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

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.

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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.

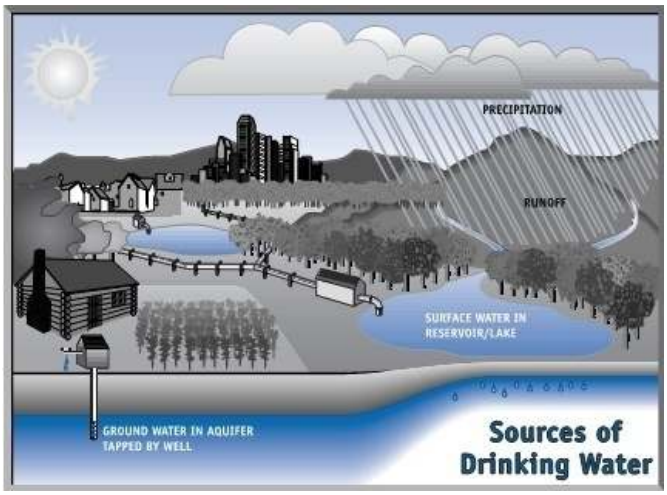

Figure 1.1: Sources of Drinking Water

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.