \frac{CDI}{RfD} \quad (\text{US EPA, 2000})$$

[Equation 2]

Where,

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

RfD = Reference dose (mg/kg/day)

The higher the health index value, the higher the probability of an adverse non-carcinogenic effect on health. RfD was 1.6mg / kg / day for this study (US EPA, 2000). If the HI value shows more than 1 ($HI > 1$), a significant concentration of risk was shown.

3.9 Data Analysis

The data obtained were analyzed using version 22 of the IBM SPSS (Social Sciences Statistical Package). The type of analysis used for this study, based on the study objectives as were shown in the table below.

Objectives	Type of analysis
To determine demographic data of the respondents	Descriptive Analysis
To identify the concentration of nitrate in groundwater	Descriptive Analysis
To determine the association between distance of well from source of nitrate with concentration of nitrate.	Parametric: Pearson Correlation Non-Parametric: Spearman correlation
To determine the hazard index due to exposure of nitrate	Descriptive Analysis

3.10 Ethical Consideration

- a. Approval letter was given to the village representative to obtain consent from the resident involved in this study.
- b. The respondents were given some explanation about the health risk assessment that was held in terms of the purpose of the assessment, the procedure taken, and also respondents' right in the study.
- c. The respondents were given some explanation about the activities involved in the study.

CHAPTER 4

RESULTS AND DATA ANALYSIS

4.1 Socio Demographic Data

This study was carried in Telaga Ara village and involved 56 respondents. From 56 respondents, 11 (19.64%) respondents were male and 45(80.36%) respondents were female. Most of the respondents are user of underground water since there were lacks of piped water supplied toward the residential area.

Table 4.1: Distribution of Respondents

		N= 56	
Variables		Frequency	Percentage (%)
Gender	Male	11	19.64
	Female	45	80.36

From the table below showed that Mean \pm SD of the weight of the respondents which was 61.02 \pm 14.39 (kg) and the respondents' weight had a range between 30.0 – 109.0 (kg).

Table 4.2: Weight of respondent

Variable	Mean \pmSD	Range (kg)
Weight	61.02 \pm14.39	30.0 – 109.0

N=56



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4.2 The Concentration of Nitrate in Groundwater.

Concentration of nitrate and well characteristic (age, depth, distance, and source of nitrate) were parameter measured. The reading of nitrate in groundwater was between 1.67-56.85 ppm with mean of 10.52 ± 1.24 ppm.

Table 4.3- Nitrate concentration in groundwater

Parameters	N=56		
	Range (ppm)	Mean (ppm)	(±)SD
Nitrate concentration			
in groundwater	1.67-56.85	10.52 ± 1.24	9.25

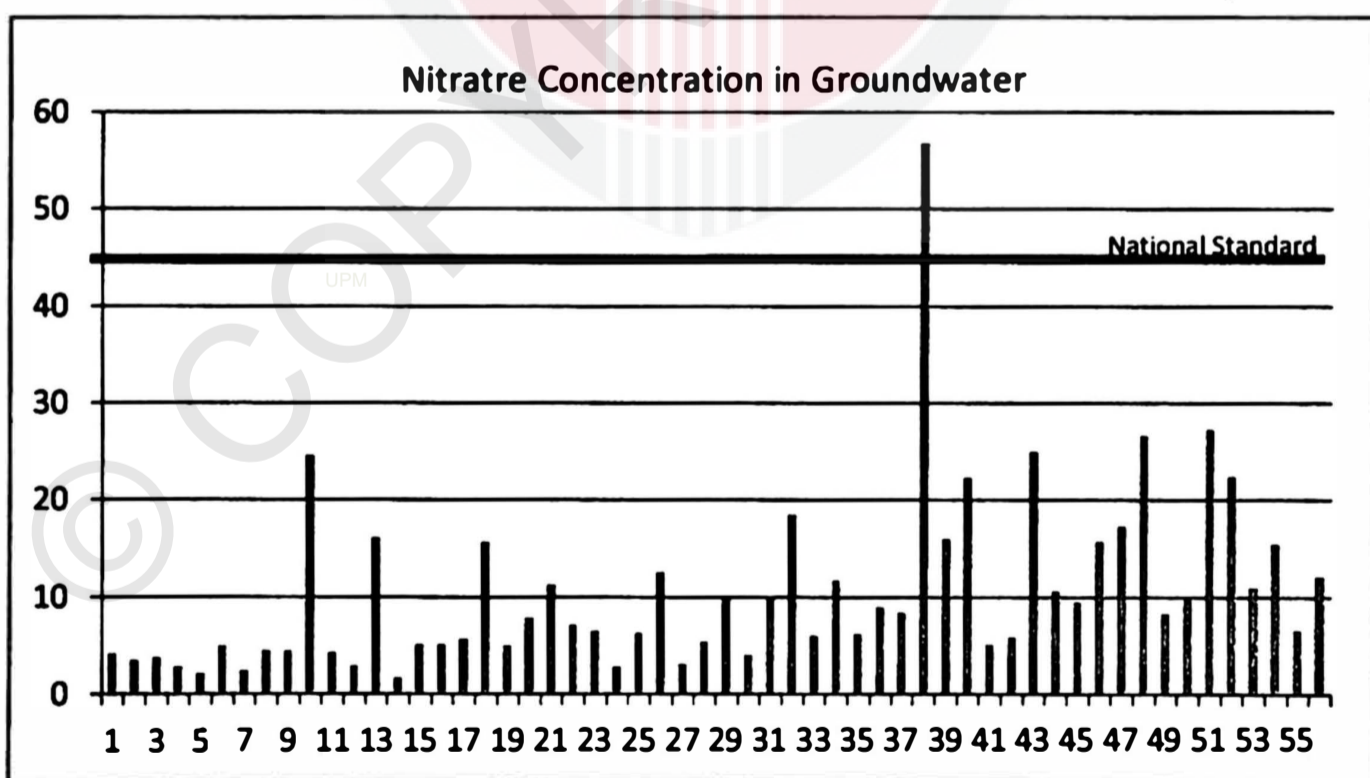


Figure 4.3- Comparison of Nitrate concentration in groundwater with National Standard

4.3 The association between well characteristic (age, depth of well and distance of well from paddy field) with nitrate concentration in groundwater.

The study was conducted in non-parametric test, thus, Spearman rho test was used to determine the significant difference between nitrate concentration in groundwater and well characteristics (age, depth, distance, and source of nitrate). There was no significance difference as the reading was $p > 0.05$, then the null hypothesis was rejected as a conclusion.

Table 4.4- The association between well characteristic (age, depth of well and distance of well from paddy field) with nitrate concentration in groundwater.

Variables		Nitrate_ Concentration	Age_ Well	Depth_ Well	Distance_ Source
Nitrate_ Concentration	Correlation Coefficient	1.000	-.065	-.145	-.173
	Sig. (2-tailed)		.633	.286	.203

Table 4.5-The wells characteristics (age, depth, and distance) of the respondents

Variables	Frequency (%)	Mean \pmSD (meters)	Range (meter)
Age of Well			
<5 years	10(17.9%)		
5-10 years	5(8.9%)		
11-15 years	3(5.4%)		
16-20 years	6(10.7%)		
>20 years	32(57.1%)		
Depth of Well			
<5 meters	0(0%)		
5-10 meters	24(42.9%)		
11-15 meters	21(37.5%)		
>15 meters	11(19.6%)		
Distance of Well From Paddy Field	56(100%)	212 \pm 273.59	10-1000

Table 4.5 above shows about the well characteristic that consist of age, depth, and distance from source of nitrate (paddy field).The characteristics were analyzed using questionnaires that was given to respondent. From the findings, most of age of well were >20 years which were 32 (57.1%) from 56 of samples. There consisted of ,11-15 years old of well (5.4%),5-10 years (8.9%),16-20 years(10.7%) and <5 years (17.9%) of well respectively.

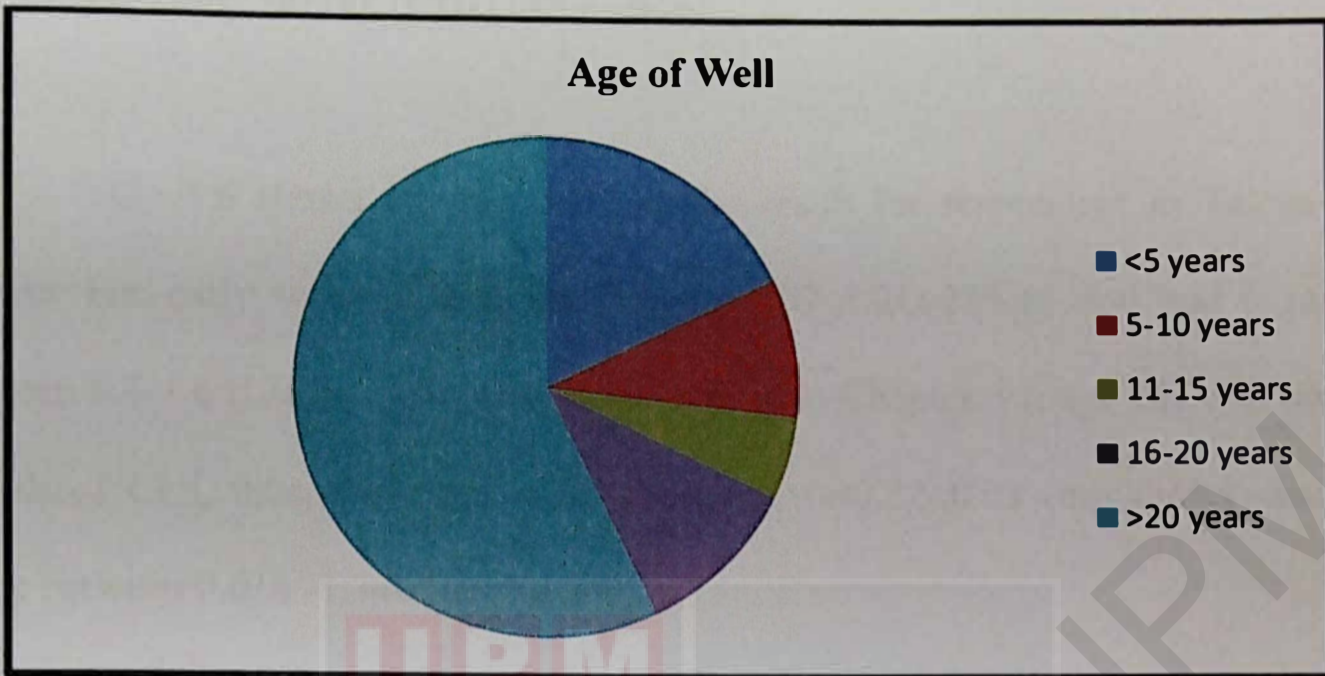


Figure 4.1-Age of Well

In addition, throughout the questionnaire information for depth of well were also obtained from respondent. From Figure 4.3.2, most of the wells were at depth between 5-10 meters 24(42.9%). Other reading were 11-15 meters by 21 (37.5%), >15 meter was 11 (19.6%), and none of wells depth were in <5 meter.

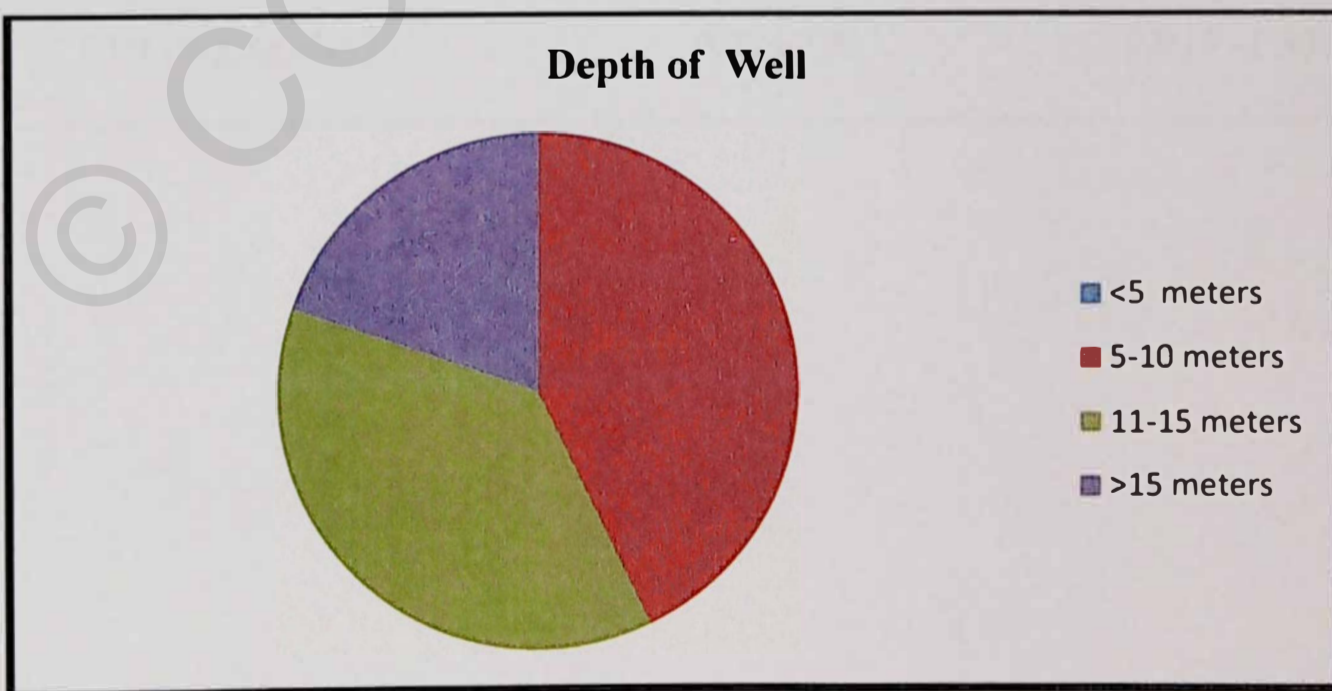


Figure 4.2-Depth of Well

4.4 Chronic Daily Intake (CDI) estimation

Table 4.6 shows chronic daily intake result for respondent in Telaga Ara village. For daily water intake, the Mean \pm SD 1.21 \pm 239.45 and had a ranged between 0.4-1.6 (L/day). After that, the equation in Chapter 3 (page 24) was used to calculated CDI, thus, the mean \pm SD for CDI was 0.22 \pm 0.03 (mg/kg/day) and the range between 0.014 -1.340 (mg/kg/day).

Table 4.6 chronic daily intake estimation

Variable	N=56	
	Mean \pm SD	Range
Nitrate Level (ppm)	10.52 \pm 1.24	30.0 – 109.0
Daily Water Intake(L/day)	1.21 \pm 239.45	0.4-1.6 L/day
Weight(kg)	61.02 \pm 14.39	30-109
CDI (mg/kg/day)	0.22 \pm 0.03	0.014 -1.340

4.5 Health risk (weight) of the respondents due to exposure to nitrate.

Spearman's rho test was used to determine the correlation between health risk (weight) of respondent and exposure of nitrate, since, it was not normally distributed. The significance value were $p=0.878$ ($p>0.05$) respectively and the null hypothesis was failed to be rejected. This concluded there was no significant relationship between the health risks (weight) of the respondents due to nitrate exposure.

Table 4.7-Association between health risks of the respondent with exposure toward nitrate concentration.

Variables		Nitrate_ Concentration	HI
Spearman's rho	Nitrate_ Concentration	Correlation Coefficient	1.000 .878
		Sig. (2-tailed)	. .000
		N	56 56

** . Correlation was significant at the 0.01 concentration (2-tailed).

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

DISCUSSION

5.1 Socio-Demography Background

The study involved 56 respondents from Telaga Ara Village in Bachok, Kelantan. All the respondents were selected based on the inclusive and exclusive criteria (page 17) . The weight of the respondent was taken for health risk assessment. Majority of the respondents race in this study were malay (100%), because population area was highest in malay races due to Kelantan was one early state that populated with islamic region (Asran & Melastura 2014).

5.2 Concentration of nitrate in groundwater.

The nitrate groundwater was measured by using pH/ORP/ISE Meter and HI4113 Nitrate Combination Ion Selective Electrode. The result shows that the nitrate concentration in the drinking water ranged from 1.67ppm - 56.85 ppm with a mean of 10.52 ± 1.24 . The permissible concentration of nitrate by world Health Organization (WHO) was below 45ppm .By comparing the result obtained with the permissible nitrate concentration range, the mean concentration of nitrate did not exceed the national standard, however, there was a result on nitrate has the reading exceeded the permissible range that was 56.85 ppm.

According to Rezaei et al., 2017 high level of nitrate detected was contributed from usage of inorganic nitrogenous fertilizers. Through spatial distribution, nitrate level analyzed, shows that nitrate contamination in an area can be contributed by geological process, agriculture, and disposal into absorbing well (Khosravi et al. 2017). Populations with the highest nitrate exposure from their drinking water are those living in agricultural areas, particularly those drinking water from shallow wells close to nitrogen sources for example crop fields, animal feeding operations(Ransom,2017 ;Wheeler,2015).

5.3 Association between well characteristic (age, depth, distance, and source of nitrate) with nitrate concentration in groundwater.

This study shows the reading of nitrate in groundwater with 1(1.7%) the high reading of nitrate was 56.5 ppm while other 55 (98.3%) sample didn't show less than maximum acceptable value. Thus, aspect such as well characteristic (age, depth, distance, and source of nitrate) was measured that can be potential contributor on concentration of nitrate in groundwater.

In the literature there were consistent with high nitrate in shallow well and well under 20 years. Nitrate pollution was more prevalent in old and shallow wells, according to previous research (Hu et al., 2005; Rutkoviene et al., 2005). In general, nitrate pollution decreases with increasing depth in the soil. The close distance between the water table and the shallow surface area may cause a high nitrate concentration and potentially sources, such as fertilizers and the septic system (Rutkoviene et al. 2005; Gao et al. 2012).

Agriculture nearby can contaminate the groundwater potentially. The findings of high nitrate in the well < 50 meters from the livestock area in the farmland were consistent with these findings. Generally, a short distance to a point source led to a higher level of nitrate (Aida Soraya, 2016).

However, this study shows no significant relationships ($p>0.05$) between nitrate concentrations in groundwater with well characteristic (age, depth, distance and source of nitrate) in spearman's rho correlation.

5.4 Association health risk (weight) of the respondents due to exposure to nitrate.

The result obtained shows that the chronic daily intake (CDI) the range was between 0.014 -1.340(mg/kg/day) and the Mean \pm SD for overall respondent was 0.22 ± 0.03 (mg/kg/day). In the chapter 3 it shows that the result of hazard index (HI) can be calculated via stated equation. Throughout the result it shows that overall risk was acceptable to respondents as the hazard index less than 1 (HI<1).

Drinking water nitrate may present a threat to health when the MCL was higher than 10 mg/l (Coss et al. 2004; Liu et al. 2011) .Agriculture uses large quantities of fertilizer and manure compost on farmland and causes significant groundwater nitrate pollution.

A number of adverse health consequences, including Diabetes, gastric and thyroid disorders, have been associated with elevated nitrate in groundwater (Coss, 2004 ; Kuo et al., 2007 ; Ruckart, 2008 ;Wilfoy, 2012) and other conditions (Klein et al., 2013).

However, the risk was not significant in this study as the hazard index was less than 1 as indicated by Jamaludin et al. (2013) from the previous study. The amount of health risk can be significant if there is an increase consumption of daily drinking intake of the contaminated water above 3 Litre(L) of intake. This can affect human health deterioration in a long run because health risk were correlate with amount of daily drinking water intake and level of nitrate in drinking water.



CONCLUSION

The study was carried out to assess the nitrate concentration in groundwater in Telaga Ara village, Bachok, Kelantan. It is found that all but 1 respondent have safe level of nitrate in groundwater in Telaga Ara Village. Furthermore, there was a no significant correlation between between nitrate concentrations in groundwater with well characteristic (age, depth, distance and source of nitrate). There was no significance difference as the reading was $p>0.05$. Various factor were determined by variant concentration of nitrate concentration, due to various activities that was anthropogenic such as agricultural that contribute towards increase of effluent and nitrate disposal.

Based on this study, there were 56 respondents take part shows no health risk contributed from nitrate in groundwater. This concluded there was no significant relationship between the health risks (weight) of the respondents due to exposure to nitrate. Therefore, groundwater in telaga ara village is safe for human consumption, however, periodically monitoring is needed to unsure the nitrate groundwater level doesn't exceed the national permissible limit of 10 mg/L.

LIMITATION

There were a few limitations that can affect in this study such as bias, limitation of time, lack of geological data. First of all, study bias such as recall bias might be affect the data sampling as it is not 100% valid because it depends on human cognitive on remembering past information.

Next, due to time constrain the data for contaminations of nitrate in groundwater were obtained according to pre-planting season. The data obtained for other phases should be monitored in order to observe a significant different in nitrate level between other planting phases.

Last but not least, lack of area geological data information limits on finding groundwater flows that can contribute toward source of nitrate contamination. It is also can triggers other co-founding factor that might affect the end result over period of time. Therefore, through data obtained in this study it can help future research to establish a guideline value according to seasonal paddy planting.

RECOMMENDATION

As for the improvement for upcoming study, there are a few other assessments that could be carried out such as geostatistical village information and village soil profile. For instance, by analyses history and soil profile of village area can get a view about previous history location that could contribute towards any changes in groundwater quality. The previous land use can affect the groundwater contamination, and nearby anthropogenic activities such as placement of septic tank and types of agricultural activities also need to be considered as it can affect reading of nitrate.

In the nutshell, a precautionary step and action should be taken care of upon excessive usage of nitrate fertilizer that could impact on health and deteriorates the groundwater quality. Related government intuitional and organization are encouraged to publicly promote and sharing relevant knowledge to potential risk groundwater user using direct approach to spread awareness. Moreover, safe agricultural practice can also be emphasize in the village can cause contamination of nitrate in groundwater. Therefore, it is advisable to conduct an awareness program related on the safety of groundwater.

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APPENDIX 1

**ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS
(JKEUPM)
UNIVERSITI PUTRA MALAYSIA**

Research title : A Cross Sectional Study on Contamination of Nitrate in Groundwater and Health Risk Assessment Among Rural Residential in Bachok, Kelantan .

Study Site : Bachok, Kelantan

JKEUPM Ref No. : JKEUPM-2018-356

Researcher : Mohd Akmal Asyiq bin Zulkiflee

Supervisor : Dr. Shaharuddin bin Mohd Sham

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 29/10/2018
2. Respondent Information Sheet & Consent (Malay), Version 1 dated 29/10/2018
3. Proposal (English), Version 2 dated 10/12/2018
4. Questionnaires/ Interviews (Malay), Version 1 dated 29/10/2018
5. Curriculum Vitae of:
 - a. Dr. Shaharuddin bin Mohd Sham

The University Research Ethics Committee, Universiti Putra Malaysia (JK1 UPM) operates in accordance to the ICH-GCP Guidelines.

Decision by JKEUPM:

- Approved
- Permission **MUST BE OBTAINED** from the respective hospital/ institutions before conducting the research
- Disapproved

Please note that the approval is **VALID UNTIL 20 DECEMBER 2019**

Researchers should comply with the following:

- I. Complete a Study Final Report upon study completion (Form 3.2).
- II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.
- III. Applicable for Clinical Trial Studies and Clinical Interventional Studies only: Progress Report has to be submitted to JKEUPM at every 6 months from the date of approval (Form 3.1). Report occurrences of all Serious Adverse Events (SAEs), Suspected Unexpected Serious Adverse

A large, light gray watermark of the UPM logo is oriented diagonally across the page. The logo features a shield with a book, a scale, and the letters 'UPM'.

APPENDIX 2

BORANG SOAL SELIDIK

Semua maklumat adalah untuk kegunaan kajian sahaja dan maklumat ini akan dianggap sulit.
Maklumat anda hanya digunakan untuk membahagi responden mengikut kategori yang sama.
Arahan: Sila jawab semua soalan dan tandakan (/) pada ruang yang disediakan.

Bahagian A: Maklumat responden

No ID :

tahun

Umur :

Jantina : Lelaki Perempuan

Pekerjaan :

Pendapatan Sebulan : RM

Taraf Pendidikan :

- Tidak bersekolah
- Sekolah rendah
- Sekolah menengah
- Universiti
- Lain-lain

Berat : kg

Bahagian B: Maklumat penggunaan air paip

Apakah punca air paip di rumah?

Air Kelantan SB Bawah Tanah Kedua-duanya Lain-lain, sila nyatakan:

Jika kedua-duanya, yang manakah yang lebih digunakan: AKSB Bawah Tanah Sama rata

Berapa gelas air yang anda minum setiap hari? gelas (200 ml)

Penggunaan air dari dapur: Memasak Minum Kegunaan domestik Lain-lain,

sila nyatakan

Adakah anda berpuas hati dengan kualiti air paip yang digunakan? Ya Tidak Tidak Pasti

Ya Tidak

Adakah anda menggunakan sistem penapisan air persendirian di rumah?

Jika ya, sila nyatakan jenama yang digunakan:

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	

