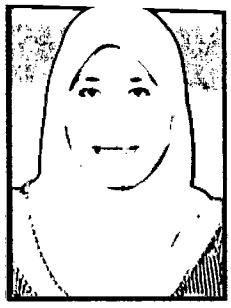
ULTRAFILTRATION OF GROUNDWATER AND RAINWATER AS DRINKING



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Abstract

Clean water access for drinking water is a basic human right. However, at present, about 1.9 million children die, 20% from diarrheal disease per year. In the world, 4 person dies from water-related disease every minute (UNICEF 2005). Most of the water have untreated human sewage and agricultural activities have caused severe surface water contaminations. At the same time, other sources of fresh water are unreliable for drinking. Ground water is acidic due to the soil conditions and iron leaching, rain water from water shed also contain some chemical or poison material and water supply from private vendors also faced some problem in order to get safe drinking water for people. Using both primary and secondary data from water sample , this study analyzes the effectiveness of the aeration and ultra-filtration process to treated water. From the result before and after treated, the process show its effective in order to remove color units and turbidity value to comply drinking water standard by The National Safe Drinking Water Standard (SDWA). This can be another method to treated water in order to provide safe drinking water to people usage.

Abstrak

Kemudahan terhadap air bersih bagi kegunaan air minuman adalah satu hak asasi bagi manusia. Walau bagaimanapun, dalam dunia hari ini terdapat lebih kurang 1.9million kanak-kanak mati dan 20% darinya adalah disebabkan oleh keracunan dalam perut. Di dunia, akan berlaku empat kematian pada setiap minit disebabkan oleh penyakit yang berkaitan dengan air yang diminum (UNICEF 2005). Kebanyakkan air mengandungi kumbahan manusia yang tidak dirawat dan kesan daripada aktiviti pertanian juga menjadi sebab terkandungnya bahan-bahan yang tidak selamat untuk diminum. Dalam masa yang sama, sumber-sumber lain bagi air bersih tidak sesuai untuk diminum. Air bawah tanah sedikit asid bergantung kepada keadaan tanah, air hujan yang dikumpul dalam tadahan juga mengandungi bahan-bahan kimia dan beberapa bahan yang mungkin berbahaya serta air yang disalurkan kepada setiap rumah juga mengandungi masalah yang lebih kurang serupa bagi menyediakan air yang selamat diminum. Berdasarkan kedua-dua data yang diperolehi, kajian ini dijalankan untuk mengetahui keberkesanan proses pengudaraan dan juga ultra-penapisan untuk merawat air. Berdasarkan keputusan sebelum dan selepas rawatan, ia menunjukkan kedua-dua proses berkesan bagi mengurangkan kadar kekeruhan dan nilai warna dalam air berdasarkan standard yang ditetapkan oleh The National Safe Drinking Water Standard (SDWA). Ianya boleh menjadi salah satu kaedah yang berkesan untuk merawat air bagi menyediakan air minumam yang selamat untuk kegunaan semua.

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LIST OF ABBREVIATIONS

UF	- Ultra-filtration
TMP	- Trans-membrane Pressure
SDWA	- Safe Drinking Water Standard
EPA	- The Environmental Protection Agency
UNEP	- United States Environmental Protection

LIST OF SYMBOLS

%	- Percent
NTU	- Turbidity Unit
HU	- Hazen Unit- Color Unit
mg/L	- Milligrams per liter
°C	- Degree Celsius

CHAPTER 1

INTRODUCTION

1.1 Background of Study

MALAYSIA's economic growth over the past decades, changing lifestyles, coupled with population growth reaching more than 27 million people are among the key factors contributing to the need for huge improvement in infrastructure and utilities of the country.

With increasing per capita income, continuous supply of safe affordable clean treated drinking water is now a necessity, not only for the urban dwellers but also the rural areas.

Drinking water or potable water is water pure enough to be consumed or used with low risk of immediate or long term harm to the user. In most developed countries, the water supplied to households, commerce and industry is all of drinking water standard, even though only a very small proportion is actually consumed or used in food preparation. Typical uses include washing or landscape irrigation.

Drinking or using such water in food preparation leads to widespread acute and chronic illnesses and is a major cause of death and misery in many countries. Reduction of waterborne diseases is a major public health goal in developing countries.

Water has always been an important and life-sustaining drink to humans and is essential to the survival of all organisms. Excluding fat, water composes approximately 70% of the human body by mass. The United States Environmental Protection Agency in risk assessment calculations assumes that the average American adult ingests 2.0 liters per day. Drinking water of a variety of qualities is bottled. Bottled water is sold for public consumption throughout the world.

In this study, the objective of collecting and analyzing water samples is to determine the water quality from a variety of sources. The water quality study will inform in the next part of this thesis in which samples are from rainwater and groundwater. The samples will be treated in ultra filtration process to know if it's complying with drinking water standard.

Safe drinking water may contain naturally occurring minerals and chemicals such as calcium, potassium, sodium or fluoride which are actually beneficial to human health (UNEP 2008). In general, good quality drinking water is "free from disease-causing organisms, harmful chemical substances and radioactive matter, tastes good, is aesthetically appealing and is free from objectionable color or odor" (Life Water Canada 2007).

1.2 Problem Statement

Demand for treated water in the Klang Valley, which comprises Selangor, Kuala Lumpur and Putrajaya has been on an uptrend from 127 mld in 1960 to 3,889 mld in 2008.With the present production capacity and growing demand, the Klang Valley is projected to face a water supply shortage as early as 2010.

The situation will get worse similar to that of the 1998 water crisis, forcing the Government to take drastic measures such as using water sources from lakes, ponds and cloud seeding.

The 1998 water crisis and subsequent intermittent water shortages in the past years, had prompted the Government to ensure sustainability of the nation's water supply, which include the Pahang-Selangor interstate water transfer, building of new dams, water conservation campaign and so on.

Even though Malaysia is blessed with abundant fresh water from its lakes and rivers, most of these water courses are severely polluted, making it costly to treat for drinking water supply.

Adding to the dilemma is the rapid depletion of our catchments areas, all in the name of economic development, which in turn resulted in lower quality of fresh water. This situation has caused the water treatment operators to face daily challenges to ensure the ability to provide sustainable water supply to serve the nation's needs.

The current water crisis in Kedah, Negeri Sembilan, Johor and Sabah is a good example of how climate will affect the consistency in water supply service.

This factor has been another challenge for us to provide a better water management service in this country.

Because of this problem, we become with new alternatives for water sources which is rainwater and underground water and treated it with Ultra filtration method to know whether the parameter of water quality from this sources complying with drinking water standard. Trans-membrane pressure is one of the process in the ultra filtration system.

Nevertheless, this project is to get the water quality monitoring for the critical parameters such as pH, turbidity, color, fluoride, and chromium iv for heavy metal from this water sources. In order to fulfill the demand of treated water to human, this method can give new sources for drinking water in Malaysia.

1.3 Research Objective

Basically this project is base on these objectives:

I. To determine rainwater and underground water characteristic in terms of color, pH, turbidity and heavy metal parameter after ultrafiltration process.
II. To determine the effectiveness of aeration process on rainwater and underground water quality.
III. To determine the effect of Trans-membrane Pressure (TMP) in terms of turbidity and color parameter of the water.

1.4 Scope of Study

The scope of this study is to determine the characteristic of rainwater and underground water in terms of the turbidity, pH, color and heavy metal parameter. In order to ultra filtration this sources of water as drinking water, lab experiment which is aeration process will be done about 30 and 60 minutes to know the effectiveness of that water quality.

Other than that, this study will determine the effect of Trans-membrane Pressure (TMP) in 1,2 and 3 bars for the turbidity and color parameter.

After the experiment done, the data collect in order to see whether it comply with Drinking Water Standard as set by Ministry of Health Malaysia.

1.5 Expected outcomes

The expected outcomes from this project are:

i. To analyze what is the parameter for this sources of water in term of the color, turbidity, pH, and heavy metal.
ii. To analyze the efficiency of this treatment in the water quality.
iii. To analyze the effect of the method in significant parameter that contribute to the treatment.

1.6 Significance of study

The significance of study are:

i. The process can be as the learning purpose to the student, researcher and industry.
ii. The projectile can give some solution in order to reduce water crisis that we face right now.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There is a difference between "pure water" and "safe drinking water." Pure water does not contain any minerals or chemicals, and does not exist naturally (EPA 1999). Safe drinking water may contain naturally occurring minerals and chemicals such as calcium, potassium, sodium or fluoride which are actually beneficial to human health (UNEP 2008). In general, good quality drinking water is "free from disease-causing organisms, harmful chemical substances and radioactive matter, tastes good, is aesthetically appealing and is free from objectionable color or odor" (Life Water Canada 2007).

Clean water access is a basic human right. However, at present, about 1.9 million children die, 20% from diarrheal disease in India per year.The major costs include the initial construction cost of rainwater harvesting system and the maintenance costs. The major benefits include an increase in household dispensable income, time and energy saved from collecting water, and reduction of epidemic outbreaks and associated medical costs (Christina 2009).

In Malaysia, the demand for water has increased with the level of development. This has been a boon to Malaysians as the water that is necessary for drinking, cooking, personal hygiene and house cleaning has been made readily available to almost all the people through piped supply(Malaysian National Society 2009).

However, in recent years the populace has become careless in the use of water. Although blessed with abundant rainfall, Selangor's water demand has all but surpassed it's natural supply. Average consumption per person in the home and at work has increased to an alarming level. Average consumption just at home now stands at about 226 litres per person per day (LPD). This level of usage is far greater than many developed countries which have begun to mind how their water is used (Malaysian National Society 2009).

By this chapter the main aim of this review is the effectiveness of some process in water treatment which is aeration process and ultrafiltration in order to get safe water drinking By the result that obtained, it can be allow classifying are this technique is a good method to treating underground water and rainwater.

This project is provided the instrument for aeration and ultra filtration process which can explore of considered of great significance in improving the method and manage it to increase the quality which complies with the Malaysian standard or world standard.

This chapter is summarizing of all the literature review gathered from many academic resources such as journals and etc.

2.2 Paper Review

2.2.1 Groundwater

Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table (Wikipedia 2011).

Ground water is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs and seeps, and can form oases or wetlands. It's also often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells. The study of the distribution and movement of underground water is hydrogeology, also called groundwater hydrology (Wikipedia 2011).

Typically, underground water is thought of as liquid water flowing through shallow aquifers, but technically it can also include soil moisture, permafrost (frozen soil), immobile water in very low permeability bedrock, and deep geothermal or oil formation water. Underground water is hypothesized to provide lubrication that can possibly influence the movement of faults. It is likely that much of the Earth's subsurface contains some water, which may be mixed with other fluids in some instances (Encyclopedia of Earth,2010).

For a region as a whole, the chemical and biological character of underground water is acceptable for most non-potable uses. The quality of underground water in some regions, particularly shallow underground water, may be changing as a result of human activities. Underground water is less susceptible to bacterial pollution than surface water because the soil and rocks through which water flows screen out most of the bacteria. Bacteria, however, occasionally find their way into underground water, sometimes in dangerously high concentrations. But freedom from bacterial pollution alone does not mean that the water is fit to drink (The Groundwater Foundation 2012).

2.2.2 Rainwater

For years, irrigation from a "rain barrel" or cistern was a familiar use for rainwater. Now, more people are looking at rainwater as a potable water source. Lye says that due to the current search for more "green" building solutions, the number of inquiries from consumers about rainwater systems is now about equally divided between those interested in potable water and others looking into irrigation.

"The first thing they're concerned about is the quantity, and they usually have to end up supplementing it to some extent" from a well, public water or a water hauler.That's especially true for a rainwater system that will be used for irrigation (Tom Williams 2010).

In Malaysia, rainfall varies with seasons and locality. There are two distinct monsoon season can be observed, for north region, the East Monsoon (October/November to March/April) is prevalent and for the south region, the West Monsoon (May/June to August) is prevalent. During the off monsoon periods, local convectional rainfall are prevailed in most part of the country (M.Pauzi M.Taha 2010)

Water provided by rainwater harvesting is generally of good quality (Appan, 1982) in which the quality levels are of high order especially when compared to other sources where the dissolved solids are generally higher. However the quality of water at early part of the rain is suspected because it may carries dust, bird droppings and other debris accumulated on the roof(M.Pauzi M.Taha 2010)

The most common water quality complaint heard from rainwater system owners is the taste and odor issue. Some have cartridge filters in their systems, but they usually don't replace them frequently enough."The filters always have a microbial load — they do not maintain them the way they should," adding that entire microbial "communities" can grow on rooftops. So the system should first have a leaf or debris excluder to keep out the largest debris such as twigs, leaves and insects (Tom Williams 2010).

2.2.3 Drinking water

Water has always been an important and life-sustaining drink to humans and is essential to the survival of all organisms. Excluding fat, water composes approximately 70% of the human body by mass. It is a crucial component of metabolic processes and serves as a solvent for many bodily solutes. The United States Environmental Protection Agency in risk assessment calculations assumes that the average American adult ingests 2.0 litres per day. Drinking water of a variety of qualities is bottled. Bottled water is sold for public consumption throughout the world.

2.2.3.1 Definition of drinking water

Drinking water or potable water is water pure enough to be consumed or used with low risk of immediate or long term harm. In most developed countries, the water supplied to households, commerce and industry is all of drinking water standard, even though only a very small proportion is actually consumed or used in food preparation. Typical uses include washing or landscape irrigation.

Over large parts of the world, humans have inadequate access to potable water and use sources contaminated with disease vectors, pathogens or unacceptable levels of toxins or suspended solids. Drinking or using such water in food preparation leads to widespread acute and chronic illnesses and is a major cause of death and misery in many countries. Reduction of waterborne diseases is a major public health goal in developing countries (Wikipedia 2011).

There is no such thing as naturally pure water. In nature, all water contains some impurities. As water flows in streams, sits in lakes, and filters through layers of soil and rock in the ground, it dissolves or absorbs the substances that it touches. Some of these substances are harmless. In fact, some people prefer mineral water precisely because minerals give it an appealing taste.

However, at certain levels, minerals, just like ma n-made chemicals, are considered contaminants that can make water unpalatable or even unsafe.

Some contaminants come from erosion of natural rock formations. Other contaminants are substances discharged from factories, applied to farmlands, or used by consumers in their homes and yards. Sources of contaminants might be in your neighborhood or might be many miles away. Your local water quality report tells which contaminants are in your drinking water, the levels at which they were found, and the actual or likely source of each contaminant.

EPA has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. EPA sets these standards to protect the health of everybody, including vulnerable groups like children(EPA 1999).

2.2.3.2 Characteristic of water

Water quality is the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water (EPA 2011).

2.2.3.2.1 Physical Characteristic

Water is a unique substance with unique physical properties. It is in constant motion, enter into relations with other substances and change them. This substance is odorless and tasteless at normal temperature and pressure. It is the only substance which could be in all the three aggregate states: liquid, solid and gaseous. The liquid water has no color and because of that living organisms – plants and animals – survive underwater (Tottolotto, March 2011).

2.2.3.2.2 Chemical characteristic

The most important chemical characteristics of water are its acidity, alkalinity, hardness, and corrosiveness. Chemical impurities can be either natural, man-made (industrial), or be deployed in raw water sources by enemy forces.

Some chemical impurities cause water to behave as either an acid or a base. Since either condition has an important bearing on the water treatment process, the pH value must be determined. Generally the pH influences the corrosiveness of the water, chemical dosages necessary for proper disinfection, and the ability to detect contaminants.

- **pH**

pH is a measurement of the acidity or basic quality of water. For example, lemons, oranges and vinegar are high in acid ("very acidic"). Acids can sting or burn, which is what you feel when you eat some kinds of fruit with a sore in your mouth. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic), with 7 being neutral. The pH of natural water is usually between 6.5 and 8.2 (Earth Force, 2010).

pH value is a good indicator of whether water is hard or soft. The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5, and the pH range for groundwater systems is between 6 to 8.5. Alkalinity is a measure of the capacity of the water to resist a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is needed to determine the corrosiveness of the water (APEC, 2011).

- **Heavy metal**

Groundwater used for drinking water applications is typically found in aquifers and wells. In these cases, some small quantities of certain heavy metals are actually acceptable because they are nutritionally essential for a healthy life, but large amounts of them may cause acute or chronic toxicity (poisoning). Trace elements such as iron, copper, manganese, and zinc are commonly found naturally in foods we consume or as part of a vitamin supplement.

The metals most often linked to human poisoning have links to learning disabilities; cancers and death are typically copper, nickel, cadmium, chrome, arsenic, lead and mercury. Many of these metals are required by humans in trace amounts but in larger, persistent dosages, these heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs(Water Tech. 2010).

(Flouride)

Water fluoridation is the controlled addition of fluoride to a public water supply to reduce tooth decay. Fluoridated water has fluoride at a level that is effective for preventing cavities; this can occur naturally or by adding fluoride. Fluoridated water operates on tooth surfaces: in the mouth it creates low levels of fluoride in saliva, which reduces the rate at which tooth enamel dematerializes and increases the rate at which it rematerializes in the early stages of cavities. A 1994 World Health Organization expert committee suggested a level of fluoride from 0.5 to 1.0 mg/L (milligrams per liter), depending on climate. Bottled water typically has unknown fluoride levels, and some domestic water filters remove some or all fluoride (CDC 2009).

(chromium vi)

Chromium(VI) compounds are powerful oxidants at low or neutral pH. Most important are chromate anion (CrO2−4) and dichromate ($Cr_2O_7^{2-}$) anions, which exist in equilibrium:

$$2\,[CrO_4]^{2-} + 2\,H^+ \rightleftarrows [Cr_2O_7]^{2-} + 2\,H_2O$$

Chromium(VI) halides are known also and include hexafluoride CrF_6 and chromyl chloride (CrO_2Cl_2The dominant species is therefore, by the law of mass action, determined by the pH of the solution. The change in equilibrium is visible by a change from yellow (chromate) to orange (dichromate), such as when an acid is added to a neutral solution of potassium chromate. Both the chromate and dichromate anions are strong oxidizing reagents at low Ph(Hollman, 1985).