A STUDY OF DRINKING WATER QUALITY IN KOTA BHARU, KELANTAN: A SPECIAL CONCERN ON FLUORIDE CONTENT

by

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LIST OF ABBREVIATIONS AND SYMBOLS

AKSB	Air Kelantan Sdn Bhd
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
Free-Cl	Free- Chlorine
GPS	Global Positioning System
MOH	Ministry of Health Malaysia
mg/L	Milligram per Litre
NH_3-N	Ammoniacal Nitrogen
ORP	Oxidation Reduction Potential
R^2	R-Square (Coefficient of determination)
USEPA	United States Environmental Protection Agency
WTP	Water Treatment Plant

KAJIAN KUALITI AIR MINUM DI KOTA BHARU, KELANTAN:
PERHATIAN KHUSUS TERHADAP KANDUNGAN FLUORIDA

ABSTRAK

Kandungan fluorida dalam air minum penting untuk kesihatan gigi. Pengambilan yang sesuai boleh membantu untuk mengurangkan masalah karies gigi (kerosakan gigi) manakala pengambilan berlebihan boleh membawa kepada masalah kesihatan yang lain seperti fluorosis gigi dan boleh menjejaskan sistem saraf pusat (CNS) terutama dalam kalangan kanak-kanak. Selain daripada fluorida, parameter utama yang lain juga turut diukur untuk mengkaji hubungan yang wujud di antara parameter yang terlibat. Kajian ini bertujuan untuk menyiasat tahap kandungan fluorida dalam lima loji rawatan air (LRA) di daerah Kota Bharu, Kelantan. Ia juga bertujuan untuk menentukan kepekatan kandungan fluorida dalam sampel air mentah dan air terawat dari sumber air permukaan dan air bawah tanah. Di semua stesen LRA, dua titik persampelan telah dipilih iaitu di lokasi air mentah dan air terawat. Untuk analisis in-situ, parameter yang terlibat adalah pH, suhu, baki klorin dan kekeruhan manakala bagi analisis ex-situ, parameter yang terlibat adalah fluorida dan ammonia nitrogen (NH_3-N). Kesemua sampel air diambil tiga kali seminggu selama lapan minggu. Keputusan yang diperolehi kemudiannya dibandingkan dengan nilai piawai air minum daripada Kementerian Kesihatan Malaysia (KKM). Kesemua data, analisis, dan interpretasi dilakukan dengan menggunakan Microsoft Office Excel. Kesemua carta bar dan linear regresi dilakukan dengan menggunakan Microsoft Office Excel di mana nilai pekali penentuan (R^2) telah digunakan untuk mengukur garis regresi yang membantu untuk menentukan penghampiran titik hubungan yang wujud di antara pembolehubah. Berdasarkan carta bar dan nilai R^2, didapati bahawa kesemua parameter yang diukur tidak mempengaruhi kandungan fluorida dalam sampel air. Walau bagaimanapun, peningkatan paras fluorida selepas air mentah dirawat adalah disebabkan oleh bahan kimia lain seperti Kalsium Hidroksida dan Sodium Karbonat yang digunakan untuk tujuan pembetulan pH telah dikesan. Air bawah tanah didapati mengandungi tahap fluorida yang lebih tinggi berbanding air permukaan. Walau bagaimanapun, semua tahap fluorida didapati tidak mencapai keperluan minimum yang ditetapkan oleh KKM yang sepatutnya di antara 0.4 hingga 0.6 mg/L. Untuk sampel air mentah, nilai R^2 tertinggi dicatatkan di tiga daripada lima stesen LRA untuk parameter yang sama iaitu parameter NH_3-N melawan pH. Ini menyokong bahawa terdapat hubungan yang hadir di antara parameter NH_3-N dan pH. Untuk sampel air terawat, dua stesen merekodkan nilai R^2 lebih daripada 50% iaitu bagi parameter suhu melawan baki klorin dan NH_3-N melawan fluorida. Walau bagaimanapun stesen lain menunjukkan nilai-nilai R^2 yang lebih rendah di mana ia tidak mampu menyokong hubungan yang wujud di antara parameter terbabit. Oleh itu, kajian lanjut diperlukan untuk meningkatkan dan menyokong hasil penemuan. Penggunaan air terawat juga disyorkan untuk memastikan keselamatan air minum pengguna dan proses pemfluoridaan juga sangat disyorkan untuk dilakukan sebagai sebahagian daripada proses rawatan di semua stesen LRA kerana kandungan semulajadi fluorida masih tidak cukup untuk mencapai standard minimum 0.40 mg/L untuk air minum.

A STUDY OF DRINKING WATER QUALITY IN KOTA BHARU, KELANTAN: A SPECIAL CONCERN ON FLUORIDE CONTENT

ABSTRACT

Fluoride content in drinking water is important for oral health. Appropriate intake of it can help to minimize dental carries (tooth decay) whereas excess of it can lead to other health problems such as dental fluorosis and impaired development of central nervous system (CNS) especially among children. In relation to the fluoride, other main parameters also being measured in order to investigate the relationship that might be present among them. This study was aimed to investigate the level of fluoride content in five water treatment plants (WTP) in district of Kota Bharu, Kelantan. It also aimed to determine the concentration of fluoride content in raw and treated water samples from both surface water and groundwater sources, respectively. In all WTP stations, two sampling points were chosen which are at raw and treated water points. For in-situ analysis, the parameters involved were pH, temperature, free-chlorine and turbidity whereas for ex-situ analysis, the parameters involved were fluoride and ammoniacal nitrogen (NH_3-N). All water samples were taken three times in a week for eight weeks. The result obtained was then compared with standard value of drinking water from Ministry of Health, Malaysia (MOH). All the data entry, analysis, and interpretation were done by using Microsoft Office Excel. All bar charts and linear regression was performed using Microsoft Office Excel where coefficient of determination value (R^2) was used to measure the regression line that help to determine the closeness of relationship present between variables. Based on bar charts trend and R^2 values, it was found that all measured parameters did not influence the fluoride content in water samples. However, the increase of fluoride level after the water being treated was due to other chemicals such as Calcium Hydroxide and Sodium Carbonate that used for pH fixing purpose was detected. Groundwater was noted the higher level of fluoride compared to surface water. However, all the fluoride level was not even reach the minimum requirement set by MOH which it should be between 0.4 to 0.6 mg/L. For raw water samples, the highest R^2 values were recorded in three out of five WTP stations for the same parameters of NH_3-N against pH. This supported that there was a relationship present between parameters of NH_3-N against pH. For treated water samples, two stations recorded the R^2 values more that 50% which are for the parameters of temperature against free chlorine and NH_3-N against fluoride. However other station shows lower R^2 values for those parameters which it cannot support the present of relationship between the parameters. Thus, further study is needed to improve and support the findings. The usage of treated water was recommended in ensuring the safety of public drinking water and fluoridation process also highly recommended to be done as parts of treatment process in all WTP stations as natural occurrence of fluoride still not enough to reach minimum standard of 0.40 mg/L for public drinking water.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is the most basic thing needs by human being and all living things to stay alive. Water is not only play a crucial role as public water supply but it is also needed by the other sectors of economy such as forestry, agricultural, electric power production, energy resource extraction, mining and others. People get their water supply from many different sources, depending on their living area. Generally water comes from two main sources which are from natural and man-made.

Natural sources are from rainwater, oceans, river, streams, ponds and spring whereas man-made sources come from dam, tube-wells, hand pumps, canals, and others. They are further divided into two types which are surface water and groundwater. Surface water is defined as the water on the earth's surface that includes of streams, lakes, bays, as well as oceans whereas ground water is defined as the water that is below the surface of the earth (Perk, 2013). Both sources can provide people with needed water supply depending on their living area.

To stay healthy, people need to ensure that their water supplies are safe to be used from any contamination. This is important as people tend to use the supplied water as their drinking water, and the contaminants may be introduced into the body thus affecting their health. Potential contamination can either occur naturally or by human activities. Some natural potential contamination that can contaminate water sources

are from microorganism, radionuclides, radon, nitrates and nitrites, heavy metals and fluoride that may originally come from rocks, soil, runoff and others.

Others human activities that can contributes to water pollution are such as poor sewage management that can enhance the growth of bacteria and the presence of nitrates, farming activities, mining, construction, agricultural activities that use fertilizers and pesticides, industrial products and waste, and others (Environmental Protection Agency (EPA), 2012). All the potential pollutions can cause many adverse health effects to users once they pollute the water sources.

1.2 Background of study

This study was aimed to investigate the level of fluoride contents in five main water supplies in Kota Bharu, Kelantan. All of the five water treatment plants (WTP) were chosen as study locations. They were situated at Tanjung Mas WTP, Kampung Puteh WTP, Pintu Geng WTP, Chicha WTP and Bukit Cina WTP. In Kota Bharu, only Bukit Cina WTP was used surface water as a source and others WTP depend on ground water sources.

In every water treatment plant, two types of water samples were taken. They are from raw and treated water samples. Raw water is the natural water that does not undergo any water treatment process. Treated water is the water that undergoes treatment process in a water treatment plant (Alcott *et al.*, 2013). Figure 1.1 shows the flow chart of water treatment process in WTP.

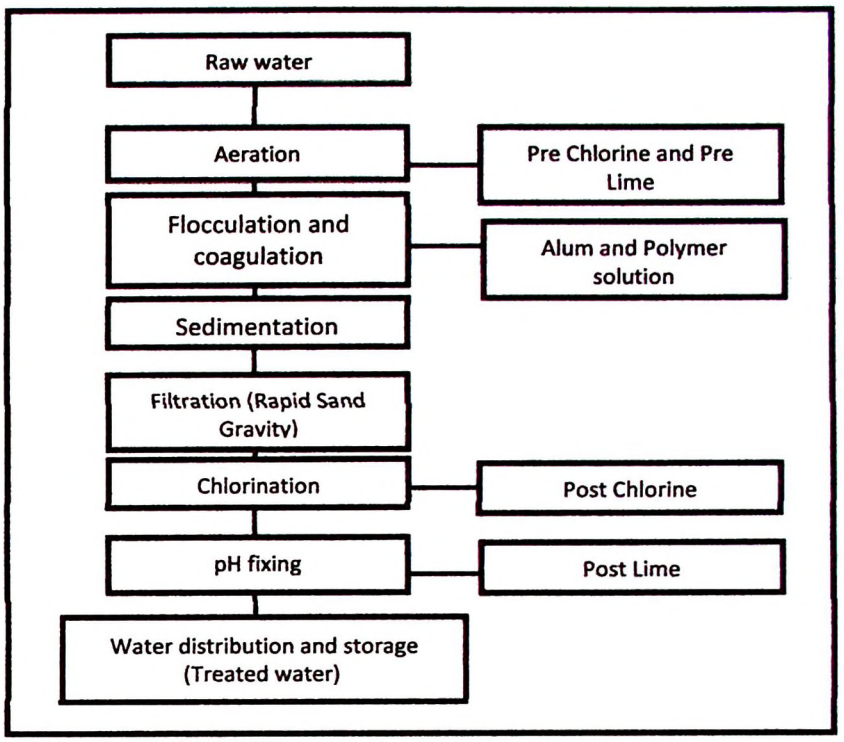

Figure 1.1: Flow chart of water treatment process
(Source: Air Kelantan Sdn Bhd (AKSB), 2014)

In all WTP, the raw water either from groundwater or surface water sources was undergo the water treatment process as in Figure 1.1. In this study, both raw and treated water samples were analysed based on its fluoride contents and other parameters. In addition, all the data obtained in this study was under the permission as refer to Appendix A.

In this study, fluoride especially in drinking water was a major concern as fluoride could give its own benefits as well as adverse health effect if the amount taken was not appropriate. Fluoride is an element that is formed when the fluorine combined with other elements (gains an electron). It is known as fluoride or the fluoride ion and is abbreviated as F^-. It is odourless, tasteless and colourless. It can be found naturally in the earth's crust such as in soils, rocks, salts, and sea water (Clausen,

2011). Fluoride content in water supply can help people to promote good dental health.

Presence of fluoride in water can helps to prevent dental carries (tooth decay). Dental carries is a disease that caused by many factors such as bacteria, carbohydrates in diets, resistance of enamel and others. The presence of fluoride in the right amounts can help in assisting remineralisation of demineralised tooth enamel through its action when it combined with saliva (Featherstone, 1999).

However, consuming excessive fluoride which is more than allowable limit can also give adverse effect especially in early childhood such as dental fluorosis and intellectual development problems. Dental fluorosis is a condition where the discolouration of teeth occurred. It can be more severe with the presence of staining and pitting in the teeth. It is recognised as one of the side-effect associated with excessive fluoride exposure (Do & Spencer, 2007).

Intellectual development problems in early childhood can also occurs with excessive fluoride exposure. Neurotoxic effect of excessive fluoride can interfered development of central nervous system (CNS). This could happen during foetal and early childhood development (Yaming *et al.*, 2006).

The parameters other than fluoride also were included in this study. They are turbidity, temperature, NH_3-N, free-chlorine, and pH. All the parameters were measured in order to find the relationship between them and also with the fluoride content in water samples. In addition, the parameters were measured so that the current conditions especially for the water that was used for drinking and cooking purposed can be known.

For the temperature, the standard limit set by Ministry of Health, Malaysia (MOH) was below 40°C. Usually, high temperature in a water body especially in a river was caused by industrial process such as unmonitored of effluent discharged. The most affected population are such as fish and other aquatic life that live within it where they cannot survive in such high temperature. Temperature also has the ability to affect other parameters such as pH. For instance, high temperature in water will increase the formation of H^+ ions, making the water more acidic (Toh, 2013).

For the turbidity, it was measured to describe the condition of the water. Low readings indicate that the water contained fewer impurities. High turbidity in drinking water can lead to many other problems where it can promote the growth of bacteria by providing them foods and shelters (Gunther *et al.,* 2011). This can be the indicator to the outbreak of waterborne diseases such as Cholera, *E. coli* infection, and others.

The parameter of ammoniacal nitrogen (NH_3-N) also becomes a major concern in drinking water supply as it can cause many adverse health effects if in excess. Higher content of NH_3-N also can be as indicator that the water has been contaminated with faecal pollution. In a water body, the toxicity of the NH_3-N also depends on many other parameters. For instance, many studies supported that temperature and pH influence the toxicity of NH_3-N (Pecson *et al.,* 2007).

Finally, the parameter of free-chlorine also was measured (in treated water samples) in order to find the relationship with other parameters. In water treatment plants, chlorine was added during treatment process for disinfection purposes. However, the amount of added chlorine can be influenced later on by many other factors such as

ammonia in a water body, unexpected raw water demands, rainfall and others (McCool, 2004).

1.3 Problem statement

Fluoride is known as an element that is important for oral health. People have to understand that the right amount of fluoride intake especially among children can help to avoid dental carries problem, but excessive of it also can lead to other problem such as dental fluorosis. The fluoride intake should be in optimum amount so that the risk of getting those problems can be avoided.

The fluoride content in drinking water also can contribute to the amount of fluoride daily intake by a person. For instance, many previous studies supported that the concentration of fluoride in water that used to prepare infant foods and drinks was directly proportional to the concentration of fluoride contents in those foods and drinks that were consumed by them (Siew *et al.*, 2009).

According to MOH, the recommended level of fluoride intake should be in a range of 0.5-0.9 mg/L (Shaharuddin, 2009) while for the treated drinking water standard, it should be in a range of 0.4-0.6 mg/L. All water treatment plants have to ensure that all the limits set by MOH is comply in order to achieve optimum level of fluoride required by people.

It also has long been suggested that a suitable intake of fluoride in children younger than 6 years old was in range of 0.5-0.7 mg/L (Fatemeh *et al.*, 2012). However, according to the American Academy of Paediatric Dentistry (2014), it stated that fluoride intake below the 0.6 mg/L among children can lead to dental carries

problem. Thus, 0.7mg/L is the optimal for dental health benefit especially among children below 6 years old in minimizing dental carries and dental fluorosis (American Dental Association, 2011).

Fluoride can get into water supplies either naturally or by human made (fluoridation process). Naturally, fluoride can enter water body as a result of geological composition of soils and bedrocks. Fluoride can pass easily especially into groundwater by the movement through gaps and pore spaces between rocks and soils (Environmental Protection Agency (EPA), 2013).

Many people trusted that the natural occurrence of fluoride already enough in drinking water especially when it comes from groundwater sources where the fluoridation process was unnecessary. Fluoridation process also commonly associated with high socio-economic status as it requires high cost. However, a study done by Jones & Worthington (2000) in North of England stated that there was a 50% difference in dental carries problems reported between fluoridated and non-fluoridated area. The non-fluoridated area also showed more problems regarding the poor dental health such as dental pain, embarrassment of teeth conditions and others.

In Kelantan, the demand and supply of raw groundwater is the highest compared to other states in Malaysia which is 75,206 million litres per year in 2009 and the demand was increasing over the year (National Water Services Commission, 2009). As a capital, Kota Bharu consists of the largest proportion of population compare to other districts in Kelantan, which is about 551,200 people in year 2014 from total of 1,691,900 people (Department Of Statistics, Malaysia, 2014).

In addition, all of the water treatment plants (WTP) in Kota Bharu were using groundwater as their sources while only one of them get their water supply from surface water (from Kelantan River). While comparing to other districts in Kelantan, mostly they depend on surface water sources (AKSB, 2014). Thus, Kota Bharu was the most strategic district to be the research site. Table 1.1 shows the number of population according to Department of Statistics (2014).

Table 1.1: Number of Population according to Department Of Statistics, Malaysia 2014

No	District	Total
1	Bachok	146.9
2	**Kota Bharu**	**551.2**
3	Machang	99.1
4	Pasir Mas	203.3
5	Pasir Puteh	123.4
6	Tanah Merah	134.5
7	Tumpat	166.8
8	Gua Musang	102.3
9	Kuala Krai	119.5
10	Jeli	44.8
	KELANTAN (total)	1691.9

(Source: Department of Statistics, Malaysia, 2014)

A part from that, according to a report by AKSB (2015), there were only approximately 319,110 people in Kota Bharu used treated water at home. Another 232,090 people still depend on raw water by which represented about 42% of total population. Raw water that was used at home mostly unmonitored, thus exposing the users to the risk of using polluted water at home. In order to help people in Kota Bharu get their drinking water more safe, the sources of water supply must be

checked. This was done to investigate the water content especially in all WTP in Kota Bharu.

1.4 Objectives

1.4.1 General objectives

The main aim of this research is to investigate the level of fluoride content in five main water supplies in Kota Bharu, Kelantan, using two sampling methods (in-situ and ex-situ).

1.4.2 Specific objectives

i. To determine the concentration of fluoride content in raw water and treated water samples in five water treatment plants in Kota Bharu, Kelantan.
ii. To determine the concentration of fluoride content in surface water and groundwater samples.
iii. To identify the relationship between the all parameters.

1.5 Research questions

i. What are the concentrations of fluoride content in five main water supplies in Kota Bharu, Kelantan?
ii. Are there any differences between fluoride content with the type of water sources (groundwater and surface water)?

iii. Are there any differences of fluoride content between raw water and treated water?

iv. How does fluoride get into drinking water?

v. What are advantages and disadvantages using fluoride in water supply?

vi. Are there any relationships present between the other main parameters?

vii. Are the other parameters giving different result between raw and treated water samples?

viii. What are the standards that should be comply by water treatment plant in treating drinking water?

1.6 Research hypothesis

1.6.1 Alternate hypothesis

i. There is a difference between the concentrations of fluoride content with the type of water sources (groundwater and surface water).

ii. There is a difference between the concentrations of fluoride contents with the type of water sample (raw water and treated water).

1.6.2 Null hypothesis

i. There is no difference between the concentrations of fluoride content with the type of water sources (groundwater and surface water).

ii. There is no difference between the concentrations of fluoride contents with the type of water sample (raw water and treated water).

1.7 Significance of study

This study provide the information on current reading of fluoride level in water sources used by people in Kota Bharu which could help them in estimating daily intake of fluoride. After all, this study can give the information on the advantages and disadvantages using fluoride in drinking water (either from groundwater or surface water sources) providing with the safe limits to be consumed by publics as well as with the appropriate control measures.

A part from that, this study also helped to provide the information on current condition of raw and treated water used in Kota Bharu. This is very important as almost 42% people from total population in district of Kota Bharu still depend on the raw water sources at home (AKSB, 2015). By measuring all the involved parameters, at least the current condition of the raw water can be determined and can be compared with treated water samples. The current condition of raw water was very important in order to predict the safety aspect of using raw water especially for domestic use in future.

In addition, this study not only important to publics, but also important to the management of water treatment plant so that they can enhance and improve the treatment process in future. For instance, the finding on fluoride level can assist them to estimate the amount of fluoride that was still needed in their water supply. Other than that, this study also can help them to improve the water treatment process through the finding of relationship that might be present between all parameters since certain parameters depend on each other action. This information could help to enhance the quality of the treatment process.

Moreover, this information is useful to the authorities especially in maintaining and increasing the health status of publics. The implementation and enforcement of related regulation and standards also need to be done in order to improve the safety and quality of public water supply. This also important to the country where it helps to give the country good reputation in aspect of managing their public water supply.

Finally, this study also can give some beneficial information to be used by authorities or other related parties for further improvement. Thus, the improvement especially in water quality aspects is hoped to give better health status towards the publics in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Fluoride

Fluoride is an inorganic anion of fluorine with F^- symbols. It is formed when the elements of fluorine gains an electron after combining with other elements. In a periodic table, fluorine is the first element in a group 17 and also known as one of the halogens. The term halogens are referring to the salt former. Any compound that combines with halogens will form salt.

Fluorine is the lightest halogens with a weight of 19 atomic mass and exists in the states of gas at room temperature. It is the most electronegative and extremely reactive elements. Most all the elements including some of noble gases will still form a compound when combine with fluorine. At any combination with other elements once the fluorine gain the electron from its partner, it will be called as fluoride which means it carries one extra electron thus gives it a negative charge F^- (Norbani *et al,*. 2009).

In the earth's crust, fluorine usually can be found in the form of combined minerals such as fluorite, fluorapatite and cryolite. Fluoride consists of so many types depending on the combined elements. There is a vast range of fluoride compound because fluorine has the capability to combine with almost all the elements.

Some commonly forms of fluoride are such as sodium fluoride, calcium fluoride, sodium aluminium fluoride, stannous fluoride and sulfuryl fluoride. Each of them has

different applications. For instance, sodium fluoride is commonly being used in toothpastes, dental preparation, nutritional supplements or mouthwashes. Sodium fluoride also can be used for water fluoridation purpose as well as other types of fluoride such as fluorosilic acid and sodium fluorosilicate (Spellmann, 2008).

In addition, fluorine is a very strong oxidizing agent. This characteristics help fluorine to combine with other elements much easier. It is a non-metal element. If it combines with another non-metal element, it will later on form the covalent bond whereas if the fluorine combines with another metal element, it will form the ionic bond. Both types of the compounds will have difference kind of characteristics.

Covalent compound that is formed from the combination of fluorine and non-metal elements (usually organic compound) will have the characteristics such as low melting point and boiling point, cannot conduct electricity, low polarity and many of them soluble in non-polar liquids but not in water. For the ionic compound, that is formed from combination of fluorine with metal elements (usually inorganic compound) will have the characteristics such as high melting and boiling points, can conduct electricity and many of them are soluble in water but not in non-polar liquids (Tan & Ashy, 2010).

2.2 Previous Study

In Malaysia, Shaharuddin *et al.*, (2010) stated that fluoride level in few states in Malaysia were below or within the range of 0.5-0.9 mg/L. Even though Kelantan, Terengganu and Sabah states were reported higher cases of dental fluorosis among the population, but they found that the fluoride levels in drinking water had no relationship with the dental fluorosis problem.

Dental fluorosis often associated with excessive exposure towards the fluoride intake. This included the excessive level of fluoride in drinking water. However, Kelantan, Terengganu and Sabah were the three states that do not have artificial fluoridation but still reported higher dental fluorosis amongst the population (MOH, 2010).

According to Molly *et al.*, (2013), fluoridation process helped in reducing oral health problems especially among children and poor or vulnerable adults. Fluoride can help to minimize dental carries (tooth decay) and other dental health problems. They stated that, on-going promotion on fluoridation in public water supply needs to be done especially by dentists and educators so that the knowledge on the importance of fluoridation can be explained to publics. However the allowable limits should be complied in order to achieved optimum benefit of fluoridation.

Optimum level of fluoride can help to minimize dental problems. But the intake of fluoride should be monitored as excessive of it may developed others health problems. Few studies on effects of excessive intake of fluoride were done by many researchers.

For instance, based on the study by Teresa *et al.*, (2004), they found that infant formulas that were prepared using excessive fluoridated water can increase the risk of dental fluorosis in primary teeth among children below 6 years old. The primary tooth fluorosis can be associated to the intake of beverages and fluoride from these beverages during infancy.

Excessive ingestion of fluoride during development of tooth especially below 6 years old can lead to structural changes in tooth enamel. It will alter the protein metabolism of teeth that later on produced the disorganized crystal structure and hypomineralization condition called dental fluorosis (Wright *et al.*, 1996). In preventing the dental caries, knowledge on optimal recommendation for fluoride content must be known. Excessive uptake of fluoride during the early period of tooth development may cause fluorosis problems (Rozier, 1999).

Samuel *et al.,* (2000) reported that increase level of fluoride intake among infants and children can be associated with increase of enamel fluorosis unless intervention measures were taken. The fluorosis tends to make the tooth enamel to appear opaque. The clinical features of teeth will change from fine white to chalky white teeth. By time, the enamel will become so porous that the outer layer of teeth will breakdown and the exposed subsurface becomes discoloured (Fejerskov *et al*, 1996).

High level of fluoride not only can cause fluorosis among children, but it also may influence the intellectual development of children. A study in Iran which done by Seraj *et al.*, (2012) found that children who residing in area of higher than normal water fluoride levels showed more impaired development of intelligence. Through the study they also found that the increased level of fluoride may affect other organs too such as thyroids, bones, kidney, liver, lung and brain. In brain, fluoride may exert

its neurotoxic effect which later on will generate free radicals and alter the level of neurotransmitter in the brain (Vani & Reddy, 2000).

Alteration of neurotransmitter can interfere with the normal development on central nervous system (CNS) during fetal and early childhood development. During this stage, the brain was very sensitive to any changes or the increased level of certain elements. It may affect the neurobehavioral development of the children. Any cerebral impairment that occurs in this stage could lead to cognitive and intellectual deficits (Li *et al.*, 2008). Other possible mechanism of neurotoxic effect of fluoride also can be occurred during maternal period. Fluoride can pass through the placenta by the exposure of the mother towards the high fluoride level during prenatal periods (Fawel *et al.*, 2006).

Furthermore, a study in China by Xiang *et al.*, (2003), reported that the higher fluoride levels in drinking water were significantly associated with higher rates of mental retardation and borderline intelligence. Through the measurement of Intelligence Quotients (IQ) among children in two different villages that consist of different level of fluoride content in their water supply, it was found that in the village of high-fluoride the mean IQ was significant lower than the low-fluoride village. They concluded that drinking water with a fluoride content greater than 1.0mg/L adversely affect the development of children's intelligence.

Water used to prepared foods also could reflect the amount of fluoride consumed by human body. Zubaidah *et al.*, (2014) reported that, high fluoride and low pH level have been detected in popular flavoured beverages in Malaysia. They were indicate that fluoride content were varies with different types of beverages. This can be explained as the level of fluoride content in the water used to prepare the beverages

were different according to different regions in Malaysia. Thus, due to these variations, they were suggested that fluoride concentration and pH level should be monitored and controlled in beverages so that dental fluorosis and erosion could be prevented.

Other than that, few studies also were done by many researchers regarding the quality of using raw water as domestic use. Most of study focused on usage of raw water from groundwater sources. For instance, Pritchard *et al.,* (2007) reported that raw water samples from shallow wells in Malawi were contaminated microbiologically during wet seasons. They compared the result obtained with dry seasons and found that the water samples were less contaminated. The result also recorded increase of turbidity readings during the wet season where this could be the major reason contributed to the increase of bacteria in water body.

In addition, a study done by Haydar *et al.,* (2009) regarding to the raw water samples from tube wells (groundwater) reported that there were differences recorded in few parameters reading before and after monsoon season. The physicochemical parameters (pH, turbidity, total dissolved solids and ammonia) and biological parameters where changed drastically after the monsoon season. After the monsoon season, the parameters measured recorded the exceeded values while many samples also shown the increase of bacteriological contaminations. This can be due to the monsoon season where the cross connection between tube wells and nearest sewer occurred. Thus, it contaminated the groundwater samples.

Contamination of the groundwater especially from nearest sewage can caused many other health effects especially when the water used for drinking and cooking purposes. For instant, a study done in Pahang by Awatif *et al.*, (2012) found that the

Blastocystis infection tend to occur among rural children that used raw water as their drinking water at home. *Blastocystis* infection was caused by parasite that lived within human stools. Therefore, any contamination from sewage that seeps into the groundwater source can develop such infection.

In Africa, a study on the safety of using raw water (groundwater) as a drinking water also was done by Adriano & Joana (2007). They stated that, even though the water was found to be acidic (pH below 5.12) but the water samples still contaminated with heavy faecal contamination (increased of ammonia reading). Thus, they suggested that, the appropriate treatment still need to be done so that the raw water from the majority wells can be used safely for the domestic use. The treatment that can be applied was such as chlorination treatment process.

Chlorination was good to kill the harmful pathogens in water body. However, a study done by Richardson & Postigo (2011), stated that the usage of disinfectants such as chlorine, chloramine, ozone and chloride dioxide can also lead to many health problems such as bladder cancer, early-term miscarriage and birth defect. This happen due to the drinking water disinfection by-product (DBPs). It was also found that DBPs not on enter the body through ingestion process, but also from other routes such as inhalation and dermal exposure. Therefore, the usage of disinfectants must be controlled and monitored continuously once the disinfectants being added to water body. This can help to minimize the risk of getting adverse health effects.

2.3 Other main parameters

In determining the level of fluoride in a water samples, other main parameters also need to be included so that any effect towards the fluoride readings could be noticed. There were such as the parameters of temperature, turbidity, ammoniacal nitrogen, free-chlorine and pH.

2.3.1 Temperature

Temperature of water was important parameter as temperature may affects many activities including the physicals, chemicals and biological activities that occur in water body. Temperature of water can be defines as the measurement of heat content of the water mass that may influence the survivability and growth rates of aquatic life (Davis & McCuen, 2005). Temperature also has the ability to alter the biological and chemicals characteristics of water. For instance, high temperature affects the dissolved oxygen level to become lower in water body. This happen as high temperature will initiates the metabolic rate of aquatic life thus increased their biochemical oxygen demand (Rivera, 2015).

2.3.2 Turbidity

Turbidity is a measurement of clarity of water body. Its principle is by measuring the light that travels through the water. The high reading of turbidity may indicate the presence of high suspended particles such as clay, soil, organic and inorganic matters and others. Turbidity has a directly relationship with total suspended particles

(Farrell, 2000). This happen as with the high presence of suspended solid in water, the transparency of the water will become lower thus increasing the turbidity value.

Too high values of turbidity also may affect the environment of the water where it prevents the growth of fauna and flora within it. High values of turbidity indicate low penetration of sunlight that is needed in photosynthesis process in water. This could lower the daytime release of oxygen in water body that is required by aquatic life.

2.3.3 Ammoniacal nitrogen (NH_3-N)

Ammoniacal nitrogen is one of the important parameter in water quality. It can be the indicator of polluted water samples with many sources of ammonia such as decaying plants and animals, animal waste, industrial waste effluent, sewage systems, agricultural runoff, and others. In water, ammonia can be oxidized by certain bacteria to the forms of nitrites and nitrates with presence of enough dissolved oxygen (United States Environmental Protection Agency (USEPA), 2002).

Other than that, ammonia also is the source of nutrient for algae and other plant life thus presence of ammonia enhancing their growth and pollute the water body. Many studies also indicate that higher pH can initiate higher ammoniacal nitrogen values in water (Stuart & Levit, 2010).

2.3.4 pH

pH in water is a measurement of acidity or alkalinity of the water. Most aquatic life can adapted with pH ranges from 6.5 to 8.0. pH less than 7 indicates acidity whereas more than 7 indicate alkalinity. It measures the free hydrogen and hydroxyl ions in water. Acidic water has more free hydrogen while alkaline water has more hydroxyl ions (Springer, 2014). Other compound that present in water body will reacts differently with different pH. Thus, high changes in pH will affect the activities occur in water body.

2.3.5 Free-chlorine

Free-chlorine refers to the disinfection that is commonly used for chlorination process. When the chlorine is added to the water system, it is basically will combine with contaminants such as ammonia or organic nitrogen to form chloramines, monochloramines or other forms of combine chlorine. The excess chlorines that do not combine with contaminants are called as free chlorine (Osinski, 2001). The free-chlorine is measured and monitored so that the levels are in the allowable limit which already set by MOH to be complied. Appendix B shows the Standard of drinking water quality given by MOH for all involved parameters.

2.4 Statistical analysis

In analysed the data, Microsoft Office Excel was used in order to interpret the result through the bar chart plotted and to find the coefficient of determination (R^2). Bar charts help to displayed measured values on one or two axis with simplest way. It was also an easy tool that can be used in many studies in order to interpret and observe the trend of measured variables. For instance, a study done by Gogana (2014), involving water quality parameters in India was used bar charts in order to describe the level of measured parameters such as temperature, NH_3-N, pH and others. Furthermore, Gampson *et al.,* (2014) also used bar charts to describe and compare few types of heavy metal with different seasons.

In addition, linear regression also was used in this study. Linear regression was used to predict the relationship present between measured parameters. In Microsoft Office Excel, the regression line that represented the data was measured by using the coefficient of determination, R^2. The R^2 was useful to be used as it helps to describe the closeness of relationship present between two measured variables. The R^2 value was such that $0 \leq R^2 \leq 1$, by which the closer the R^2 value to 1 shows the greater linear association between two variables. R^2 value was always between 0 to 100%. It described the percentage of response variable from total variation. The closer the R^2 value to 1, the better the line fits the data and R^2 value that close to 0 indicates a poor fitting-line. The equation for coefficient of determination, R^2 was given by Albright, (2011).

$$R^2 = \frac{SS_{Tot} - SS_{Res}}{SS_{Tot}} \qquad \text{Equation (2.1)}$$

Where,

$$SS_{Tot} = SS_{Reg} + SS_{Res} \qquad \text{Equation (2.2)}$$

(Total variation = explained variation + unexplained variations)

SS_{Tot} (total sum of squares) represents total variation, SS_{Reg} (regression sum of squares) represents explained variation while SS_{Res} (residual sum of squares) represents unexplained variations. Equation (2.1) was the definition of coefficient of determination (R^2) which could represent the overall percentage of explained variation while equation (2.2) shows the total variation equal to explained and unexplained variation.