DETERMINATION OF HEAVY METALS IN WATER SAMPLED FROM SELECTED VENDING MACHINE IN KUBANG KERIAN, KELANTAN

by

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Abbreviations

DOE	- Department of Environment
AKSB	- Air Kelantan Sdn. Bhd
FAAS	- Flame Atomic Absorption Spectrometer
WHO	- World Health Organization
NTU	- Nephelometric Turbidity Units
WVM	- Water Vending Machine
MOH	- Ministry of Health
mg/L	- Milligram per Litre
Mn	- Manganese
Cu	- Copper
Zn	- Zinc
Pb	- Lead
Fe	- Iron
Cd	- Cadmium

Penentuan Logam Berat Dalam Air Yang Disampel Daripada Mesin Pendispen Air Terpilih di Kubang Kerian, Kelantan

Abstrak

Air adalah penting dalam mengekalkan kehidupan semua organisma. Justeru, air minuman yang bersih dan selamat adalah penting untuk kehidupan yang sihat. Bagi negara yang sedang membangun, masalah pencemaran air yang tercemar dengan logam berat perlu diatasi dengan segera. Oleh itu, penggunaan mesin pendispen air adalah sumber alternatif lain yang lebih bersih dan selamat untuk diminum. Walau bagaimanapun, penggunaan mesin pendispen air khususnya dari aspek keselamatan dan kesihatan berkenaan pencemaran logam berat masih tidak diketahui. Sehubungan itu, matlamat kajian ini adalah untuk menentukan serta mengukur kehadiran dan kuantifikasi logam berat daripada sampel air khususnya dari mesin pendispen air yang dipilih di sekitar Kubang Kerian, Kelantan. Tahap kepekatan beberapa logam berat terpilih telah diuji dengan menggunakan mesin Spektroskopi Penyerapan Atom (FAAS). Logam berat terpilih yang diuji adalah Zinc (Zn), tembaga (Cu), Iron (Fe), Mangan (Mn), Lead (Pb) dan Kadmium (Cd). Melalui kajian ini telah mendapati bahawa 100.00% daripada sampel mengandungi Mn. Walau bagaimanapun, terdapat enam sampel iaitu (20.00%) mempunyai tahap kepekatan Mn yang berada di bawah nilai yang telah ditetapkan oleh Standard Kebangsaan bagi Kualiti Air Minuman. Selebihnya (80.00%) mempunyai kepekatan melebihi had yang ditetapkan iaitu 0.05 mg / L. Lapan belas sampel didapati mempunyai tahap kepekatan Cd yang tidak mematuhi Piawaian Kebangsaan bagi Air Minuman. Namun, terdapat lima sampel mematuhi standard yang ditetapkan iaitu 0.003 mg / L. Kepekatan logam berat bagi elemen Pb daripada mesin layanan diri mendapati bahawa 50.00% daripada sampel tidak mematuhi Standard Kebangsaan Air Minuman. Bagi elemen Cu, Fe dan Zn menunjukkan kepekatan di bawah standard dan terdapat 14 sampel dari elemen Cu, sembilan dan enam sampel dari Fe dan elemen Zn tidak boleh dikesan oleh FAAS masing-masing kerana terlalu rendah kepekatan untuk elemen ini. Kesimpulannya, sampel air tidak selamat untuk diminum kerana ianya mempunyai kepekatan logam berat yang melebihi had.

Determination Of Heavy Metals In Water Sampled From Selected Vending Machine In Kubang Kerian, Kelantan

Abstract

Water is essential in sustaining life in all living organisms. Therefore, clean and safe drinking water is essential for healthy living. As many parts of the world becoming industrialized and urbanized, problems of water pollution are becoming more intensified with many areas of surface water and groundwater are being contaminated with heavy metals. Due to that, the usage of vending machines are the alternative source of cleaner and safer drinking water for the household consumer nowadays. However, the safety and health aspect for these water vending machine with the respect to heavy metals contamination in particular is not known. It is the aim of this study to determine as well as to measure the presence and quantification of heavy metals in water sampled from selected vending machine in Kubang Kerian, Kelantan. The concentration levels of several selected heavy metals were tested using Flame Atomic Absorption Spectrometry (FAAS). The heavy metals elements tested were Zinc (Zn), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb) and Cadmium (Cd). It was found that 100.00% of the samples contained Mn. However, it was also found that only six samples which present 20 .00% that have the concentration level of Mn that is under the maximum acceptable value which set by the National Standard for Drinking Water Quality. The rest of the samples (80.00%) have the concentration exceed the limit which is 0.05 mg/L. Eighteen samples were found to have the concentration level for Cd that are non-compliance to the National Standard for Drinking Water where as there are five samples are comply with standard which is 0.005 mg/L. The excessive concentration of Pb in the water vending machine found that 50.00% of the samples did not comply with National Standard Drinking Water. The rest of the element which are Cu, Fe and Zn shown the concentration were under the standard and there were also found that 14 samples from Cu element, nine and six samples from Fe and Zn element respectively cannot be detected by FAAS respectively due to too low concentration of these elements. Water from water vending machines is unsafe for consumption due to the presence of heavy metals exceeding the minimum safety limit.

CHAPTER 1

INTRODUCTION

1.1 Study Background

Water is essential in sustaining life in all living organisms. Water is important because it provides a source of nutrients to the body as well as it uses in washing and cleaning. There are estimated 1.8 billion people living by consuming contaminated water and more than 660 million people living without clean and safe drinking water every day (World Health Organization, WHO, 2016). Therefore, consuming treated and clean water will ensure continuous health wellbeing to human populations. Drinking water source that is free from heavy metals, chemicals, pesticides and pathogenic microorganism contaminations is very important in ensuring safety to consumers. If source of drinking water is contaminated with these contaminants, then it is most inappropriate and unsafe for use by the consumer. The treated water supply in Kubang Kerian is provided by Air Kelantan Sdn. Bhd (AKSB) which is sourced from groundwater. Continuous monitoring of treated water quality before and after treatment is carried out by ASKB, State Health Department and State Environmental Department at several sampling points in accordance with the National Standard Quality of Drinking Water set by the Ministry of Health (MOH, 2012). It is important to mention that periodic analysis of treated water in Kelantan reveals high levels of Fe, Mn and Al and 26% and 10% of treated water samples contain unacceptable levels of total coliforms and faecal coliforms (Auditor General Report, 2009). Mn and Fe content are usually high in groundwater and cause apparent changes in the physical properties of the water

(Fawell & Nieuwenhuijsen, 2003). The changes in the physical properties of treated water are very obvious with the presence of these metals. The water will either turn dark or red with rusty odor and consumers will refrain from using it for drinking and even washing purposes. Thus, most of the household consumers nowadays are looking for alternative source of cleaner and safer drinking water. At present, many consumers are resorting to water vending machine for their drinking water supply. The water vending machine provides cheap supply of drinking water as well as easy accessibility. Water vending machine uses reverse osmosis (RO) system with sets of membranes which removes nearly all microorganisms, colloidal silica, particulates, organics and large percentage of ionic contaminants from water. However, many studies reported that drinking water from water vending machine too could be a cause for human health concern (Al Moosa *et al.*, 2015).Such studies revealed that heavy metals poisoning attributing to poor quality of source water, lack of hygiene in dispensing process and improper handling and inadequate maintenance of filters.

Many cases of heavy metals poisoning such as Cd poisoning have been implicated with water vending machines (Fratellone Medical, 2017). Analysis on water from water vending machine has not been part of routine food-water hygiene standard and checks in Kelantan. Hence, information on its safety remains lacking. Water vending machine installed with reverse osmosis membrane system, should be able to separating water from other contaminating materials effectively. But, the effectiveness of water vending machine ability in filtering unwanted residues or contaminants rely on its reverse osmosis membrane system regular maintenance schedule. If it is not properly or adequately maintained, the filtration process may become ineffective and ultimately cause contamination. One of the major contaminations may come from heavy metals

presence in water supply source. Another issue pertaining to the quality of drinking water from the water vending machine is its water source. This water source may come from the treated water through the municipal water supply or from the underground water source through bored tube.

The outbreak of diarrheal disease and other water contaminants may be associated with water vending machine (WHO, 2008). Therefore, the water supply from the water vending machine should be clean and safe to consume and have to comply with the same standard which is Drinking Water Quality Surveillance Programme by the Ministry of Health Malaysia. If the quality of drinking water from the water vending machine does not comply with this standard, it is considered as unsafe for drinking. Table 1.1 shows the drinking water standard adapted from National Standard for Drinking Water Quality prepared by the Ministry of Health (MOH), Malaysia.

Table 1.1 Drinking Water Standards: Ministry of Health Malaysia

Parameters	**Drinking Water Quality Standards**
Physicochemical Parameters	
Turbidity	<5 NTU
pH	6.5-9.0
Free Residual Chlorine	0.2-5.0 mg/L
Total Dissolved Solid	1000 mg/L
Heavy Metals*	
Zinc(Zn)	3.00 mg/L
Copper (Cu)	1.00 mg/L
Iron (Fe)	0.30 mg/L
Manganese (Mn)	0.01 mg/L
Lead (Pb)	0.01 mg/L
Cadmium (Cd)	0.003 mg/L

Source: National Standard for Drinking Water Quality (Ministry of Health)(2012)
*Selected heavy metals

One of the major pollutants in water is heavy metals contamination (Zamani, *et al.*, 2012). The major global concern of water pollution is the level of heavy metals in aquatic environment is become increasing due to human industrial activities. The example of heavy metals that can be identified in the polluted environment are Arsenic (As), Cu, Cd, Pb, Chromium (Cr), Nickel (Ni), Mercury (Hg) and (Lone *et al.*, 2008). Zn, Cu, Fe, Pb, Cd and Mn are the heavy metals pollutants in water source in Malaysia. Thus, consuming water with excessive presence of heavy metals will cause acute and chronic diseases. The acute gastrointestinal, respiratory damage, brain and kidney damages are examples of health effect by intake of excessive Cd and Zn. The sources of various heavy metals are listed in Table 1.2.

Table 1.2 Heavy Metals and its source of contamination

Heavy metals	Sources
Cu (Cu)	Electroplating industry, smelting and refining, mining, biosolids.
Zn (Zn)	Electroplating industry, smelting and refining, mining, biosolids.
Pb (Pb)	Mining and smelting of metalliferous ores, burning of Pbed, gasoline, municipal sewage, industrial wastes enriched in Pb, paints
Fe (Fe)	Drinking water pipes, pigments in paints and plastic, food colours, coagulation
Cd (Cd)	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Mn (Mn)	Industrial emissions, fossil fuel combustion, and erosion of Mn-containing soils. Released to the envFement through the use of MMT as a gasoline additive

Sources: Phytoremediation of heavy metal polluted soils and water: Progresses and Perspectives. *Journal of Zhejiang University Science B* (2008)

1.2 Problem statement

Clean and safe drinking water is essential for healthy living. As many parts of the world becoming industrialized and urbanized, problems of water pollution are becoming more intensified with many areas of surface water and groundwater are being contaminated with heavy metals (Anton *et al.*, 2007). Naturally occurring heavy metals in nature are not harmful to our environment as they are only present in small amounts (Tuzen and Soylak, 2006). Heavy metals are introduced into the environment through human activities such as agricultural practices, transport, industrial activities, waste disposal and improper use of natural water source (Kamarudin *et al.*,2009). Unlike organic wastes, heavy metals are non-biodegradable and can accumulate in living tissues and cause various diseases and health disorders. However, if the levels of these heavy metals exceeded the levels required for health concerned, then it will cause negative outcome to health. Thus, it is very important to avoid such negative health impact on the human populations. Table 1.3 showed the clinical conditions associated with the heavy metals contamination. Toxic doses of chemicals or heavy metals in foods and drinks may cause either acute or chronic ill health effect. Food poisoning is an example of an acute effect of heavy metals contamination in foods. The national incident rate of food poisoning was 36 per 100,000 populations. However, Kelantan state recorded among the highest incident rate of food poisoning at 85 per 100,000 populations (Department of Statistics, 2010). However, the levels of chemicals heavy metals in drinking water are seldom high enough to cause acute ill health effects but they are more likely to cause chronic health effects that occur long after exposure to small amount of chemicals (Salem *et al.*, 2000). As the water vending machine is commonly used for the purpose of drinking, its standard as well as quality should be

of that of drinking water. If the quantity of heavy metals from the water vending machine does not comply with the same standard of drinking water, the general consumers could experience adverse ill health effects in the long term. In Kelantan, water supply to the water vending machine may come from water supply concessionaire such as Air Kelantan Sdn. Bhd. (ASKB) and from private bore well. In additional, the state of Kelantan has the worst water services coverage in Malaysia (Association of Water and Energy Research Malaysia, 2011). Thus, it is no surprise that more consumers are turning to the water vending machine as drinking water source. There is yet a monitoring or assessment to be done on the presence of heavy metals in drinking water above the standard limit from the water vending machine. In other perspective, 3.5% of water vending machine was found to be contaminated and deemed unsafe for human consumption (InfoMed, 2015). The information on the regular maintenance of the water vending machine is scarce. Therefore to date, the quality of drinking water with respect to the presence and quantity of heavy metals is questionable.

Table 1.3: Clinical condition associated with heavy metals contamination

Types of heavy metals	Clinical condition
Cd	Fatigue, headaches, nausea, vomiting, abdominal cramps, diarrhea, fever, yellowing of the teeth, tachycardia, anemia.
Pb	Headaches, vomiting, constipation, lack of appetite, unusually pale skin, convulsion, incoordination, insomnia.
Mn	Fatigue, confusion, hallucinations, rigidity of the trunk, stiffness, psychiatric abnormalities.
Cu	Metal fume disease and disturbances in the blood.
Zn	Metal fume fever, stomach, intestinal disturbances, liver dysfunction.
Fe	Fatigue, weight loss, joint paint, heart disease, liver problems and diabetes.

Source: National Organization for Rare Disorders (NORD), (2006)

1.3 Research Objectives

1.3.1 General Objectives

To determine the presence and quantity of heavy metals in water samples from selected water vending machines in Kubang Kerian, Kelantan.

1.3.2 Specific Objectives

1) To determine the presence of heavy metals in water samples from selected water vending machine in Kubang Kerian.

2) To quantify the heavy metals presence in the drinking water from water vending machine.

3) To determine the compliancy status of the water from water vending machine with the National Standard of Drinking Water Quality.

4) To determine the association between physicochemical parameter (turbidity and total dissolved solid) with heavy metals in water samples.

1.4 Research Hypothesis

1.4.1.1 Null Hypothesis

1. There is no significant difference between the heavy metals presence in water from water vending machine and standard drinking water.
2. There is no significant difference between the heavy metals concentration in water from water vending machine and standard drinking water.
3. There is compliancy by water from water vending machine to the standard drinking water quality.
4. There is no association between physicochemical parameter (pH, turbidity and total dissolved solid) with heavy metals in water samples.

1.4.1.2 Alternative Hypothesis

1. There is a significant presence of heavy metals in water from water vending machine.
2. There is a significant difference between heavy metals concentration in water from water vending machine and standard drinking water.
3. There is no compliancy by water from water vending machine to the standard drinking water quality.
4. There is association between physicochemical parameter (pH, turbidity and total dissolved solid) with heavy metals in water samples.

1.5 Significance of Study

As drinking water from the water vending machine is gaining acceptance from more and more consumers as an alternative source of drinking water which is readily available and cheaper, its standard as well as its quality should be that of standard drinking water quality. To date, the safety and quality of water from the water vending machine has not been reported. Hence, this study will try to provide important information to the consumers regarding the safety and quality of water from the water vending machine. This study will also provide information regarding the presence of heavy metals and its concentration in water samples from water vending machine with respect to standard drinking water quality. Lastly, the study may provide suggestions for improving the quality of water from the water vending machine by the respective authorities and vendors.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The water vending machine is becoming popular among the consumers for source of safe and clean drinking water. Since it is use as drinking water, it should comply to the standard drinking water quality. However, its safety is questionable. There are only few studies conducted on the presence heavy metals in water samples from selected vending machines. One of the main concerns regarding the quality of water from vending machine is the concentration level of heavy metals. The contamination of heavy metals in water vending machine could occur in any water filtration system. Thus, it is pertinent to carry out this study for the benefit of the doubt.

2.2 Water Vending Machine

The water vending machines are available in major cities and towns and at the grocery shop and also can be found outside or near the entrance of stores. This machine dispenses purify, and also demineralized drinking water. The consumer will bring their own refill bottles and dispense the quantity of water depending on the amount required (United States Patent,1996).

Nowadays, there are several basic installation of water vending machines such as self-contained, and freestanding floor models which are located outside or inside the grocery store, convenience mart or retail outlet (Mcswane *et al.*, 1994). The purpose of the water vending machine designed is focusing on the treatment process which is to

reduce taste, odors and turbidity of the source water. The treatment process will beginning according on the quality of the source of water. Hence, the mechanical filter will start to remove sediment and residue. The second mechanical process called 'pre-filtration process' is followed by activated carbon filtration which helps to remove carbon from carbon filter. Instead of removing or reducing the chlorine, it also can damage the Reverse Osmosis membranes. Total Dissolved Solids (TDS) metals such as arsenic, Cd, Cu, Pb and sodium, nitrates, asbestos, radium can be reduce by using reverse osmosis system. There are some factors that influence the effectiveness of reverse osmosis membrane which is age, type of contaminants and the concentration of solids in the feed water. Thus, safety issues by consuming water from water vending machines are of concern. Frequent maintenance and strict enforcement are required in order to prevent any ill health problem due to consuming drinking water from this source. .

2.3 Heavy Metals Contamination of Water Source in Water Vending Machine

According to Barrel, Hunter and Nichols (2000), the common problem with water vending machine is the contamination by coliforms organisms which is caused mostly by damage filter membranes and lack of maintenance. Hence, to overcome these problems, appropriate designing and frequent maintenance of the vending machines is important to ensure delivery of safe and clean drinking water. It is also important that the water supply to the machine must also comply with the National Standard for Drinking Water. In Malaysia, the Department of Environment (DOE) is the agency that is responsible to monitor the quality of water. The Environmental Health Engineering Section under the Ministry of Health is responsible to monitor the quality of treated

piped water supply. Based on Eleventh Malaysian Plan (n.d), the percentage of Kelantan's population served with treated water supply in 2013 is 63.0% compared to 57% in 2010. Moreover, it also stated that Kelantan has worst water services coverage in Malaysia. This is seen with the usage of alternative sources such as tube wells and underground sources among people in Kelantan state. However, the government authorities take the responsible to improve the infrastructure to which resulted in percentage increase of treated water supply. Kelantan recorded an increase of 6.0% from 57.0% in 2010 to 63.0% in 2013.

Nowadays, issues of groundwater contaminations is one of the main concern in environmental issues even though at low concentration (Malassa *et al.*, 2013). The quality of water also depends on geographical location in which the composition of the soil and pollutants such as heavy metal will be effected (Mcswane *et al.*, 1994). The concentration of heavy metals in the environment increases due to human activities such as industry, agriculture and solid waste disposal. Other than that, natural and anthropogenic activities can cause heavy metals to enter into the environment. The natural weathering of earth's crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents are the example of source of heavy metals. In fact, food and water are the main source of heavy metals can enter directly, whereas industrial activities are the source of heavy metals enter indirectly. Hence, it will give effect to the health status if the concentrations of heavy metals exceed the standard limits.

2.4 Health Effects of Heavy Metals Contamination

The heavy metals are most considerable contaminants in groundwater. Therefore, if the level of heavy metals exceed the standard limit, it will cause short term and long term ill health effects to the human being (Raju, Prasad,Varalakshmi & Reddy, 2014). However, small amount of heavy metals are needed in diet and are essential for healthy body. In general, excessive consumption of heavy metals will increase health risk to the human body such as reducing in growth and development, cancer, organ damage, nervous system damage which can lead to death. Moreover, the development of autoimmunity will occur if the consumer is exposed to the heavy metals such as mercury and Pb. If the heavy metals are not metabolized by the body and accumulate in the soft tissue, it will become toxic (Malassa et al,. 2013).

In fact, in groundwater, Fe can exist in the form of ferric hydroxide with concentrations less than 500 µg/L. For the physical properties, the Fe exists in dark-grey metal. However, it usually found as ores which is combination with other elements. The Fe can be reactive element when there is presence of oxygen which causing it to easily oxidizes. In the corroded pipes, the ferric Fe can deposits within it and generate rusty tap water. The excessive consumption of this type of heavy metals will cause 'anemia' disease. If the consumer consumes drinking water with high concentration may Pb to liver disease which is haermosiderosis. On other hand, there are also diseases which correlate with prolonged consumption of this type of heavy metals such as Alzheimer's disease, neurodegenerative disease, arteriosclerosis and diabetes mellitus. The condition of drinking water also change which result in poor tasting.

In addition, the most significant of heavy metals is Pb because it is toxic and harmful even though in small amounts. Therefore, it is very dangerous to human health. The Pb contamination can be exposed through the air, water and also by ingestion/food. The route exposure of Pb contamination can be various ways such as from industrial sources. The examples of industrial sources are smelters and Pb manufacturing, recycling industries from cottage industry uses and contaminated landfills. Other than that, Pb contamination can occur through inhalation of Pb paints in dust. In addition, Pb piping and lead-combining solders are the examples of main source of Pb contamination through the water. Excessive consumption of Pb also can cause damaging system of body involving nervous and reproductive system, high blood pressure and also anemia. For pregnant women, Pb contamination is harmful to the developing of brains of fetus. According to WHO in 2016, state that Pb can cause convulsion, and death if the consumption of Pb at very high levels.

Besides, Cd also can be found in drinking water through corrosion of galvanized pipes, erosion of natural deposits, discharges from metal refineries which runoff from waste batteries and paints. Commonly, Cd can be used as stabilizers in PVC products, color pigment and several alloys. Thus, if the consumer were exposed to this heavy metals can associated with renal dysfunction which can Pb to kidney damage. In fact, for those expose in long term of Cd can have problem with bone defects which is Osteoporosis disease. The increase of blood pressure also one of the health effect of Cd contamination.

On other hand, Cu contaminations also give impact to human health especially to liver, gastrointestinal distress and kidney damage (Ling, Benham & Forrester, 2011). Commonly, the health effect is depending on toxic doses of chemical that consume by human. Therefore, the acute or chronic health effect depends on the toxic doses of

chemical. However, in human life, Cu is one of the substance which necessary to life. The blood circulation problems, anemia and growth inhibition are the examples health effect on human if the lack of Cu intake (Jenning et al, 1996 cited in Salem, Eweida & Farag, 2000). The safe level in humans is below 1.00 mg/L (MOH, 2012). But, the development of anemia, liver and kidney damage were related with exposure contaminant of Cu in drinking water. The sources of Cu contaminations in water are from corrosion of water pipes made of Cu and also industrial wastes. Moreover, high Cu exposure may Pb to diarrhea in children. As stated by Salem et al (2000), another ill health effect which may occur in human life are abdominal pain, vomiting, headache, nausea and diarrhea.

According to Nriagu (2007) stated that Zn contamination from environmental sources are extremely rare. Hence, it can consider as non-toxic and instance of acute poisoning if taken orally. The examples of adverse effect in Zn contamination are nausea, vomiting and diarrhea if the intake of Zn in drinking water exceeded 15 mg/L. Moreover, severe injury to the mouth, throat and stomach may occur due to Zn to be corrosive and ingestion. The burning of the mouth, pharynx with vomiting, erosive pharyngitis, esophagitis and gastritis are the examples of initial symptoms due to exposure of Zn to human. In severe cases, the hypoglycemia and tachycardia and eventually death may occur due to consumption of Zn sulfate which exceeded the limit. The severe chronic cholestasis liver diseases were associated with excess consumption of Zn in children. Besides, the results of consumption of high levels of Zn may Pb in lethargy, lightheadedness, staggering, difficulty in writing clearly, anxiety, depression, somnolence and comatose (Nriagu, 2007).

2.5 Physicochemical parameters

In determining the level of heavy metals in water samples, other main parameters also need to be included so that any effect towards the heavy metals readings could be noticed.

2.5.1 Turbidity

Turbidity is a measurement of clarity of water body. Its principle is by measuring the lights that travel through the water. The reading of turbidity may indicates the presence of high suspended particles such as clay, silt, organic and inorganic matter, soluble coloured organic compounds, plankton and microscopic organisms (Virtual Amrita Laboratories Universalizing Education, nd). Turbidity has directly relationship with total suspended particles. This happen as with the high presence of suspended solid in water, the transparency of water will become lower thus increasing the turbidity value. High values of turbidity indicate low penetration of sunlight that is needed in photosynthesis process in water. This could lower the daytime release of oxygen in water body that is required by aquatic life.

2.5.2 pH

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

2.5.3 Free-chlorine

Free-chlorine measurement is commonly used in chlorination process. When the chlorine is added to the water system, it is basically will combine with contaminants such as ammonia or organic nitrogen to form chloramines, monochloramines or other forms of combine chlorine. The excess chlorines that do not combine with contaminants are called as free chlorine (Osinski, 2011). The free-chlorine were monitored and measured so that the levels are in the allowable limit 0.2 – 5.0 mg/L which is set by MOH.

2.5.4 Total Dissolve Solid

There are many sources of total dissolve solid in drinking water which are originate from natural sources, sewage, urban run-off, industrial wastewater and also chemical used in water treatment process. The definition of total dissolved solid concentration is the sum of the cation (positively charged) and anion (negatively charged) ions in the water (Oram, 2014). Therefore, there are standard limit concentration which set by National Standard Drinking Water (1000 mg/L) in order to ensure the safety of consumer.

2.6 The Use of Flame Atomic Absorption Spectrometry in Analyzing Heavy Metals

According to Bakircioglu, *et al* (2003), one of the techniques for determination of trace amount of metal are by using Flame Atomic Absorption Spectrometry (FAAS) which is well established. Moreover, this analytical technique is sensitive so that it can measure a sample until ppb of a gram. In addition, FAAS was found to be widely used for determination of trace metal ions due to the relatively simple and inexpensive to operate. Due to this analytical technique is very reliable, the performance by FAAS shown very excellent as a rapid tool that allows the fast acquisition of data samples introduced into the flame (Tokalioglu, *et al.*, 2002). There are some basic components of an atomic absorption instrument which are the light source that emits the spectrum of the element of interest. Plus, an absorption cell in which atoms of the sample is produced. Next, the monochromator for light dispersion and a detector in which measures the light intensity and amplifies the signal. Moreover, there are two basic types of AAS instruments which are single beam and double beam (Analytical Methods for AAS, n.d). These component is necessary to ensure the process is done completely.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study Design

This is a quantitative cross sectional study where the samples were randomly selected tested and on several locations. This study is descriptive as it is based on water vending machine sampled taken randomly from 30 drinking water vending machines in Kubang Kerian area and also in USM campus. Physical parameters (pH, turbidity, chlorine and total dissolved solid) were also examined. Figure 3.1 show the overview of this study design.

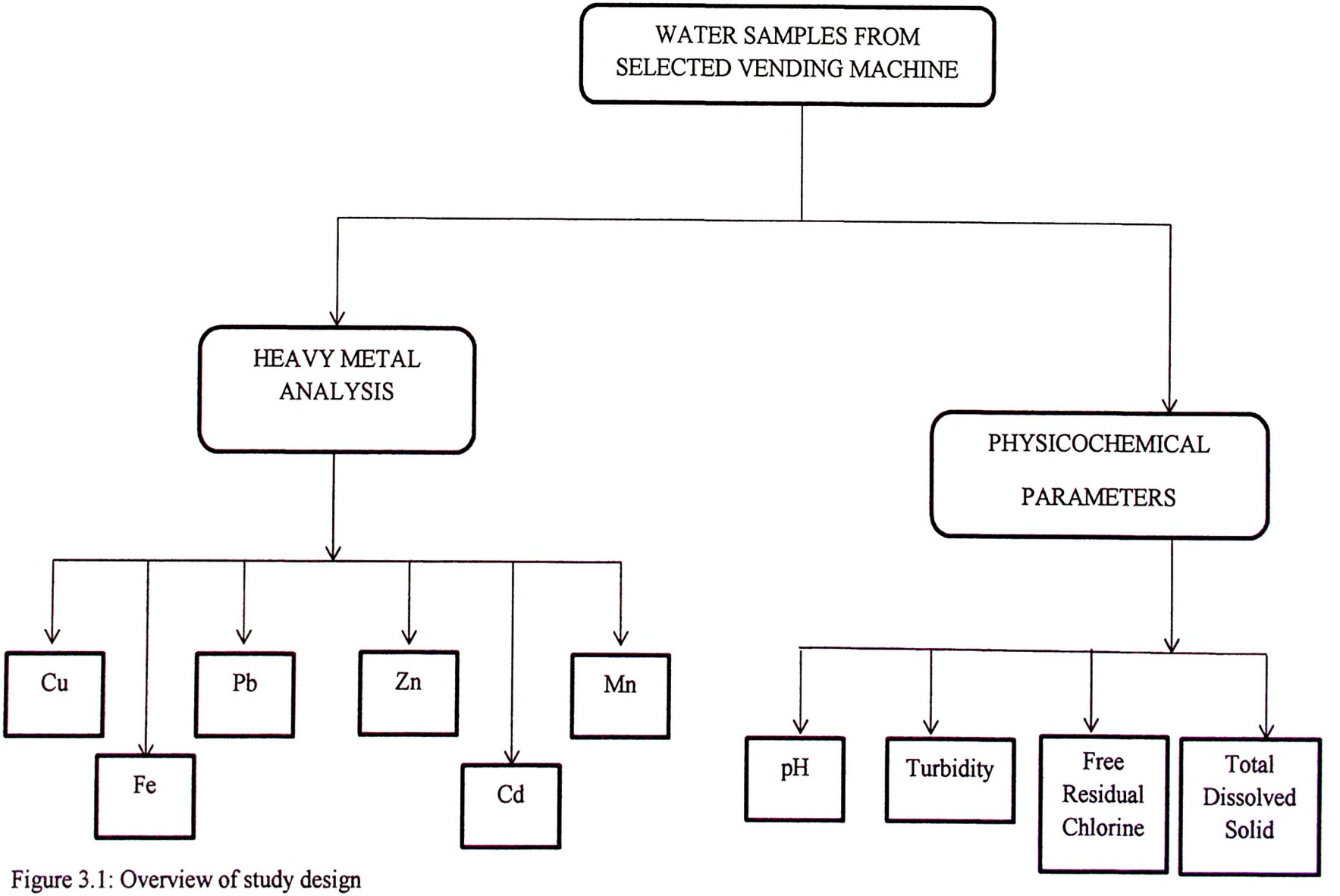

Figure 3.1: Overview of study design

3.2 Study Location

The study was done in the vicinity of Kubang Kerian. The location was selected due to high number of water vending machine available.

3.3 Study Period

This study was conducted from December 2016 until June 2017.

3.4 Research Conceptual Framework

Figure 3.2 below shows the framework which is used to outlined the research upward in this study.

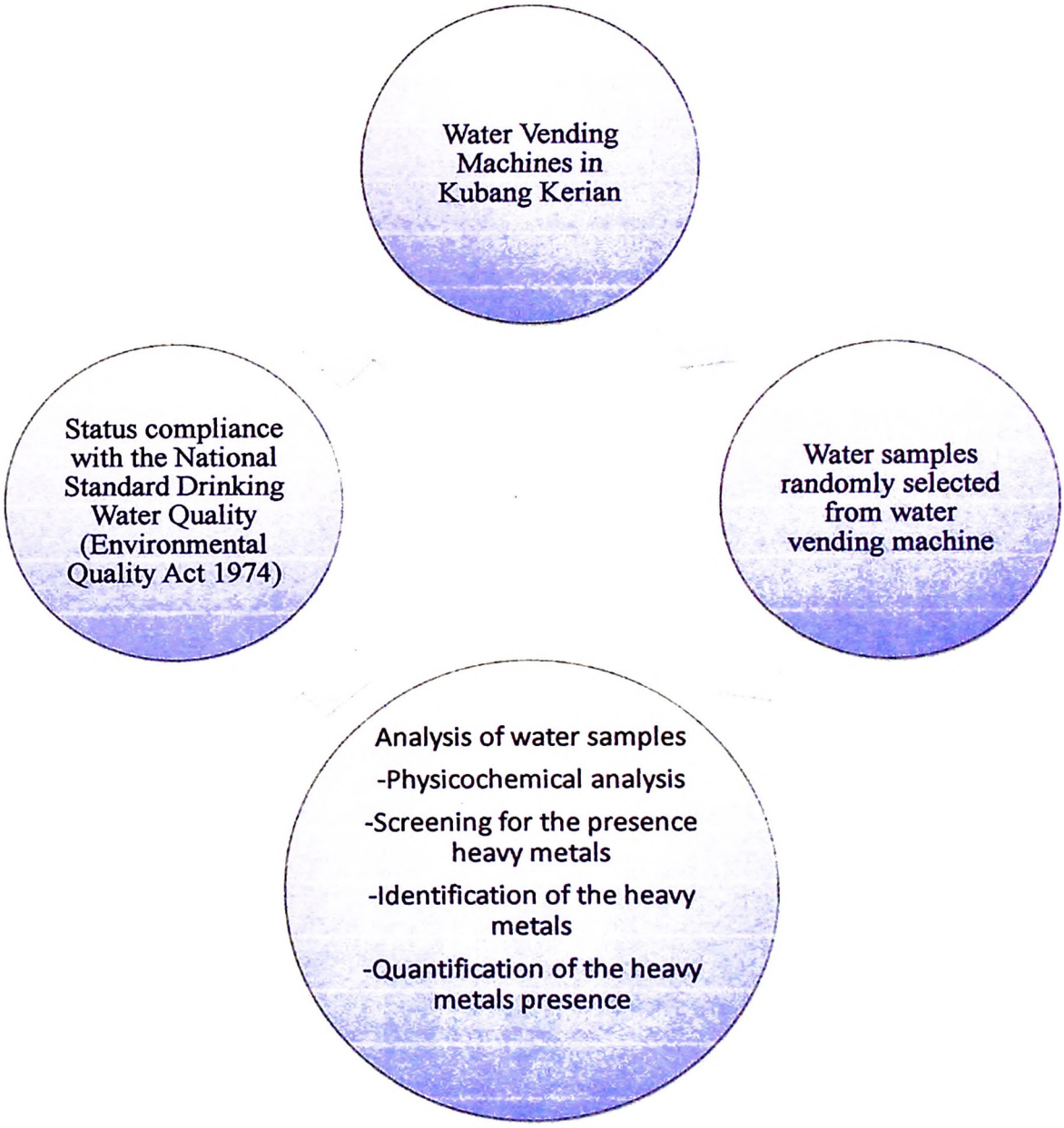

Figure 3.2: Research Conceptual Framework

3.5 Study Method and Sampling Procedure

The study location section is shown in Figure 3.3. The location mapping was done for all the vending machine in Kubang Kerian district. All vending machine were numbered on the map and 10 were randomly selected. The water samples were taken from 10 selected WVM on the location throughout the study. Three samples each from WVM was taken at different time. A total of 30 samples were taken. The bottled mineral water, bottled drinking water and tap water were used as controlled for standard drinking water. The water were collected and stored in 100 mL Duran bottle as shown in Appendices A. Then, 0.5 ml of nitric acid was added into the water samples for preservation. After that, the samples were filtered with springe filter which has 0.2 μm diameter and stored in 50 mL falcon tube. The samples are stored at 4^0C before the samples being analyzed. The water samples were analyzed for the presence of Cu, Fe, Pb, Zn, Cd and Mn by using Flame Atomic Absorption Spectrometry.

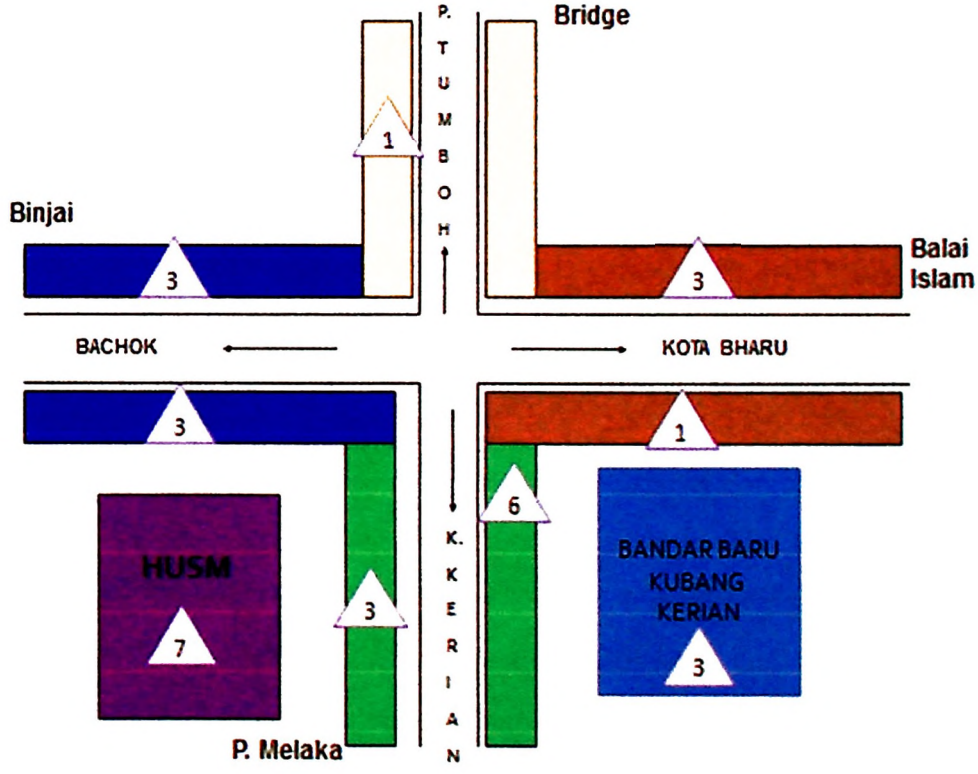

Figure 3.3: Study Location Section

3.6. Sample Analysis

The determination of Pb, Cu, Cd, Mn, Fe, Zn concentrations were done by using Atomic Absorption (AAS). The procedure of AAS was referred to operating manual provided by AAS Model Perkin Elmer A Analyst 800. The standard solutions for each metal were prepared before every analysis.

3.6.1 Preparation for Pb Standard Solutions

1. Calculation of 20 ppm of Pb standard solution using the formula below :

$M_1V_1 = M_2V_2$

Where,

M_1 = 1000 ppm (stock solution)

V_1 = total volume of stock needed

M_2 = 20 ppm (standard solution)

V_2 = 50 ml of deionized water in volumetric flask

$(1000\ ppm)(V_1) = (20)(50)$

V_1 = 1 ml

1 ml of Pb was needed to do standard solution. Five bottles of volumetric flask were prepared and labeled with 20 ppm, 10 ppm, 5 ppm, 2.5 ppm, and 1.25 ppm. Then, 1 ml of Pb stock was pipette from the 10 ml beaker and was put into 50 ml of volumetric flask for 20 ppm. After that, deionized water was added into the volumetric flask to mark up until 50 ml. The solution was shaken a few times. Next, 25 ml was pipetted out to fill up another 50 volumetric flask for 10 ppm. Lastly, deionized water was added