COMMUNITY WATER QUALITY MONITORING

NUR DIYANA BINTI MOHD SAMSUDDIN

UNIVERSITI MALAYSIA PAHANG

COMMUNITY WATER QUALITY MONITORING

NUR DIYANA BT MOHD SAMSUDDIN

Report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Applied Science (Honours) in Industrial Chemistry

Faculty of Industrial Sciences & Technology
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2011

SUPERVISOR'S DECLARATION

“I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Honor) in Industrial Chemistry.

Signature :

Name of Supervisor : Dr. Rossi Setiadji

Position : Lecturer

Date :

* Delete if unnecessary

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature	:
Name	: Nur Diyana Bt Mohd Samsuddin
ID Number	: SA08041
Date	:

DEDICATION

Special dedication to my beloved father, mother, brothers and sisters……………….

ACKNOWLEDGEMENTS

I would like to take this opportunity to acknowledge and extend my sincere thanks to all those who have directly and indirectly contributed to the successful completion of my final year project. I would like to express my gratitude to my supervisor Dr Rossi Setiadji for his ideas, invaluable guidance, continuous encouragement and constant support in making this project possible. I also would like to thanks him for every time and money that were spent during sampling trip.

My sincere thanks go to all my lab mates, member of the laboratory staff and lecturers of Faculty Industrial Science and Technology UMP for helped me during running this project. I also would like to express special thanks to my classmate and friends who always spends time to share the problems and give support when I am facing difficulties.

My very special thanks from the bottom of my heart goes to my parents, brothers and sisters for their understanding, encouragement, moral and financial support and emphasis on the value of education.

ABSTRACT

Malaysians receive drinking water every day from their public water systems, which may be publicly or privately owned. There are a number of health risks from drinking water if not properly treated or disinfected, or if distributed through an improper maintenance of distribution system. In this study, six stations of drinking water sources in Kuantan and Gambang area were sampled and analyzed for their water quality parameters, including pH, dissolved oxygen, total dissolved solid, hardness, chemical oxygen demand, biochemical oxygen demand, heavy metals and anions. Standard methods were used to measure each of parameters. Results were evaluated based on National Drinking Water Quality Standards for Malaysia. The concentration of all contaminants was within the levels recommended by National Drinking Water Quality Standards. As a conclusion, drinking water in Kuantan and Gambang area were considered safe to consume.

ABSTRAK

Rakyat Malaysia menerima sistem bekalan air minuman setiap hari dari sistem air awam yang mungkin secara umum atau milik peribadi. Terdapat beberapa risiko kesihatan disebabkan air minuman yang tidak dirawat dengan betul atau dibersihkan ataupun melalui sistem pengagihan yang tidak sempurna. Dalam kajian ini, enam stesen sumber air minuman di kawasan Kuantan dan Gambang telah diambil sampel dan dianalisis untuk parameter yang mana terdiri daripada pH, oksigen terlarut, jumlah pepejal terlarut, keliatan, keperluan oksigen kimia, keperluan oksigen biokimia, logam berat dan anion. Kaedah piawai telah digunakan untuk mengukur setiap parameter. Keputusan dinilai berdasarkan Standard Kualiti Air Minuman Kebangsaan Malaysia. Kepekatan bahan tercemar di dalam air minuman di kawasan Kuantan dan Gambang berada pada tahap yang disyorkan oleh Piawaian Kualiti Air Minuman Kebangsaan. Kesimpulannya, air minuman kawasan Kuantan dan Gambang adalah selamat untuk diguna.

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

CHAPTER 2 LITERATURE REVIEW

CHAPTER 3 METHODOLOGY

CHAPTER 4 RESULTS AND DISCUSION

CHAPTER 5 CONCLUSION AND RECOMMENDATION

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

ºC	Degree Celcius
%	Percent

LIST OF ABBREVIATIONS

$CaCO_3$	Calcium carbonate
COD	Chemical oxygen demand
BOD	Biochemical oxygen demand
DO	Dissolved oxygen
DWT	Drinking Water Treatment
EDTA	Ethylenediamine tetraacetate
EPA	Environmental Protection Agency
HCl	Hydrochloric acid
MPN	Most probable number
NH_4Cl	Ammonium Chloride
NH_4OH	Ammonium Hydroxide
NTU	Nephelomtric Turbidity Units
TCU	True Color Units
TDS	Total dissolved solid
UMP	Universiti Malaysia Pahang
UNICEF	United Nations Children's Fund
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Water is the basic component of life; without it life would not exist. It is second most main resource for human because water is everywhere and it flows freely when we turn on the tap. Clean drinking water is important to humans and other life forms. Drinking water or known as potable water is water of sufficiently high quality that can be consumed with low risk of immediate or long term harm.

A clean and constant supply of drinking water is essential to every community. People in large cities frequently drink water that comes from surface water sources, such as lakes, rivers, and reservoirs. Sometimes these sources are close to the community and some get the water from sources many miles away. In rural areas, well become sources of drinking water to the communities. Most ground water is naturally filtered as it passes through layers of the earth into underground reservoirs known as aquifers. Water that pumped from wells generally contains less organic material than surface water and may not need to go through any or all of the treatments. The quality of the water will depend on local conditions.

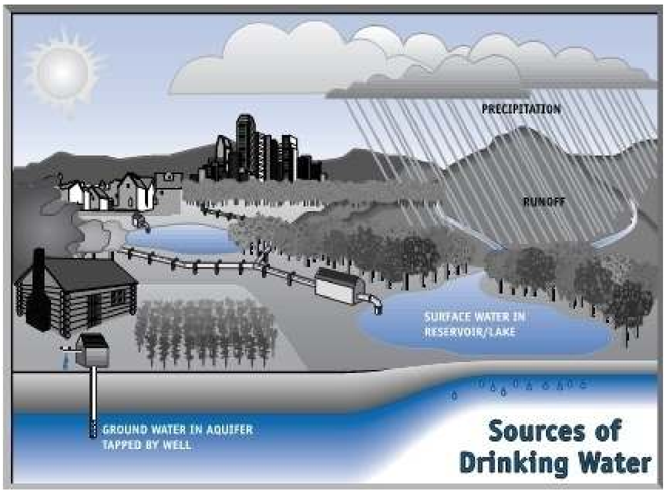

Figure 1.1: Sources of Drinking Water

Drinking water standard is supplied to households, commerce, industry and only a very small proportion is used in food preparation. Population grows will increase the usage of water until the demand sometimes overshoots the supply or availability. Humans have not enough access to potable water in some places of the world due to the limited sources of water. Some of them have to use sources contaminated with disease vectors, pathogens or unacceptable levels of toxins or suspended solids. Using such water in food preparation leads to widespread acute and chronic illnesses which is a major cause of death and misery in many countries. Decreasing water quality had give implications to economic, social, environmental and community health.

More than 90% of Malaysia's water supplies are derived from surface water sources. Many river systems are moderately to grossly polluted by domestic and industrial wastes. Thus, the drinking water treatment (DWT) process forms the single most important barrier to safeguard human health from threats of water-related illnesses and diseases. Nonetheless, studies have shown that many DWT plants are not functioning optimally (or are technologically inappropriate), and that biological and chemical water quality violations occur frequently. (Yaziz and Pillay, 1995).

1.2 PROBLEM STATEMENT

Malaysia is rich in water resource. Population growth and urbanization, industrialization, the expansion of irrigated agriculture and pressure on water resources are imposing rapidly increasing demand leading to rising of water pollution. 98% of the urban population in Malaysia were served through reticulated systems from water treatment plants using all or some of the conventional treatment processes of aeration, coagulation and flocculation, sedimentation, filtration and chlorination by the year 2000. However, the water that used by consumer might be not properly treated due to effectiveness of some smaller treatment plants which is in development. This research is important to give information to community about the taps water that have been use everyday. This is because nowadays human are not concerned about the quality of water anymore. Based on the information given, communities' awareness to the drinking water can be raise.

1.3 SCOPE OF STUDY

The scope of this study is the water that been consumed for daily life. The water might one of the factors that effect communities' health. My research was limited to drinking water sample with parameter which is physicochemical includes anions, heavy metals, chemical oxygen demand and biochemical oxygen demand.

1.4 OBJECTIVE

The objective of this study is to monitor and evaluate the drinking water quality in Kuantan and Gambang area.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Tap water available in urban areas of the developed world during the last quarter of the 19th century, and common during the mid-20th century. A complex and carefully designed system of collection, storage, treatment and distribution is required to provide tape water to the large urban populations. Tap water is susceptible to biological or chemical contamination.

2.2 THE STUDY/ ISSUES OF CONTAMINANTS IN DRINKING WATER

2.2.1 Natural Contamination

Major sources of drinking water come from groundwater and surface water. Groundwater is any subsurface water that occurs below the water table in soil. While, surface water is water occurring in lakes, rivers, streams or other fresh water sources. Natural contamination can occur in both sources. Groundwater contains pesticide chemicals and nitrate while surface water contains most bacteria and other microorganisms. There is no 100 percent clean water because in nature, all water contains some impurities due to water flows in streams, sits in lakes, and filters through layers of soil and rock in the ground, dissolves or absorbs the substances that it touches. Some of these substances are harmless. Some contaminants come from erosion of natural rock formations and other contaminants are substances discharged from factories, applied to farmlands, or used by consumers in their homes and yards.

2.2.2 Contamination from Drinking Water Treatment (DWT) Plants.

Raw water from river, lakes and reservoir will undergo Drinking Water Treatment (DWT) plant before can be use by customers. Originally, the purpose of water treatment is to improve the aesthetic qualities of drinking water. Then, at early 4000B.C. the methods to improve taste and odor of drinking water were recorded. Early 1500 B.C. the Egyptians started to use chemical alum to clarify the water. Scientists have gained better understanding of sources and effects of drinking water contaminants during the mid to late 1800s. The DWT systems was built in U.S during the early 1900s to focus on drinking water quality mostly on disease that causing microbes in public water supplies. Today, the effective treatment techniques for protecting water supplies from microbes are filtration and chlorination. Other advance treatments technique also was used by some modern DWT plants. Furthermore, the number of treatments technique and combination of techniques was developed to increase the effectiveness of plants (EPA, 2009).

The most commonly used process includes flocculation, filtration, ion exchange, adsorption and disinfection. Flocculation process will combine all small particles in water into large particle which settle out of the water as sediment. Alum and iron salts or synthetic organic polymers are used to promote coagulation. As a result, sedimentation will occurs naturally as flocculated particles settles out the water. Most of DWT plants use filtration process to remove all particles includes natural organic matter, microorganism and silts and clay from water. Filtration will clarifies water and enhances the effectiveness of disinfection. Besides, ion exchange process are used to remove inorganic contaminants that remain in the water. This process can be used to treat hard eater and remove arsenic, chromium, excess fluoride, nitrates, radium and uranium (EPA, 1999).

Adsorption process is used to remove organic contaminants, unwanted colouring and odor causing compounds. All of these contaminants will stick to the surface of granular or powder activated carbon and then are removed from the water. Chlorine or chlorine oxide are used in disinfection process. The water is disinfected before enters the distribution system to ensure that the water is free from dangerous microbes.

DWT plants are just able to reduce the level of trace contaminants to within WHO recommended levels. However, the level of some trace contaminants may occasionally exceed recommended levels. Although the concentrations detected are low, exposure to these contaminants over a long period may pose potential hazards to the health of consumers (Yaziz and Pillay, 1995).

If treatment is not optimized, unwanted residues of chemicals used in water treatment can also cause contamination, and give rise to sediments in water pipes. Drinking water treatment as applied to public water supplies consists of a series of barriers in a treatment train that will vary according to the requirements of the supply and the nature and vulnerability of the source. Broadly these comprise systems for coagulation and flocculation, filtration and oxidation. The most common oxidative disinfectant used is chlorine. This provides an effective and robust barrier to pathogens and provides an easily measured residual that can act as a marker to show that disinfection has been carried out, and as a preservative in water distribution. Tap water contamination is a worldwide distributed problem which deserves large attention due to its risks to the human health and then reduce economic of country (Fawell and Nieuwenhuijsen, 2003).

2.2.3 Man-made Inorganic Water Contaminants

Man-made inorganic contaminants in drinking water give badly effect on health of people living organism (Shy, 1987). Chemicals are classified as one of inorganic contaminants. Man-made chemicals are metals, salts and other compounds that do not contain carbon. These chemicals present in the water because of carelessness and runoff from industrial facilities. Lead is main environmental health treat to children in the United States. Lead that occurs in the drinking water comes from the corrosion of water utility pipes in the distribution system. This element is dangerous to infants, young children and pregnant women's fetuses because it can cause serious illness for example permanent brain damage, increase blood pressure, harm kidney function, affect the nervous system, and damage red blood cells. Beside that, agriculture is another source of chemical contaminations. Nitrate can be found in most of fertilizers that used in agriculture. Nitrate can cause methaemoglobinaemia, or blue-baby syndrome, in bottle-fed infants under 3 months of age. Exposure to high levels of nitrates in water can cause shortness of breath, nausea, vomiting, diarrhea, lethargy, loss of consciousness and even death to the infants.

Several studies have been done on the heavy metals contaminant in drinking water. Many heavy metals cause nervous-system damage, with resulting learning disorder in children. Ingestion of mercury can cause the severe breakdown of the nervous system, and metals such as lead and nickel can cause autoimmune reactions. Pb, Zn, Cu, Mn, Co, Ni, Cd, Cr, and Mo are toxigenic and carcinogenic agents consistently found as contaminants in human drinking water supplies in many areas around the world (Groopman et al., 1985).

Most of diseases that occur due to the drinking water is diarrhoeal diseases. Over 90% of deaths from diarrhoeal diseases in the developing world today occur in children under 5 years old. Malnutrition, especially protein-energy malnutrition, can decrease the children's resistance to infections, including water-related diarrheal diseases. In 2000-2003, 769,000 children under five years old in sub-Saharan Africa died each year from diarrheal diseases. As a result of only thirty-six percent of the population in the sub-Saharan region having access to proper means of sanitation, more than 2000 children's lives are lost every day. In South Asia, 683,000 children under five years old died each year from diarrheal disease from 2000-2003. During the same time period, in developed countries, 700 children under five years old died from diarrheal disease. Improved water supply reduces diarrhea morbidity by twenty-five percent and improvements in drinking water through proper storage in the home and chlorination reduce diarrhea episodes by thirty-nine percent (WHO and UNICEF, 2005).

2.3 SIGNIFICANCE OF STUDY

The communities' health depends on the availability of a safe drinking water supply. In some parts of this country, drinking water is a limited resource, while in other areas abundant water supplies are available. Increasing water demands from a growing population economic expansion and increasing use per capita leading to proper management and protection of this resource. Both community and private sources of drinking water are risk to different chemical contaminants, biological pollutants and nuisance water problems that may vary depending on site conditions and other factors. Some of the more common chemical pollutants include pesticides, fertilizers, petroleum products, and industrial solvents. Some problem organisms, including viruses, bacteria, protozoa and algae, cause nuisance problems with taste and odor while others are potential pathogens. United State Environment Protection Agency (EPA) has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. So, it is important to aware the community about the quality of water.

2.4 DRINKING WATER STANDARD

Drinking water quality at Kuantan's area is determined based on National Drinking Water Quality Standard (NDWQS).

Table 2.1: National Drinking Water Quality Standard (revised December 2000)

Group	Parameters	Unit	Benchmark	
			Min	Max
I	Total Coliform	MPN	Absent	Absent
	E.Coli	-	Absent	Absent
	Turbidity	NTU	0	5
	Colour	TCU	0	15
	pH	Unit	7	9
	Residue chlorine	mg/L	0	5
	Total chlorine	mg/L	0	1
II	Total dissolved solids	mg/L	0	1000
	Biological oxygen demand	mg/L	-	-
	Chemical oxygen demand	mg/L	-	-
	Total organic carbon	mg/L	-	-
	Chloride	mg/L	0	250
	Anionic detergent MBAS	mg/L	0	1
	Ammonia	mg/L	0	1.5
	Nitrate	mg/L	0	10
	Iron	mg/L	0	0.3
	Fluoride	mg/L	0.4	0.6
	Hardness	mg/L	0	500
	Aluminium	mg/L	0	0.2
	Manganese	mg/L	0	0.1
III	Mercury	mg/L	0	0.001
	Cadmium	mg/L	0	0.003
	Arsenic	mg/L	0	0.01
	Cyanide	mg/L	0	0.07
	Lead	mg/L	0	0.01
	Chromium	mg/L	0	0.05
	Copper	mg/L	0	1
	Zinc	mg/L	0	3
	Sodium	mg/L	0	200

Table 2.1: Continued

Group	Parameters	Unit	Benchmark	
			Min	Max
	Sulphate	mg/L	0	250
	Mineral oil	mg/L	0	0.3
	Phenol	mg/L	0	0.002
IV	Aldrin/dieldrin	mg/L	0	0.00003
	DDT	mg/L	0	0.002
	Heptachlor & Heptachlor poxide	mg/L	0	0.00003
	Methoxychlor	mg/L	0	0.02
	Lindane (BHC)	mg/L	0	0.002
	Chlordane	mg/L	0	0.002
	Hexachlorobenzene	mg/L	0	0.001

CHAPTER 3

METHODOLOGY

3.1 EXPERIMENTAL DESIGN

3.1.1 Experimental Variable/ Parameters

The water quality measures are classified into physicochemical includes anions, heavy metals, organic and inorganic.

3.1.1.1 pH

pH value or the "potential of hydrogen", is a measure of the concentration of hydrogen ions in the water. pH value indicates the acidity or alkalinity of the water. The pH of pure water is 7 which is neutral. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is basic. The pH of the water is important, because it affects the solubility and availability of nutrients, and how they can be utilized by aquatic organisms (Addy et al., 2004). For this study, pH was determined on in-situ measurement using sampling field kit.

3.1.1.2 Hardness

Hard water is water that has high mineral content which is high concentrations of Ca^{2+} and Mg^{2+} ions. Determination of hardness in water is to measure the amount of minerals which is Ca^{2+} and Mg^{2+} in water. Hard water causes scaling which is the precipitation of minerals, called lime scale. At higher concentration hardness can cause problems to consumer for example:

i. Soap scum on tubs and showers will obviously occur.
ii. White mineral deposits will occur on dishes and more noticeable on clear glassware.
iii. Accumulation of hardness can reduce the heat transfer efficiency, because it will act like insulation and reducing the efficiency of heat transfer.

Water hardness is reported as mg calcium carbonate per liter of water (mg/L). The water is classified based on hardness scale:

Table 3.1: Classification of hardness

Concentration(mg $CaCO_3$/L)	**Classification**
0-75	soft
75-150	moderately hard
150-300	hard
> 300	very hard

3.1.1.3 Total Dissolve Solid (TDS)

Dissolved solids refer to any minerals, salts, metals, cations or anions dissolved in water. Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in water. TDS in drinking-water is a measure of the amount of dissolved solids that are in solution. This is an indicator of nonpoint source pollution problems associated with various land use practices. The TDS measurement is expressed in (mg/L).

3.1.1.4 Anions

a) Fluoride

Fluoride can enter drinking water from natural resources. Fluoride is also added to public drinking water supplies to prevent tooth decay. Fluoridation of public drinking water system is the last segment in the process of turning raw water from the river into potable water suitable for human consumption. Before the processed water is sent into holding tanks, fluoride in the form of sodium fluoride (NaF) or hydrofluoric acid (HF) is added into the water. (Shaharuddin et al.,2009). In high concentration, fluoride can cause toxic.

b) Chloride

Almost all natural waters contain chloride ions even though its have different concentrations according to the mineral content found in the earth. Water that contains chloride ion has briny and brackish taste. Usually chloride concentrations found in water supplies are low and only give problems in large concentrations. The taste threshold of the chloride anion in water is dependent on the associated cation. Chloride in surface and groundwater from both natural and anthropogenic sources, such as the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas.

c) Nitrates

Nitrate (NO_3) is a water-soluble molecule consists of nitrogen and oxygen. Nitrogen from ammonia or other sources will combines with oxygenated water to formed nitrate. Nitrate is a natural element of plants and is found in vegetables at different levels depending on the amount of fertilizer applied and on other growing conditions. Water naturally contains less than 1 milligram of nitrate-nitrogen per liter and is not a major source of exposure. The water is contaminated in high level concentration of nitrates. Common sources of nitrate contamination come from fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris.

d) Sulphate

Sulphates occur naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4 \cdot 7H_2O$) and gypsum ($CaSO_4 \cdot 2H_2O$) (Greenwood and Earnshaw, 1984). These dissolved minerals contribute to the mineral content of many drinking-waters. Sulphates and sulphuric acid products are used in the production of fertilizers, chemicals, dyes, glass, paper, soaps, textiles, fungicides, insecticides, astringents and emetics. They are also used in the mining, wood pulp, metal and plating industries, in sewage treatment and in leather processing (Greenwood and Earnshaw, 1984). Aluminium sulphate (alum) is used as a sedimentation agent in the treatment of drinking-water.

e) Phosphate

Water treatment facilities may add phosphate to tap water to prevent pipe corrosion and reduce concentrations of heavy metals in drinking water. Tap water is chemically treated with chlorine, soluble silicates, phosphate polymers and many other chemicals. In addition, the source water itself may contain a variety of contaminants, including phosphates from fertilizer and manure on eroded farmland and from laundry detergent accumulating in sewage runoff.

3.1.1.5 Heavy Metals

Heavy metals are inorganic chemical elements with relatively high density and are toxic even at low concentrations. Heavy metals are natural components of the Earth's crust which is cannot be degraded or destroyed. Heavy metals enter our bodies via food, drinking water and air in small amount. As trace elements, some heavy metals are essential to maintain the metabolism of the human body. However, they can lead to poisoning at higher concentration from drinking-water contamination high ambient air concentrations near emission sources, or intake via the food chain. Heavy metals are dangerous because they tend to bio accumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater. water For this study, three heavy metals are measured which is lead (Pb), copper (Cu) and cadmium (Cd). Table 3.2 shows sources of heavy metals in drinking water.

Table 3.2: Sources of heavy metals in drinking water

Heavy Metals	**Sources of Contaminant in Drinking Water**
Lead (Pb)	Corrosion of household plumbing systems; erosion of natural deposits
Copper (Cu)	Copper pipes, as well as from additives designed to control algal growth.
Cadmium (Cd)	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints.

3.1.1.6 Organic and Inorganic

i. Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite by a strong chemical oxidant.

ii. Biological Oxygen Demand (BOD)

Biological Oxygen Demand is a measure of quantity oxygen that was used by microorganisms in the aerobic oxidation, or breakdown of organic matter in the streams. Usually, the higher the amount of organic material found in the stream, the more oxygen is used for aerobic oxidation. This will reduce the amount of dissolved oxygen available to other aquatic life. This measurement is obtained over a period of five days, and is expressed in mg/L.

3.1.2 Sampling Design and Method

3.1.2.1 Study Area

Kuantan, located 250 km. away from the central capital of Kuala Lumpur is a state capital of Pahang Darul Makmur. It is situated on the east coast of Peninsular Malaysia and located approximately 3°53’ North and 103°21’ East in the tropical rain forest country. Kuantan’s temperature is between 24°C and 34°C throughout the year and receives high rainfall in the Monsoon Season (from October to January). The topography of Kuantan is low and gentle at the coastal areas and undulating and hilly in the west bound. The total population of Kuantan is increasing from 255, 974 people at year 1991 to 358,261 at year 2000. It will be expected to increase 503,450 people by the year 2010. The growth of population will increase the drinking water demand. The major sources of potable water in Kuantan are Kuantan River and underground. Eleven separate water treatment plants was built Bukit Ubi, Pasir Kemudi, Bukit Goh, Kampung Pandan, Paya Bungor, Kuala Kenau, Kampung Kolek, Bukit Kunin, Kampung Penor, Alur Batu, and Semambu. The Bukit Ubi and Semambu treatment plants together supply more than 90.0 percent of the water demand in the district of Kuantan. A total six sampling points in Kuantan’s area were select in determining the location for water sampling that represents the state of study location.

Table 3.3: Location of drinking water monitoring stations

Stations	Locations
1	UMP Gambang
2	Gambang
3	Sungai Lembing
4	Jaya Gading
5	Permatang Badak
6	Kuantan

Figure 3.1: Drinking water monitoring stations

3.1.2.2 Sample Preservation Techniques

Sample water was collected using pre-cleaned plastic and glass container. The sample containers were cleaned and rinsed with diluted acid and deionised water before run the sampling. The collected samples is identified with unique sample numbers, efficiently tracked in the field and stored in a secure location for the preservation of sample integrity and transferred to the laboratory. Each sample has its own sample IDs and is recoded on sample labels together with the information related to sampling and analysis, such as the following:

i. Sampling point ID
ii. Date and time of sampling
iii. Sampler's name
iv. Chemical preservation method

Sample Tracking Log was also keep for this study and ties together the following field and laboratory information that is vital for data review, data management, and report preparation. Sample tracking log should consist:

i. Field sample ID
ii. Sample collection date
iii. Sample location (soil boring, depth, monitoring well, grid unit, etc.)
iv. Sampler's name
v. Sample matrix
vi. Requested analysis
vii. Sample type (field sample, field duplicate, equipment blank)

Sample preservation is important to minimize the degradation of contaminant concentrations in samples and assure the 'collected sample' representativeness. Although complete sample preservation is practically impossible, a significant reduction in contaminant degradation rates can be achieved by using proper sample containers; preserving samples with chemicals; keeping them refrigerated; and by observing the holding time requirements. Table 3.3 shows the sample storage and preservation for drinking water sample.

Table 3.4: Sample storage and preservation

Determination	Container	Preservation	Maximum Storage
Hardness	Plastics	Add HNO_3 to pH< 2	0.50
Alkalinity	Plastics	Refrigerate at 4 ºC	24 hours
pH	Plastics	Analyse immediately	0.25 hours
Anions	Plastics	Refrigerate at 4 ºC	-
Heavy metals	Plastics	Add HNO_3 to pH< 2	-
COD	Glass	Analyse as soon as possible or Add HNO_3 to pH< 2, Refrigerate at 4 ºC	7 days
BOD	Glass	Refrigerate at 4 ºC	6 hours

3.1.2.3 Tap Water Sampling

The water from tap was sampling to determine the drinking water quality. A water sample collected from a tap must accurately represent the water in the pipes and in the other elements of a water distribution system. Once samples are collected in their respective containers avoid prolonged exposure to the sun. Samples were kept into the carriage containers and delivered as soon as possible to the laboratory.

For the sampling procedures, first a tap which is most frequently used was chosen. Any external fittings, such as filters and other contaminants (e.g. grease, slime, sediment build-up etc) around the spout, was removed with a clean cloth. Before taking the sample, tap outlets which are suspected to be contaminated must be disinfected first. Disinfect by swabbing the outside of the tap and as much of the inside as possible with a 0.1% sodium hypochlorite solution. Then, allow it to stand for a few minutes (to allow full disinfection) before proceeding to the next step. Sodium hypochlorite is a strong oxidizing agent and is highly corrosive. It was handled with great care and wears appropriate PPE (gloves, safety glasses). Next, the tap was turn on to a steady stream and run for at least 2-3 minutes to remove any stagnant water in the plumbing network. Then, the water sample was collected into the sampling bottle.

In Situ measurement is used to determine some parameter such as pH, dissolve oxygen and total dissolve solid in drinking water using portable pH meter kits. These parameters have to measures on the spot to minimize the contamination of water before sample is taking to the laboratory.

Figure 3.2: In Situ measurement

3.1.3 Data Collection (Measurement) Method

Table 3.5: Analytical method for parameters

Parameters	Analytical Method/ Instruments	Method
pH	pH meter kit	
Total dissolve solid (TDS)	pH meter kit	
Hardness	Titration using a standard ethylene diamine tetraacetic acid (EDTA) solution	EPA 130.2
Anions	Ion Chromatography	EPA 300.0
Heavy metals	Atomic Absorption Spectrometer	
COD	Titration using standard ferrous ammonium sulfate	
BOD	DO meter (DO testing after the 5-day incubation period)	

3.1.4 Data Evaluation and Analysis Methods

In environmental chemical data collection, the purpose of field implementation is to collect representative samples for the production of valid and relevant data. To be representative, the samples must have all of the following attributes:

i. Be collected from the sampling points selected in the course of a systematic planning process
ii. Be collected according to appropriate sampling procedures
iii. Be unaffected by ambient contamination and cross-contamination from other samples
iv. Be placed in proper sampling containers and correctly preserved
v. Have a traceable custody chain and reliable field records.

3.2 EQUIPMENTS AND INSTRUMENTS

Table 3.6: List of equipments and instruments

Parameters	**Instruments and Equipments**
pH	pH meter kit
Hardness	Burette, pipettes, Erlenmeyer flask, volumetric flasks and retort stand
Total dissolve solid (TDS)	pH meter kit
Anions	Ion Chromatography, micropipettes, volumetric flasks, beakers.
Heavy metals	Atomic Absorption Spectrometer , volumetric flasks, beakers, micropipettes
COD	Reflux apparatus, round bottom flask, condenser, heating mantel, conical flask, burette, pipettes
BOD	DO meter, glass bottle.

3.3 PROCEDURE

3.3.1 Procedure to Determine Hardness in Drinking Water

Water hardness was determined using titration method. Standard laboratory titrimetric equipment was used in this experiment. Six reagents was prepared which is buffer solution, Eriochromate Black T indicator, Standard EDTA titrant, 0.02 N, Methyl red indicator, Standard calcium solution 0.02 N and Ammonium Hydroxide.

To prepare the buffer solution, 16.9 g NH_4Cl was dissolved in 143 mL conc. NH_4OH in a 250 mL volumetric. 1.25 g of magnesium salt of EDTA was add and dilute to the mark with distilled water. Eriochromate Black T indicator was prepared by mixed 0.5 g Eriochromate Black T with 4.5 g hydroxylamine hydrochloride and the solution was dissolve in 100 mL of 95 % ethanol. For standard EDTA titrant, 0.02 N, 3.723 g analytical reagent grade disodium ethylenediamine tetraacetate dihydrate, $Na_2H_2C_{10}H_{12}O_8N_2.2H_2O$ was placed in a 1 liter volumetric flask and dilute to the mark with distilled water.

Methyl red indicator was prepared by dissolved 0.10 g methyl red in distilled water in a 100 mL volumetric flask and the solution was diluted to the mark. To prepare standard calcium solution 0.02 N, 1.000 g anhydrous calcium carbonate (primary standard low in metals) was placed in a 500 mL flask. A little HCl was added until all of the $CaCO_3$ has dissolved. 200 mL of distilled water was added. The solution was boiled for a few minutes to expel carbon dioxide. Cool. A few drops of methyl red indicator was add and adjust to intermediate orange color by adding 3N NH_4OH or HCl. While for Ammonium Hydroxide, 1 N, 70 mL of conc. NH_4OH was diluted to 1 liter with distilled water.

First, standardization for titration was done. 10.0 mL standard calcium solution was placed in vessel containing about 50 mL distilled water. Then, 1 mL buffer solution and 1-2 drops indicator was added. The solution was titrate slowly with continuous stirring until the last reddish tinge disappears. At end point the color is blue. Total titration duration should be 5 minutes from the time of buffer addition. Normality of EDTA was calculated using equation 3.1.

$$N\ of\ EDTA\ = \frac{0.2}{mL\ of\ EDTA} \tag{3.1}$$

N = normality of EDTA

Second, 25.0 mL sample was placed in titration vessels, neutralize with 1 N ammonium hydroxide and diluted to about 50 mL. Then, 1 to 2 mL buffer solution was added and followed by 2 drops of Eriochromate Black T indicator. Next, the solution was titrate slowly with continuous stirring with standard EDTA titrant until last reddish tint disappears. Solution is blue at end point. $CaCO_3$ concentration which represents water hardness was calculated using equation 3.2.

Calculations:

$$Hardness\ (EDTA)mg\,\frac{CaCO}{L} = \frac{A \times N \times 5000}{sample} \tag{3.2}$$

where:

A = mL EDTA titrant

N = normality of EDTA titrant

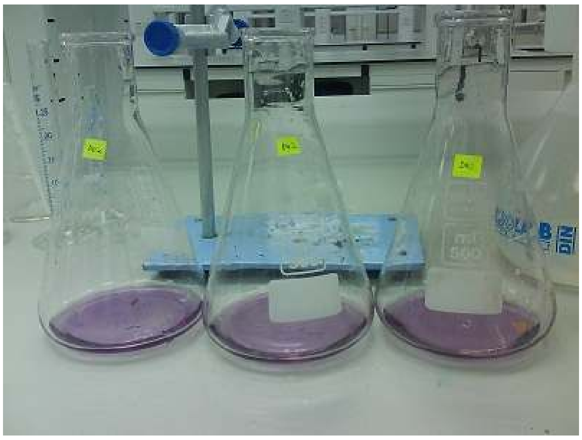

Figure 3.3: Before titration with EDTA

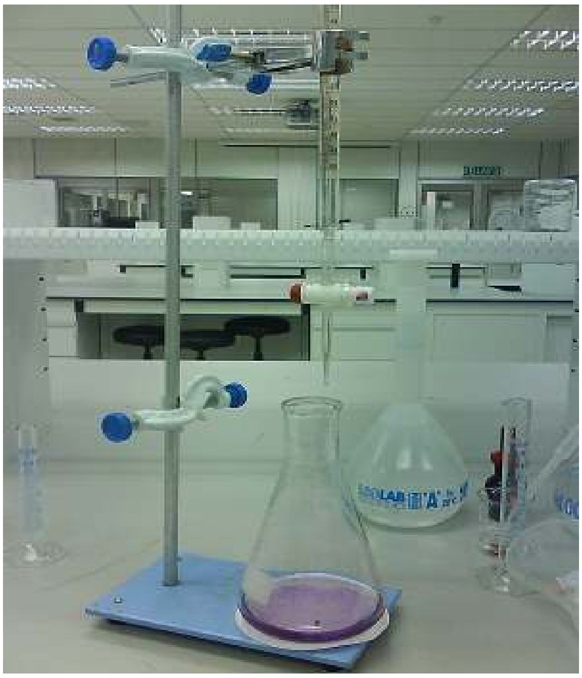

Figure 3.4: The solution is titrated with EDTA

Figure 3.5: Solution is blue in color at end point.

3.3.2 Procedure to Determine Chemical Oxygen Demand in Drinking Water

Chemical oxygen demand of drinking water sample was determined using reflux apparatus. The reagents were prepared by following these procedures:

i. Standard potassium dichromate solution (0.250 N): 12.259 g $K_2Cr_2O_7$, primary standard grade, previously dried at 103°C for two hours and was dissolved in distilled water and dilute to 1000 mL.
ii. Sulphuric acid reagent: Conc. H_2SO_4 containing 23.5 g silver sulphate, Ag_2SO_4, per 4.09 kg bottle. With continuous stirring, the silver sulphate may be dissolved in about 30 minutes.
iii. Standard ferrous ammonium sulphate (0.25 N): 98.0 g Of $Fe(NH_4)_2(SO_4)_2$ $.6H_2O$ was dissolved in distilled water. 20 mL of conc. H_2SO_4 was added, cool and dilute to 1 liter. This solution must be standardized daily against standard $K_2Cr_2O_7$ solution.
iv. Mercuric sulphate: Powdered $HgSO_4$.
v. Silver sulphate: Powdered Ag_2SO_4.
vi. Ferroin indicator solution

Firstly, standard ferrous ammonium sulphate (0.25 N) was standardize. 200 mL of distilled water was added into 25.0 mL of 0.25 N $K_2Cr_2O_7$ solution. Then, 200 mL of distilled water was added into 25.0 mL of 0.25 N $K_2Cr_2O_7$ solution. 20 mL of H_2SO_4 was added and cool. After that, the solution was titrate with ferrous ammonium sulfate using 3 drops of ferroin indicator. The color change was sharp, going from blue-green to reddish-brown. Normality was calculated using equation 3.3.

$$Normality = \frac{(mL\ K_2Cr_2O_7)(0.25)}{mL\ Fe(NH_4)_2\ (SO_4)_2} \tag{3.3}$$

Secondly, to analyse the sample, several boiling stones was placed in the reflux flask, followed by 50.0 mL of sample or an aliquot diluted to 50.0 mL and 1 g of $HgSO_4$. 5.0 mL conc. $H2SO_4$ was added and swirled until the mercuric sulfate has dissolved. Reflux flask was placed in an ice bath and slowly with swirling, 25.0 mL of 0.025 N $K_2Cr_2O_7$ was added. Then, 70 mL of sulfuric acid-silver sulfate solution was add to the cooled reflux flask, again using slow addition with swirling motion. Care must be taken to assure that the contents of the flask are well mixed. If not, superheating may result, and the mixture may be blown out of the open end of the condenser.

Heat was apply to the flask and reflux for 45 minutes. The flask was allowed to cool and wash down the condenser with about 25 mL of distilled water. Next, the mixture was transferred to a 500 mL Erlenmeyer flask. 3 drops of ferroin indicator was added to the solution. After that, the solution was titrated with excess dichromate with 0.25 N ferrous ammonium sulfate solution to the end point. The color change was sharp, changing from a blue-green to a reddish hue. A blank was determination following the same conditions but using distilled water as a sample. Concentration of COD was calculated using equation 3.4.

Calculation

Calculate the COD in the sample in mg/L as follows:

$$COD, \frac{mg}{L} = \frac{\left((A-B)N \; x \; 8000\right)}{S} \tag{3.4}$$

where:

A = milliliters of $Fe(NH_4)_2(SO_4)_2$ solution required for titration of the blank,

B = milliliters of $Fe(NH_4)_2(SO_4)_2$ solution required for of the sample,

N = normality of the $Fe(NH_4)_2(SO_4)_2$ solution, and

S = milliliters of sample used for the test.

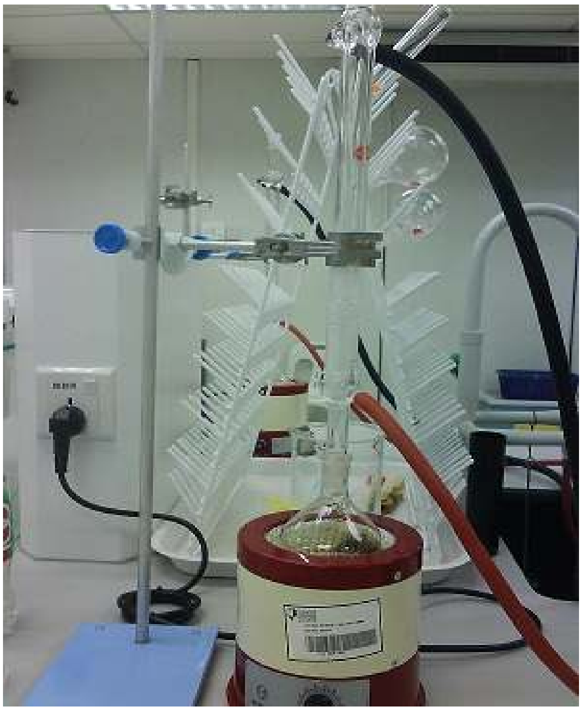

Figure 3.6: Reflux apparatus.

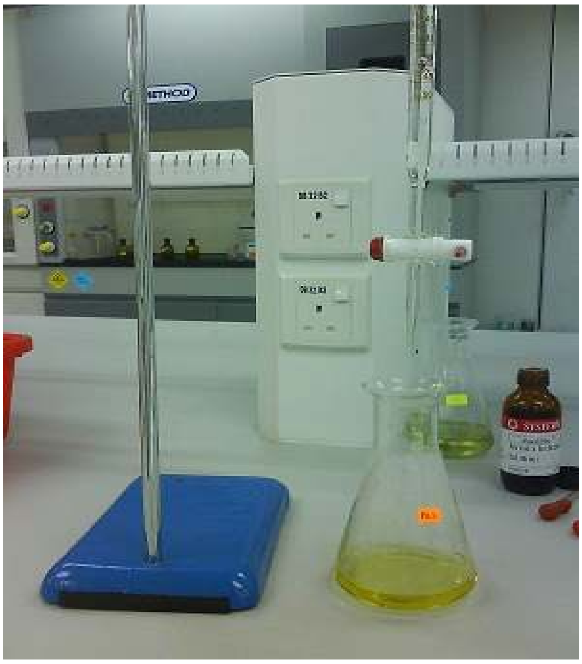

Figure 3.7: Before titration with ferrous ammonium sulphate

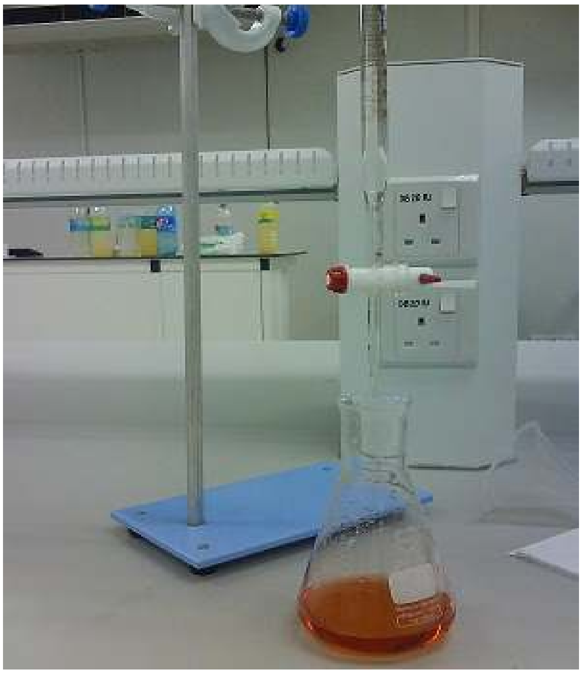

Figure 3.8: The color of solution turn into reddish hue at end point.

3.3.3 Procedure to Determine Heavy Metals in Drinking Water

Heavy metals in drinking water sample were determined using Perkin Elmer Analyst 8000 Atomic Absorption Spectrometer. Standard solution of lead (Pb), cadmium (Cd) and Copper (Cu) was prepared. Standard solution of lead (Pb) was prepared for 4, 8 and 16 ppm, standard solution of cadmium was prepared for 1, 2 and 4 ppm and standard solution of copper was prepared for 2, 4 and 8 ppm. A dropped of hydrochloric acid was added in the standard solution. Then, the spectrometer was set up as described in the operating instructions. The result obtain was used to make calibration curve for each element. From the calibration curve, the concentration of heavy metals was calculated.

3.3.4 Procedure to Determine Anions in Drinking Water

Concentration of anions was determined by using Metrohm Ion Chromatography. Anion eluent was prepared by dissolved 0.1378g of Na_2CO_3 in ultra pure water and then 0.1638g of $NaHCO_3$ was added to the solution. The solution was top up to the mark of 1L volumetric flask. The eluent was degassing for 30 minutes. Suppressor regeneration solution was prepared by pipette 5ml of concentrated H_2SO_4 into 1 litre volumetric flask filled with ultra pure water. The solution was nixed well and top up to the mark.

Standard solutions for chloride, fluoride, nitrate, sulphate and phosphate were prepared for 1, 2 and 5 ppm using following procedures:

i. 100 µL of fluoride standard 1000ppm was pipette with micropipette into 100mL volumetric flask.
ii. 100 µL of each chloride, nitrate, phosphate and sulphate standard 1000ppm was pipette into the same volumetric flask.
iii. The mixture was top up until the mark with Ultra Pure Water (UPW)
iv. Steps (i – iii) were repeated by using 200µL to prepare standard solution 2ppm and 5002µL to prepare standard solution 5ppm.

To analysis the samples, ion chromatography was set up following the standard operation procedure. A small volume of sample, and standards solution typically 2-3 mL, was introduced into an ion chromatography. Result was obtained and calibration standards were prepared. Concentration of anions was calculated using equation 3.5.

Calculation

Calibration curve was prepared for each anions. Sample concentration was calculate using equation of calibration curve

$$Y = mX + C$$

$$X = \frac{(Y-C)}{m} \tag{3.5}$$

where:

X = concentration of anion
m = response slope
Y = sample peak area
C = intercept

Figure 3.9: Metrohm Ion Chromatography

3.3.5 Procedure to Determine Biochemical Oxygen Demand in Drinking Water

Biochemical oxygen demand in water sample was determined using two dissolved oxygen bottles (one clear and one black) which filled with sample water. The dissolved oxygen value for this sample was determined in mg/L. The black sample bottle was placed in the dark and incubates for five days at 20ºC). After five days, the level of dissolved oxygen (in mg/L) of this sample was determined. The BOD level is determined by subtracting this DO level from the DO level found in the original sample taken five days previously.

$$BOD \ = \frac{mg}{L} DO\ (Original\ sample) - \frac{mg}{L} DO\ (after\ incubation) \tag{3.6}$$

CHAPTER 4

RESULT AND DISCUSION

4.1 INTRODUCTION

This chapter explains community drinking water monitoring results that obtained from the field sampling in Kuantan district and their experimental analysis. The results are interpreted using the data recorded. Parameters like pH, dissolved oxygen (DO) and total dissolved solid (TDS) were measured in situ. Hardness and chemical oxygen demand (COD) were determined using titration method. Heavy metals and anions were calculated based on their absorbance and peak area obtained from Atomic Absorption Spectroscopy and Ion Chromatography, respectively. All of the measured parameters for each sampling station are discussed. LOD for Atomic absorption spectrometer and Ion chromatography was obtain from the guidelines of Perkin Elmer atomic absorption spectroscopy (Perkin Elmer, 2004) and Metrohm water analysis (Metrohm, 2009).

4.2 DRINKING WATER QUALITY AT MONITORING STATION 1 (UMP GAMBANG)

Table 4.1 shows the result of drinking water quality parameters measured from first sampling station (UMP Gambang). Based on the physical characteristic analysis from Table 4.1, pH of the water samples was between the ranges from 6.53 to 8.5. The samples were nearly alkaline. Such a high drinking water pH showed that high levels of alkalinity minerals were present in the samples. As a result, they produced an alkaline taste and made the water bitter. High pH in the water also could cause scale build-up in plumbing and lowered efficiency of electric water heaters. The hardness at this sampling point was between 77.5 and 87.1 mg/L. It could be classified as moderately hard water based on hardness scale. TDS within the sample water was from 77.20 to 77.76 mg/L. Sample at this station contains chloride, sulphate, and nitrate ions as much as from 10.54 mg/L, 3.03 mg/L and 0.5 mg/L, respectively.

Meanwhile, COD and BOD were not detected. The concentration of heavy metals in drinking water was below the detection limit. There is also no detection of phosphate in drinking water in this particular sampling site.

4.3 DRINKING WATER QUALITY AT MONITORING STATION 2 (GAMBANG)

Table 4.2 shows the result of drinking water quality parameters measured from second sampling station (Gambang). Based on the in situ measurement, pH of the water samples at this station was ranging from 6.71 to 8.12. It showed that the pH was still within the range of National Drinking Water Standard. In term of water hardness, second sampling stations could be classified as moderately hard as it contained hardness ranging from 96.8 to 100.7 mg/L. The sample water at this station contained TDS from 45.23 to 49.18 mg/L. Besides that, the concentration of chloride was from 3.39 to 10.82mg/L, sulphate from 2.81 to 3.00 mg/L and fluoride 0.04 mg/L. The concentration of nitrate was from 1.75 to 1.76 mg/L. Common sources of nitrates were from agriculture industry. COD value for this sample water is from 0.087 - 0.874 mg/L. The industrial and municipal waste might be the major sources of pollutant.

There was no detection value for BOD. The concentration for heavy metals and phosphate in drinking water samples were below the detection limit.

Table 4.1: Drinking water quality at monitoring station 1 (UMP Gambang)

Parameters	Unit	NDWQS	Sampling				Remarks (LOD)
			sampling 1	**sampling 2**	**sampling 3**	**sampling 4**	
pH	–	6.5 - 9.0	6.53	8.50	8.48	8.00	
Hardness	mg/ L	500	81.3	87.1	77.5	83.3	
Dissolved Oxygen	mg / L	–	6.80	6.58	5.88	7.11	
Total Dissolved Solid	mg/ L	1000	77.76	77.48	76.39	77.20	
COD	mg/ L	25	ND	ND	ND	ND	
BOD	mg/ L	25	ND	ND	ND	ND	
Heavy metals							
Lead (Pb)	mg/ L	0.010	ND	ND	ND	ND	0.015
Copper (Cu)	mg/ L	1	ND	ND	ND	ND	1.5×10^{-3}
Cadmium (Cd)	mg/ L	0.003	ND	ND	ND	ND	8×10^{-4}
Anions							
Fluoride (F)	mg/ L	0.4 - 0.6	0.05	0.05	0.05	0.05	3.7×10^{-4}
Cloride (Cl)	mg/ L	250	11.02	10.14	10.56	10.06	3.3×10^{-4}
Nitrate (NO_3)	mg/ L	10	1.75	1.71	1.74	1.73	9.9×10^{-4}
Sulphate (SO_4)	mg/ L	250	3.04	3.02	3.02	3.03	8.9×10^{-4}
Phosphate (PO_4)	mg/ L	–	ND	ND	ND	ND	8.3×10^{-4}

NWDQS – National Drinking Water Quality Standard for Malaysia

LOD – Limit of Detection

ND – No Detection

Table 4.2: Drinking water quality at monitoring station 2 (Gambang)

Parameters	**Unit**	**NDWQS**	**Sampling**				**Remarks (LOD)**
			sampling 1	**sampling 2**	**sampling 3**	**sampling 4**	
pH	–	6.5 - 9.0	6.71	8.12	6.90	7.40	
Hardness	mg/ L	500	100.7	96.8	96.8	100.7	
Dissolved Oxygen	mg/ L	–	5.85	5.90	6.05	6.70	
Total Disolve Solid	mg/ L	1000	49.18	45.23	47.20	48.67	
COD	mg/ L	25	0.874	0.175	0.087	0.087	
BOD	mg/ L	25	ND	ND	ND	ND	
Heavy metals							
Lead (Pb)	mg/ L	0.01	ND	ND	ND	ND	0.015
Copper (Cu)	mg/ L	1	ND	ND	ND	ND	1.5 x10^{-3}
Cadmium (Cd)	mg/ L	0.003	ND	ND	ND	ND	8 x 10^{-4}
Anions							
Fluoride (F)	mg/ L	0.4 - 0.6	0.04	0.04	0.04	0.04	3.7 x 10^{-4}
Cloride (Cl)	mg/ L	250	10.82	10.00	3.39	5.10	3.3 x 10^{-4}
Nitrate (NO_3)	mg/ L	10	1.75	1.76	1.75	1.75	9.9 x 10^{-4}
Sulphate (SO_4)	mg/ L	250	3.00	2.90	2.81	2.84	8.9 x 10^{-4}
Phosphate (PO_4)	mg/ L	–	ND	ND	ND	ND	8.3 x 10^{-4}

NWDQS – National Drinking Water Quality Standard for Malaysia

LOD – Limit of Detection

ND – No Detection

4.4 DRINKING WATER QUALITY AT MONITORING STATION 3 (SUNGAI LEMBING)

Table 4.3 shows the result of drinking water quality parameters measured from third sampling station (Sungai Lembing). The pH of water samples at this station was lower than the level recommended by NDWQS which was from 6.18 to 6.53. It was slightly acid due to the leaking of metal ion from plumbing fixtures and pipes. The water samples could be classified as soft water and slightly moderate hard due to the concentration of $CaCO_3$ which was from 58.1 to 77.5 mg/L. There was low total dissolve solid in the water at range from 31.83 to 35.37 mg/L. The presence of low concentration of total dissolve solid might be from this mineral that naturally occur in drinking water. Based on the tables, the concentration of chloride was from 5.20 to 7.55 mg/L, sulphate was from 0.07 to 0.47 mg/L, and nitrate was from 0.22 to 1.83 mg/L. Fluoride and phosphate concentration was below the detection limit. While, both of COD and BOD concentration cannot be detected. Heavy metals in the samples was also lower the limit of detection.

4.5 DRINKING WATER QUALITY AT MONITORING STATION 4 (JAYA GADING)

Table 4.4 shows the result of drinking water quality parameters measured from fourth sampling station (Jaya Gading). From the result, pH of this sample was from 6.53 to 8.58. The pH remains within the limit of NWQS. The water samples can be classified as moderately hard due to the concentration of $CaCO_3$ in the water which is from 77.5 to 83.3 mg/L. The total dissolved solid in the water sample was reported from 67.74 to 73.9 mg/L. BOD for this sample was from 0.03 to 0.112 mg/L. It showed that small amount of microorganism might be present in the water. Heavy metals in the samples was lower the limit of detection. Chloride concentration was in the range from 9.78 to 11.60 mg/L, sulphate was from 0.43 to 2.98 mg/L, nitrates was from 1.16 to1.21 mg/L and fluoride was from 1.16 to 1.21 mg/L and 0.05 mg/L. Phosphate concentration was below the detection limit. There was also no detection for the COD value.

Table 4.3: Drinking water quality at monitoring station 3 (Sungai Lembing)

Parameters	**Unit**	**NDWQS**	**Sampling**				**Remarks (LOD)**
			sampling 1	**sampling 2**	**sampling 3**	**sampling 4**	
pH	–	6.5 - 9.0	6.53	6.18	6.39	6.36	
Hardness	mg/ L	500	77.5	62.0	58.1	69.7	
Dissolved Oxygen	mg/ L	–	2.84	1.83	3.05	2.61	
Total Disolve Solid	mg/ L	1000	31.83	35.37	32.71	34.30	
COD	mg/ L	25	ND	ND	ND	ND	
BOD	mg/ L	25	ND	ND	ND	ND	
Heavy metals							
Lead (Pb)	mg/ L	0.01	ND	ND	ND	ND	0.015
Copper (Cu)	mg/ L	1	ND	ND	ND	ND	1.5 x10^{-3}
Cadmium (Cd)	mg/ L	0.003	ND	ND	ND	ND	8 x 10^{-4}
Anions							
Fluoride (F)	mg / L	0.4 - 0.6	ND	ND	ND	ND	3.7 x 10^{-4}
Cloride (Cl)	mg/ L	250	7.55	5.20	6.88	5.45	3.3 x 10^{-4}
Nitrate (NO_3)	mg/ L	10	0.23	1.83	0.26	0.22	9.9 x 10^{-4}
Sulphate (SO_4)	mg/ L	250	0.47	0.38	0.45	0.07	8.9 x 10^{-4}
Phosphate (PO_4)	mg/ L	–	ND	ND	ND	ND	8.3 x 10^{-4}

NWDQS – National Drinking Water Quality Standard for Malaysia

LOD – Limit of Detection

ND – No Detection

🟥 Parameters lowered than NWQS

Table 4.4: Drinking water quality at monitoring station 4 (Jaya Gading)

Parameters	**Unit**	**NDWQS**	**Sampling**				**Remarks (LOD)**
			sampling 1	**sampling 2**	**sampling 3**	**sampling 4**	
pH	–	6.5 - 9.0	6.53	7.93	8.12	8.58	
Hardness	mg/ L	500	81.3	77.5	83.3	77.5	
Dissolved Oxygen	mg/ L	–	5.81	5.43	5.63	6	
Total dissolved Solid	mg/ L	1000	67.74	73.9	68.64	69.24	
COD	mg/ L	25	ND	ND	ND	ND	
BOD	mg/ L	25	0.03	0.021	0.02	0.112	
Heavy metals							
Lead (Pb)	mg/ L	0.01	ND	ND	ND	ND	0.015
Copper (Cu)	mg/ L	1	ND	ND	ND	ND	1.5×10^{-3}
Cadmium (Cd)	mg/ L	0.003	ND	ND	ND	ND	8×10^{-4}
Anions							
Fluoride (F)	mg/ L	0.4 - 0.6	0.05	0.05	0.05	0.05	3.7×10^{-4}
Cloride (Cl)	mg/ L	250	11.60	11.04	10.77	9.78	3.3×10^{-4}
Nitrate (NO_3)	mg/ L	10	1.21	1.17	1.16	1.20	9.9×10^{-4}
Sulphate (SO_4)	mg/ L	250	2.98	2.88	2.82	0.43	8.9×10^{-4}
Phosphate (PO_4)	mg/ L	–	ND	ND	ND	ND	8.3×10^{-4}

NWQS – National Water Quality Standard for Malaysia

LOD – Limit of Detection

ND – No Detection

4.6 DRINKING WATER QUALITY AT MONITORING STATION 5 (PERMATANG BADAK)

Table 4.5 shows the result of drinking water quality parameters measured from fifth sampling station (Permatang Badak). pH for water sample at fifth sampling stations was 6.5. The pH could be considered nearly neutral. Water sample at this station could be classified as soft water due to the low concentration of $CaCO_3$ in the water which was from 42.6 to 58.1 mg/L. TDS in the samples was from 46.53 to 52.48 mg/L. There was no detection for COD value but BOD value for this sample water was from 0.52 to 1.14 mg/L due to the microorganism activities in the water. No detection was displayed for heavy metals concentration. Generally, anions concentrations in the water sample was found in a decreasing sequence of $Cl > SO_4 > NO_3$. While the concentration of fluoride and phosphate cannot be detected.

4.7 DRINKING WATER QUALITY AT MONITORING STATION 6 (KUANTAN)

Table 4.6 shows that the pH was from 6.47 to 7.13 which was alkali. The sample water could be classified as moderately hard due to high concentration $CaCO_3$ in the water which was from 96.8 to 102.6 mg/L. From in-situ measurement, TDS for this sample water was from 59.00 to 61.59 mg/L. COD value in the water sample was from 4.106 to 4.63 mg/L while there was no detection for BOD value. Chloride concentration was found higher than other anions which was from 9.83 to 10.14 mg/L, followed by sulphate concentration which was from 2.77 to 2.91 mg/L, nitrate was from 1.50 to 1.72 mg/L, and fluoride was 0.42 mg/L . There was also no detection of phosphate.

Table 4.5: Drinking water quality at monitoring station 5 (Permatang Badak)

parameters	Unit	NDWQS	Sampling				Remarks (LOD)
			sampling 1	sampling 2	sampling 3	sampling 4	
pH	–	6.5 - 9.0	6.5	6.6	6.5	6.5	
Hardness	mg/ L	500	42.6	46.5	58.1	54.2	
Dissolved Oxygen	mg/ L	–	6.41	6.61	6.02	6.64	
Total Disolve Solid	mg/ L	1000	51.35	52.48	48.49	46.53	
COD	mg/ L	25	ND	ND	ND	ND	
BOD	mg/ L	25	1.14	1	1.1	0.52	
Heavy metals							
Lead (Pb)	mg/ L	0.01	ND	ND	ND	ND	0.015
Copper (Cu)	mg / L	1	ND	ND	ND	ND	1.5×10^{-3}
Cadmium (Cd)	mg / L	0.003	ND	ND	ND	ND	8×10^{-4}
Anions							
Fluoride (F)	mg / L	0.4 - 0.6	ND	ND	ND	ND	3.7×10^{-4}
Cloride (Cl^-)	mg /L	250	9.36	8.90	8.08	6.67	3.3×10^{-4}
Nitrate (NO_3)	mg/ L	10	1.74	1.74	1.75	1.74	9.9×10^{-4}
Sulphate (SO_4)	mg / L	250	2.92	2.90	2.92	2.92	8.9×10^{-4}
Phosphate (PO^{3-}_4)	mg/ L	–	ND	ND	ND	ND	8.3×10^{-4}

NWQS – National Water Quality Standard for Malaysia

LOD – Limit of Detection

ND – No Detection

Table 4.6: Drinking water quality at monitoring station 6 (Kuantan)

Parameters	Unit	NDWQS	Sampling				Remarks (LOD)
			sampling 1	sampling 2	sampling 3	sampling 4	
pH	–	6.5 - 9.0	7.13	6.47	6.56	6.90	
Hardness	mg/ L	500	96.8	102.6	98.7	96.8	
Dissolved Oxygen	mg/ L	–	6.29	6.47	5.94	6.15	
Total Disolve Solid	mg/ L	1000	61.59	59.28	60.85	59.00	
COD	mg/ L	25	4.63	4.106	4.193	4.368	
BOD	mg/ L	25	ND	ND	ND	ND	
Heavy metals							
Lead (Pb)	mg/ L	0.01	ND	ND	ND	ND	0.015
Copper (Cu)	mg/ L	1	ND	ND	ND	ND	1.5×10^{-3}
Cadmium (Cd)	mg/ L	0.003	ND	ND	ND	ND	8×10^{-4}
Anions							
Fluoride (F)	mg/ L	0.4 - 0.6	0.42	0.42	0.42	0.42	3.7×10^{-4}
Cloride (Cl)	mg/ L	250	10.14	10.01	9.83	9.97	3.3×10^{-4}
Nitrate (NO_3)	mg/ L	10	1.50	1.72	1.72	1.52	9.9×10^{-4}
Sulphate (SO_4)	mg/ L	250	2.77	2.91	2.79	2.88	8.9×10^{-4}
Phosphate (PO_4)	mg/ L	–	ND	ND	ND	ND	8.3×10^{-4}

NWQS – National Water Quality Standard for Malaysia

LOD – Limit of Detection

ND – No Detection

4.8 SUMMARY

Conclusion, the concentration of contaminants in drinking water at Kuantan and Gambang's area was low and it could be considered as safe because the concentration was below the level recommended in National Drinking Water Quality Standard. Seven monitoring stations showed that pH were in alkali and neutral condition but pH at station 3 (Sungai Lembing) water was slightly acidic due to some organic acid, such as humic and fulvic acids. Overall, drinking water sample at Kuantan's area could be classified as moderately hard because of the lithology at Kuantan is podsolic and limestoned. The concentration of anions in the samples was found in decreasing sequence of $Cl > SO_4 > NO_3 > F > PO_4$. Chloride has the highest concentration in water samples compare to sulphate, nitrate, fluoride and phosphate. Excess of chloride might be accumulated in drinking water samples due to the chlorine that used in disinfection process of drinking water treatment. Sulphate might be occurred due to the uses of aluminium sulphate as sedimentation agent in drinking water treatment. Fluoride also has been used in drinking water treatment before it was sent to holding tank. The presence of nitrate might come from fertilizer in agriculture industry. Accumulation of anion concentration can occur after many year operations of drinking water treatment.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Monitoring of drinking water quality at Kuantan's area has been done at six stations. Eight parameter were measured which is pH, hardness, dissolved oxygen, total dissolved solid, chemical oxygen demand, biological oxygen demand, heavy metals and anions. The drinking water sampling has been done four times in a month. In-situ measurement has been applied to determine pH, dissolved oxygen and total hardness. Other parameters were determined by experiment analysis in laboratory. Water pH at Kuantan's area was slightly alkaline, while at Station 3 was slightly acidic. Drinking water at Kuantan's can be classified as moderately hard, because the lithology of Kuantan is podsolic and limestoned. Some concentration of parameter studied, i.e. heavy metals, chemical oxygen demand and biological oxygen, cannot be detected. The concentration of anions in the samples was found in a decreasing sequence of $Cl > SO_4 > NO_3 > F > PO_4$. The results confirmed the quality requirements of the National Drinking Water Quality Standard. The concentration of contaminants in drinking water at Kuantan and Gambang's area was low and, therefore, it could be considered as safe drinking water.

5.2 RECOMMENDATION

Drinking water quality monitoring is important to make sure the quality of drinking water is safe and within the level in National Drinking Water Quality Standards that recommended by Ministry of Health. More studies on the drinking water quality should be conducted periodically in order to evaluate the influence of man-made activities and drinking water treatment plants on the drinking water sources. Based on National Drinking Water Quality Standards, there are many parameters that can be detected to determine the quality of drinking water. To improve this study, parameters like microbiology, pesticides and toxic contaminants can be determine. The duration time of monitoring should be longer to get the most accurate result. More advance technology should be used to determine the parameters. This technology can minimize the monitoring works and obtain the most accurate result because it can limit the human error and sources of uncertainty. Monitoring design and operation should be improved to detect the biological and chemical threats and unexpected contaminations. Hopefully, by improvements of this monitoring, a comprehensive database of drinking water at Kuantan district can be provided to ensure the availability of safe drinking water to the population.

REFERENCES

Abouzaid, H. and Echihabi, L. 1995. Drinking water quality and monitoring in North Africa: the Moroccan experience. *The Science of the Total Environment.* **171**: 29-34.

Addy, K., Green, L. and Herron, E. 2004. pH and Alkalinity. *URI Watershed Watch*: **1**.

EPA. 1999. Drinking water treatment. Safe Drinking Water Act. http://www.epa.gov/safewater/faq/treatment.pdf (12 October 2011).

EPA. 2000. The history of drinking water treatment. http://www.epa.gov/safewater/consumer/hist.pdf (12 October 2011).

Fawell, J. and Nieuwenhuijsen, M. J. 2003. Contaminants in drinking water. *British Medical Bulletin*. **68**: 199-208.

Greenwood, N.N. and Earnshaw, A. 1984. *Chemistry of the elements*. Oxford, Pergamon Press.

Groopman, J.D., Wolff, T. and Distlerath, L.M. 1985. Substrate specificity of human liver cytochrome p-450 debrisoquine 4-hydroxylase probe using immunochemical inhibition and chemical modelling. Cancer-Res. **45** (5): 16-22.

Metrohm. 2009. Water analysis. Quality assurance of water. http://water.metrohm.com (2 November 2011)

Perkin Elmer. 2004. Guidance to Inorganic analysis. http://www.perkinelmer.com (2 November 2011)

Shaharuddin, M.S., Kamil, Y.M., Ismail, Y.M., Firuz, R.M., Aizat, I.S. and Yunus, A.M. 2009. Fluoride concentration in Malaysian drinking water. *American - Eurasian J. Agric. & Environ. Sci.* **6** (4): 417 - 420.

Shy, C.M, 1987. Chemical Contamination of Water Supplies. *Environmental Health Perspectives*. **62**. 399 – 406.

WHO and UNICEF. 2005. Water for life: make it happen. *Join monitoring programme for water supply and sanitation.*

WHO. 2008. WHO Guidelines for Drinking Water Quality, Third Edition. Geneva.

Yaziz, M.I. and Pillay, S.M. 1995. Managing potential health risks associated with drinking water supplies: some issues and approaches *Assessing and Managing Health Risks from Drinking Water Contamination: Approaches and Application.* no. **233**.

APPENDIX A

DETERMINATION OF HARDNESS IN DRINKING WATER SAMPLE

DW1 (UMP Gambang)

Table A1: titration of sample using EDTA

	Trial 1	Trial 2	Trial 3
Volume sample used (mL)	50	50	50
Initial buret reading (mL)	0.0	0.0	0.0
Final buret reading (mL)	4.3	4.3	4.0
Volume EDTA used (mL)	4.3	4.3	4.0
Moles EDTA	2.418×10^{-3}	2.418×10^{-3}	2.418×10^{-3}

Calculations

1) To determine water hardness:

Moles of EDTA = (mass of Na_2 EDTA) / (molecular weight of Na_2EDTA)

= (0.9g) / (372.24g/mol)

= 2.418×10^{-3}mol

Molarity EDTA = (moles of EDTA) / (volume of EDTA in liters)

= (2.418×10^{-3}mol) / (250×10^{-3}L)

= 9.672×10^{-3}mol/L

$$\frac{\text{Moles } Ca^{2+} \text{ ion}}{1\text{L}} = \frac{(\text{molarity EDTA})(\text{volume EDTA used in mL})}{\text{mL of unknown sample}}$$

Trial 1 :

$$\frac{\text{Moles } Ca^{2+} \text{ ion}}{1\text{L}} = \frac{(9.672 \times 10^{-3} \text{ mol/L})(4.3 \text{ mL})}{50 \text{ mL}}$$

$$= 8.318 \times 10^{-4} \text{ mol/ L}$$

Trial 2: $\frac{\text{Moles Ca}^{2+}\text{ ion}}{1\text{L}} = \frac{(9.672 \times 10^{-3}\text{ mol/L})(4.3\text{ mL})}{50\text{ mL}}$

$= 8.318 \times 10^{-4}$ mol/ L

Trial 3 : $\frac{\text{Moles Ca}^{2+}\text{ ion}}{1\text{L}} = \frac{(9.672 \times 10^{-3}\text{ mol/L})(4.0\text{ mL})}{50\text{ mL}}$

$= 7.738 \times 10^{-4}$ mol/ L

Summary :

Table A2: Moles of Ca^{2+} in each samples

Trial	Trial 1	Trial 2	Trial 3
Moles Ca^{2+} ion (mol/L)	8.318×10^{-4}	8.318×10^{-4}	7.738×10^{-4}

To calculate hardness, $CaCO_3$:

$$\text{ppm } CaCO_3 = \frac{(\text{mol Ca}^{2+})}{(1\text{L})} \text{ X } \frac{(1\text{mol } CaCO_3)}{(1 \text{ mol Ca2+})} \text{ x } \frac{(100.1\ CaCO_3}{(1\text{mol } CaCO_3)} \text{ x } \frac{(10^3\text{ mg})}{(1\text{g})}$$

Hardness for Trial 1:

$$\text{ppm } CaCO_3 = \frac{(8.318 \times 10^{-4}\text{ mol})}{(1\text{L})} \frac{(1\text{mol } CaCO_3)}{(1 \text{ mol Ca2+})} \frac{(100.1\text{g/mol } CaCO_3)}{(1\text{mol } CaCO_3)} \frac{(10^3\text{ mg})}{(1\text{g})}$$

= 83.3 mg/L or ppm

Table A3: concentration of CaCO3 in each samples

Trial	**Trial 1 (ppm)**	**Trial 2 (ppm)**	**Trial 3 (ppm)**	**Average (ppm)**	**Degree of Hardness**
ppm $CaCO_3$	83.3	83.3	77.4	81.3	Moderately Hard (75-150 ppm)

*Degree of hardness is determine based on Correlation of Water Hardness Values with Degrees of Hardness .

Table A4: Classification of hardness

Mg $CaC0_3$/L Hardness	**Degree of Hardness**
0-75	Soft
75-150	Moderately hard
150-300	Hard
>300	Very hard

Table A5: Hardness at all stations

	Interim National Water Quality Standards For Malaysia(INWQS) (mg/L)	**Sampling 1 (mg/L)**	**Sampling 2 (mg/L)**	**Sampling 3 (mg/L)**	**Sampling 4 (mg/L)**
DW1(UMP)	250	81.3	87.1	77.5	83.3
DW2 (Gambang)	250	100.7	96.8	96.8	100.7
DW3 (Sg. Lembing)	250	77.5	62.0	58.1	69.7
DW4 (Jaya Gading)	250	81.3	77.5	83.3	77.5
DW5 (Permatang Badak)	250	42.6	46.5	58.1	54.2
DW6 (Kuantan)	250	96.8	102.6	98.7	96.8

APPENDIX B

CALCULATION OF ANION CONCENTRATION

Fluoride

Table B1: peak area of standard solutions for fluoride

concentration of standard solution (ppm)	Peak Area (mV.S)
0	0
1	156.735
2	331.233
5	874.946

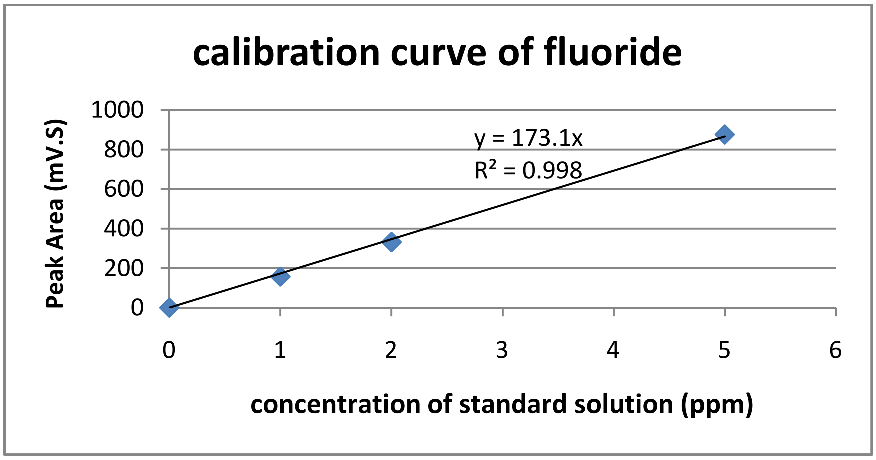

Figure B1: calibration curve of fluoride

sample concentration
$y = mx + c$
$x = (y-c)/m$

y = peak area
x = concentration of sample
m = slope

$m = 173.100$ $c = 0.000$

Table B2: concentration of fluoride for each trial

Sample	Trial 1		Trial 2		Trial 3		average (ppm)
	y	x(ppm)	y	x(ppm)	y	x (ppm)	
DW1	7.821	0.045	7.983	0.046	7.983	0.046	0.046
DW2	6.898	0.040	7.090	0.041	7.215	0.042	0.041
DW3	7.306	0.042	7.693	0.044	7.443	0.043	0.043
DW4	0.000	0.000	0.000	0.000	0.000	0.000	ND
DW5	8.329	0.048	8.685	0.050	8.136	0.047	0.048
DW6	0.000	0.000	0.000	0.000	0.000	0.000	ND
DW7	72.409	0.418	72.943	0.421	72.631	0.420	0.420

Chloride

Table B3: peak area of standard solutions for chloride

concentration of standard solution (ppm)	Peak Area (mV.S)
0	0
1	99.470
2	212.506
5	553.865

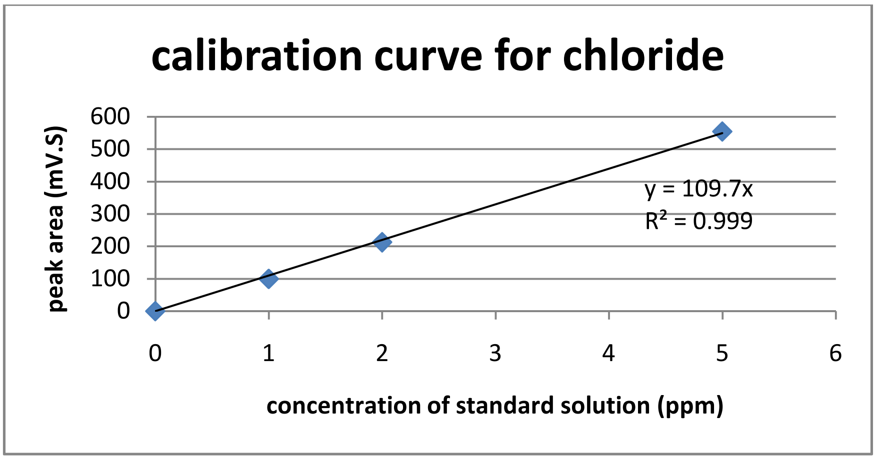

Figure B2: calibration curve of chloride

sample concentration
y = mx + c
x = (y-c)/m

y = peak area
x = concentration of sample
m = slope

m = 109.700 c = 0.000

Table B4: concentration of chloride for each trials

Sample	Trial 1		Trial 2		Trial 3		Average (ppm)
	y	**x(ppm)**	**y**	**x(ppm)**	**y**	**x(ppm)**	
DW1	1350.416	12.310	1073.600	9.787	1201.416	10.952	11.016
DW2	1180.606	10.762	1271.544	11.591	1109.620	10.115	10.823
DW3	900.380	8.208	932.143	8.497	879.245	8.015	8.240
DW4	806.602	7.353	848.890	7.738	7.540	0.069	5.053
DW5	1244.975	11.349	1271.094	11.587	1301.416	11.863	11.600
DW6	1030.223	9.391	1022.353	9.320	1027.430	9.366	9.359
DW7	1112.647	10.143	1111.115	10.129	1112.360	10.140	10.137

Nitrate

Table B5: peak area of standard solutions for nitrate

concentration of standard solution (ppm)	Peak Area (mV.S)
0	0
1	53.164
2	108.989
5	279.174

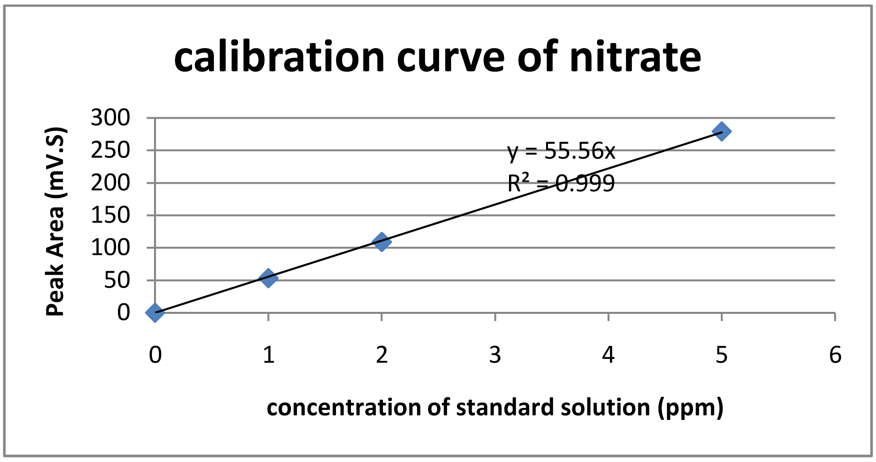

Figure B3: calibration curve of nitrate

sample concentration
$y = mx + c$
$x = (y-c)/m$

y = peak area
x = concentration of sample
m = slope

$m = 55.560$ $c = 0.000$

Table B6: concentration of nitrate for each trials

Sample	**Trial 1**		**Trial 2**		**Trial 3**		**average**
	y	**x(ppm)**	**y**	**x(ppm)**	**y**	**x(ppm)**	
DW1	98.016	1.764	97.742	1.759	96.650	1.740	1.754
DW2	97.413	1.753	98.910	1.780	95.880	1.726	1.753
DW3	103.597	1.865	101.576	1.828	102.699	1.848	1.847
DW4	19.678	0.354	19.376	0.349	18.582	0.334	0.346
DW5	0.000	0.000	101.640	1.829	99.890	1.798	1.209
DW6	95.605	1.721	97.178	1.749	97.397	1.753	1.741
DW7	82.701	1.488	83.586	1.504	83.980	1.512	1.501

Sulphate

Table B7: peak area of standard solutions for sulphate

concentration of standard solution (ppm)	Peak Area (mV.S)
0	0
1	72.347
2	145.541
5	378.045

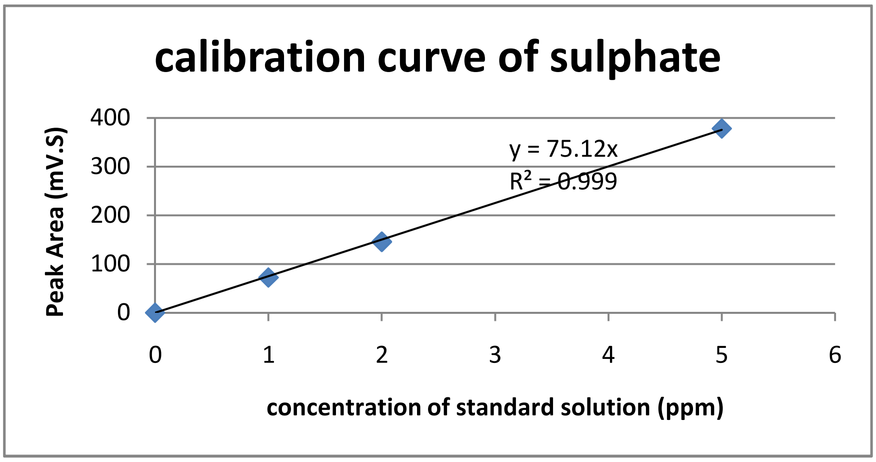

Figure B4: calibration curve of sulphate

sample concentration
y = mx + c
x = (y-c)/m

y = peak area
x = concentration of sample
m = slope

m = 75.120
c = 0.000

Table B8: concentration of sulphate for each trials

Sample	Trial 1		Trial 2		Trial 3		Average (ppm)
	y	x(ppm)	y	x(ppm)	y	x(ppm)	
DW1	228.938	3.048	227.816	3.033	227.512	3.029	3.036
DW2	225.900	3.007	226.859	3.020	222.794	2.966	2.998
DW3	200.238	2.666	199.706	2.658	197.049	2.623	2.649
DW4	41.062	0.547	30.176	0.402	35.088	0.467	0.472
DW5	222.928	2.968	224.493	2.988	223.790	2.979	2.978
DW6	219.783	2.926	218.589	2.910	219.512	2.922	2.919
DW7	208.658	2.778	207.664	2.764	207.354	2.760	2.767

Phosphate

Table B9: peak area of standard solutions for phosphate

concentration of standard solution (ppm)	Peak Area (mV.S)
0	0.000
1	22.753
5	128.637

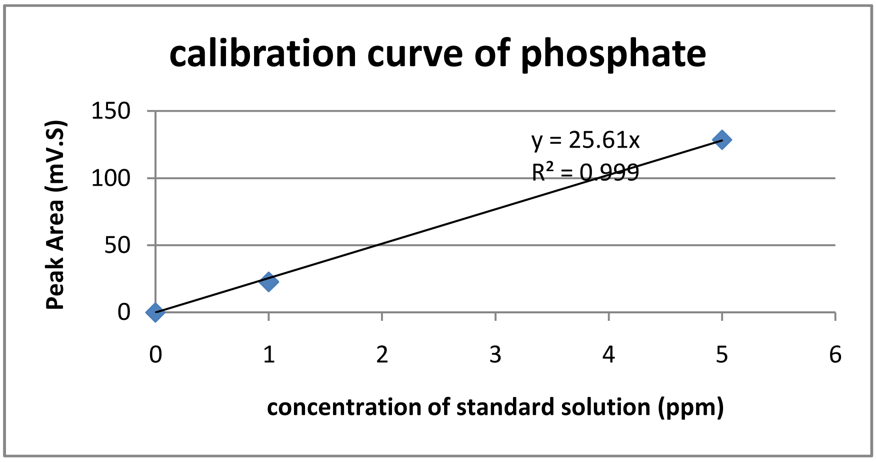

Figure B5: calibration curve of phosphate

sample concentration
y = mx + c
x = (y-c)/m

y = peak area
x = concentration of sample
m = slope

m = 25.610 c = 0.000

Table B8: concentration of phosphate for each trials

Sample	**Trial 1**		**Trial 2**		**Trial 3**		**Average (ppm)**
	y	**x(ppm)**	**y**	**x(ppm)**	**y**	**x(ppm)**	
DW1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DW2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DW3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DW4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DW5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DW6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DW7	0.000	0.000	0.000	0.000	0.000	0.000	0.000