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NURHAZIRAH BINTI ABDUL MALIK

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ABSTRACT

Demand of safe and and clean drinking water are increasing every day, especially in developing country such as Malaysia. High population will increase water demand proportionally but the supply of water is still low. Due to this concern, riverbank filtration system was implemented as an alternative to produce safe and clean drinking water in a faster and economical way. Common conventional water treatment process involve coagulation, flocculation, sedimentation, filtration and disinfection. Unlike conventional water treatment, riverbank filtration system in this study use riverbank soil modified with activated carbon (AC). Activated carbon is used as a medium of adsorption to remove all the organic contaminants found in water. Four parameters of water are taken into consideration in this study which are electrical conductivity, salinity, total dissolved solid and total hardness. These parameters will indicates the class of water. Sungai Belat water fall into the class II, which need further treatment for drinking water. Soil characteristic were also investigated to determine the type of soil of the riverbank in the area. The particle size distribution (sieve analysis and hydometer), Atterberg limit (liquid limit and plastic limit) and specific gravity were measured. Based on these test, the soil have 94 % of sand and 6 % clay. Adsorption test was conducted between different masses of soil and water using TDS as an indicator. The optimum time and mass (15 min with 2 g soil) was used in the adsorption test. This test will determine the most suitable ratio used for the filtration. 20:80 ratio was found to be the best ratio. Based on the filtration test, the filtration using natural soil with activated carbon was better than natural soil only. Three parameters which were electical conductivity, total dissolved soliad and hardness show decresing in value meanwhile salinity decreased. Further treatment should be carried out to achieve INWQS standard.

ABSTRAK

Permintaan terhadap air yang bersih dan selamat semakin meningkat setiap hari, terutamanya di negara yang sedang membangun seperti Malaysia. Populasi yang tinggi secara langsung akan meningkatkan permintaan terhadap air akan tetapi sumber air masih rendah. Disebabkan oleh masalah ini, penapisan tebing sungai (RBF) diperkenalkan sebagai satu alternatif untuk menghasilkan air yang selamat dan bersih dengan cara yang lebih cepat dan menjimatkan. Proses rawatan air yang biasa digunakan melibatkan coagulasi, flokulasi, pemendapan, penapisan and penyahinfaksi. Tidak seperti proses rawatan air yang umum, sistem penapisan tebimg sungai (RBF) menggunakan tanah tebing sungai yang diubahsuai dah dicampur dengan karbon aktif. Karbon aktif digunakan sebagai medium penapisan di dalam kajian ini untuk menyingkirkan kesemua bahan cemar organik yang terdapat di dalam air. Empat parameter air diambil kira di dalam kajian ini iaitu konduktiviti elektrik, kemasinan, jumlah pepejal terlarut dan kekuatan. Parameter ini digunakan untuk menentukan kelas air. Air Sungai Belat jatuh di dalam kelas II dimana memerlukan rawatan air umum untuk dijadikan air minuman. Selain daripada parameter air, ciri-ciri tanah juga dikaji untuk menentukan jenis tanah. Untuk menentukan jenis tanah, empat ujian dijalankan iaitu taburan saiz zarah, had Atterberg (had cecair dan had plastik) dan graviti jelas. Berdasarkan ujian ini, tanah tersebut mengandungi 94% pasir dan 6% tanah liat. Ujian penyerapan dijalankan diantara jumlah tanah yang berbeza dengan air, dan TDS digunakan sebagai penunjuk. Masa yang paling optimum (15 min dan 2g tanah) digunakan dalam ujian penyerapan ini. Ujian ini akan menentukan nisbah yang paling sesuai untuk proses penapisan. Nisbah 20:80 telah didapati sebagai nisbah paling baik. Daripada keputusan tersebut, kehadiran karbon aktif menunjukkan ia membantu mengurangkan beberpa parameter, iaitu jumlah pepejal terlarut, konduktivitielektrik dan kekerasan manakala nilai kemasinan meningkat. Rawatan air seterusnya perlu dilakukan untuk mencapai piawaian INWQS.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AC	Activated Carbon
ASTM	American Society for Testing and Materials
BAC	Biological Activated Carbon
BS	British Standard
HRT	Hydraulic Retention Time
INWQS	International Water quality Standard
LL	Liquid Limit
MLD	Mega Liter Per Day
PI	Plasticity Index
PL	Plastic Limit
PSD	Particle Size Distribution
RBF	Riverbank Filtration
USCS	Unified Soil Classification System

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Water is among the most basic and essential of human needs. Human beings not only consume water directly, but also use it in the production of food, washing, sanitation and for various industrial and domestic conveniences (Biswas, 2011). The main supply of water come from ocean (Frank, 2008). The balance of water supply and demand is affected regionally by a broad range of factors including population growth, increasing urbanization, intergovernmental relations, political and policy choice, social factors, technologies growth and lastly incertanties of climate (Rogers, 2002).

In Malaysia, like the rest of the world is faced with a growing population. The population Malaysia will rise up in its size from 28 billion in 2010 and was expected to increase to 42 billion as reported in the National Water Resources Study (2011). Due to the increasing population growth and socio-economic develpoment, demand of water driving up rapidly especially freshwater for drinking purpose (Mohamad Salleh, 2011)

According to the World Health Organization (WHO, 2006) safe drinking water is water that "does not represent any significant risk to health over a lifetime consumption, including different sensitivities that may occur between life stages". Drinking water used is either groundwater sources or surface water sources such as rivers, lakes, and streams (EPA, 2004).

Malaysia's urban environment has been regarded as one of the least polluted areas in Asia. But the goal of achieving industrial country status by the year 2020 and the related rapid economic development have began to increase industrial pollution and the degradation of urban surroundings (Rafia *et al.*, 2003). River water quality is degraded by sediments from land clearance and solid wastes. Water pollution affects water supply services, harms human health and demolishes aquatic live sand habitat (Borhan *et al.,* 2010). Under this circumtances, riverbank filtration was implemented to treat the river water.

1.2 PROBLEM STATEMENT

Riverbank filtration system is a water treatment technology that consist of extracting water from rivers by pumping wells located in the adjacent alluvial aquifer. It is used as alternative for more efficient and economical drinking-water treatment technology. Riverbank filtration itself may not be able to treat water until standard water quality achieved, as a result an alternative design should be consider by adding artificial barrier to the sand.

1.3 OBJECTIVES

1. To determine the effectiveness of nature soil as filtration media
2. To study the effectiveness of activated carbon as an artificial barrier in removing electrical contaminants.
3. To compare the changes in water parameter before and after using activated carbon

1.4 SCOPE OF STUDY

The scope of study is to investigate water quality parameters of Sungai Belat after being treated using riverbank filtration with the presence of activated carbon. Laboratory investigation was conducted in geotechnical and environmental laboratory in Universiti Malaysia Pahang (UMP) . This study focus more on the applicability of the activated carbon in removing all the electrical contaminants during filtration.

1.5 THESIS LAYOUT

This research consists of 5 chapters. The first chapter brief on the water supply and demand of freshwater in Malaysia, definition of freshwater , water pollution and finally treatment using riverbank filtration method (RBF). Then, the specific objectives also included as a guidance to achieve the goal of this study. This chapter also state problem statements that explain the rationality why this study should be conducted followed by the scope of study which elaborate the specific point of this study.

Chapter 2 (literature review) focus more on the technical aspect of the water treatment. This chapter also provide the differences of using conventional water treatment and RBF in water treatment. Other than that, study on RBF, experiences from previous countries on using and conducting RBF, advantages and disadvantages of RBF was included. It also describe and explain on the application and function of activated carbon as a medium of adsorption.

Chapter 3 (methodology) discuss the detail of the properties of soil and initial water quality parameter . It is also an arrangement of the project progress and planning for the project starting from the beginning until the end of the project. The overall experimental flowchart is presented at the beginning of thos chapter. Detailed of experimental set-up followed by the procedure of this study also included in this chapter. All the apparatus and standard use to conduct this research was also stated clearly in this chapter.

Chapter 4 (result and analysis) discuss about the result obtained from this study. To make it clear and avoid any confusion, the content and arrangement of this chapter are according to the sequences of the planning in Chapter 3. Thus, the result started with soil properties, initial water parameter, adsorption test, filtration test and finally the comparison of the parameter value with the INWQS.

Last part which is Chapter 5 (conclusion and recommendation) conclude all the finding from this research. Few recommendation also stated to make this reserch better in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provide and describe a general review on water supply and demand in Malaysia. Other than that it explain on the differences between two water treatment tecniques, which are conventional water treatment and riverbank filtration system. Some journals based on the countries that experienced RBF was also stated. Also, this chapter review on activated carbon as a medium of adsorption.

2.2 WATER SUPPLY

2.2.1 Water Sources

Water cover approximately 40 million mi^3 within the Earth. The ocean contain about 97% of all water on the earth and the other 3% is fresh water. The primary sources of fresh water include the following; (1) groundwater from springs, artesian wells and drilled or dug wells (2) surface water from water lakes, rivers, streams (3) desalinized seawater or brackish groundwater (4) reclaimed wastewater (Frank, 2008) . Malaysia received 990 billion m^3 annual rainwater every year within 330,000 km^2 in area. From that average, 566 billion m^3 become surface runoff, 360 billion m^3 evaporated and 64 billion m^3 discharges as groundwater. Generally, water consumption in Malaysia including domestic and industry use was 8949 MLD (Jamaluddin Shaaban, 2011) .

2.2.2 Water Demand In Malaysia

Zainal Abidin with his study on Operational Aspect of Water Demand Management in 2010 stated that the economic growth of Malaysia has increased tremendously since achieving independence. Due to this economic growth, demand on water supply also increase in 1990, treated water production was about 4,753 MLD, and in 2008, it had almost tripled to 12,468 MLD and projected to reach 24,485 MLD by the year 2020 .

Figure 2.1 illustrates the projected domestic and industrial water demand for penisular Malaysia up to 2050.

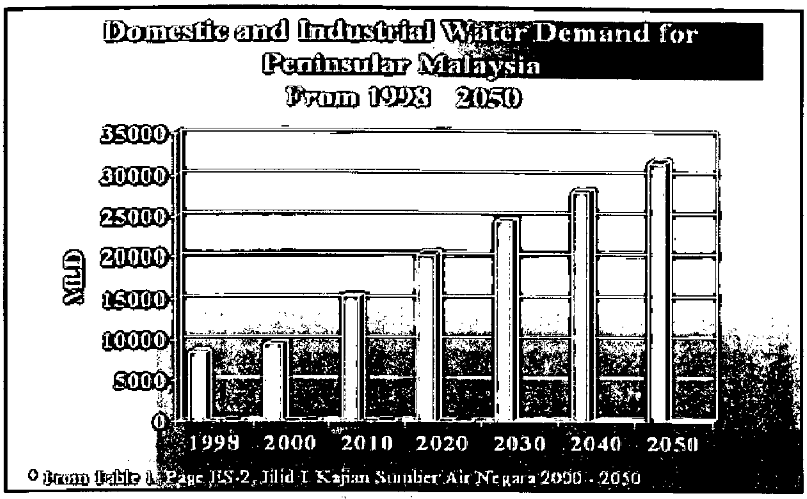

Figure 2.1 Domestic and Industrial Water Demand for Penisular Malaysia 1998-2005 (*Economic Planning Unit, Prime Minister Dept*; National Water Resource Study,2010)

2.3 WATER TREATMENT TECHNIQUE

The purpose of water treatment is to condition, modify, or remove undesirable impurities, to provide water that is safe, palatable and acceptable to users. Treatment also used to protect the water distribution system components from corrosion (Frank, 2008) . The process selected for the treatment of potable water depend on the quality of the raw water supply. Most groundwaters are clears and pathogen-free and do not contain significant amounts of organic materials. Different from ground water, surface water often contain a wider variety of contaminants than groundwater, and the treatment process may be more complex. Most surface waters contains turbidity in excess drinking-water standards (Howard *et al.,* 1990) .

2.3.1 Conventional Water Treatment

Conventional water treatment which include coagulation, flocculation, sedimentation, filtration and finally disinfection was a standard water treatment industry before distributing water to consumer (Ndabigengsere *et al.*, 1998) .

2.3.2 Riverbank Filtration System (RBF)

Riverbank filtration method describes the process of extracting water adjacent to a river, or from horizontal collector well beneath a river bed or within the banks in order to induce infiltration from the river (IRES, 2011). Figure 2.2 illustrate on the riverbank filtration system.

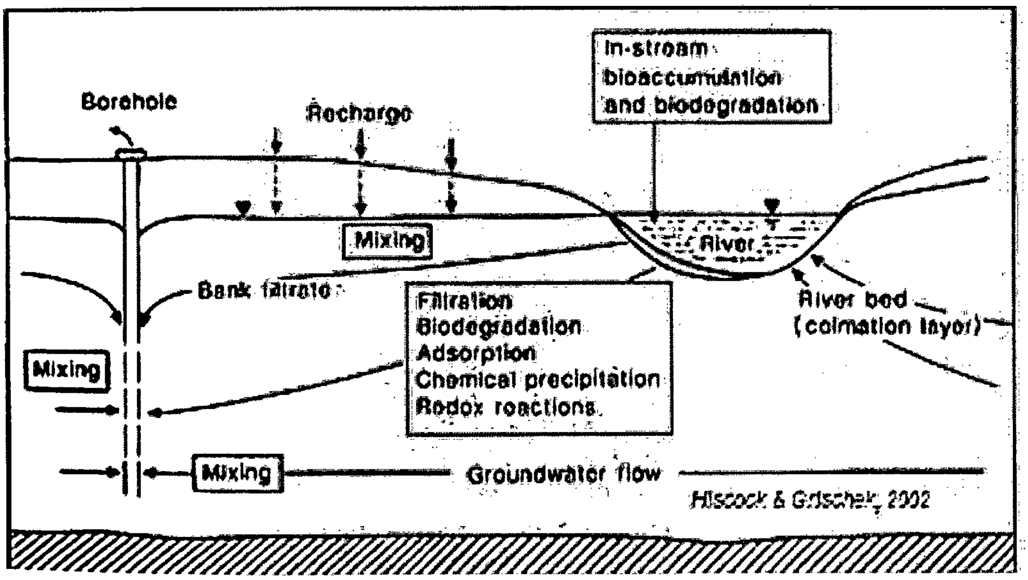

Figure 2.2 Riverbank filtration system (*IRES,2011*)

2.4 RIVERBANK FILTRATION SYSTEM

2.4.1 Purpose of RBF

The purpose of riverbank filtration was to reduced the number of pollutant. It was achieved by physical, chemical, and biological process that take place, between the surface water and ground water (Tufenkji, 2002) . The reduction of pollution level is accomplished by a number of process including physical filtration, microbial degradation, ion exchange , precipitation, sorption and dilution (Ray *et al.*, 2002) . Other factors that also contribute to the treatment are; the river water and groundwater quality, the porosity of the medium, the water residence time in the aquifer, temperature and pH of the water and lastly oxygen concentration (Kuehn *et al.*, 2011) .

2.4.2 Advantages of RBF

Tufenkji (2002) found that riverbank filtration technology has been a common practice in Europe for over 100 years, particularly in countries such as Switzerland where 80% of drinking water comes from RBF wells, 50% in France, 48% in Finland, 40 % in Hungary, 16% in Germany, and 7% in Netherlands. In the other hand, Kuehn in 2000 revealed that based on German experience with riverbank filtration, it was found that some conventional water process can be eliminated if RBF was used for example coagulation, sedimentation, and sometime filtration. Other additional advantage of RBF is relative to the fact that the flow through the aquifer acts as a barrier against concentration peaks that may result from accidental spills of pollutant (Hiscock *et al.*, 2002).

2.4.3 Disadvantages of RBF

One of the limitation in RBF is associated with hydrology and dynamics of the river and groundwater. Therefore, these aspects should be taken into account when RBF is considered as a pretreatment solution (Schubert *et al.,* 2002) . Changes in the hydraulic gradient from the river to the aquifer, and in the hydraulic conductivity of the alluvial deposits, generates changes in the pore water velocity as well as in the retention time. This may limit or change the biogeochemistry activity that take place in the hyporheic zone. Finally, changes in water temperature affect not only the hydraulic conductivity due to the reduction of the viscosity of water, but also the rate of biogeochemical process and microbial activity, which would weaken the final quality of the filtered water (Vanek *et al.*,1997).

2.4.4 Activated Carbon

2.4.4.1 Application of Activated Carbon

According to Fiore et al,. 1977, activated carbon is a natural material derived from bituminous coal, lignite, wood and coconut shell. Different applications have different requirements for the properties of activated carbon. Water treatments is the largest liquid-phase application of activated carbons. In this application detergents, pesticides, polyaromatic hydrocarbon and some trace metals may be removed from water by activated carbons (Li, 2003) .

2.4.4.2 The Use of Activated Carbon in Water Treatment

Activated carbon is commonly known as a media to support biological activity but now has recieved little attention so far for the advanced treatment of wastewater. In fact, it is potentially more efficient than sand (Gernity *et al.,* 2011). This biological activated carbon (BAC) filtration has been used for many years in drinking water treatment, usually after ozonation, and has proven to be able to significantly remove organic matter, ozonation transforming products, disinfection by products precursors as well as taste and odour compounds (Simpson, 2008).

2.5 INTERNATIONAL WATER QUALITY STANDARD (INWQS)

Table 2.1 below shows the INWQS for the water reference.

Table 2.1 INWQS

PARAMETERS	UNIT	CLASSES					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1	3	3	6	12	>12
COD	mg/l	10	25	25	50	100	>100
DO	mg/l	7	5-7	5-7	3-5	<3	<1
pH		6.5-8.5	6-9	6-9	5-9	5-9	-
Colour	TCU	15	150	150	-	-	-
Elec. Conductivity*	umhos/cm	1000	1000	-	-	6000	-
Floatables		N	N	N	-	-	-
Odour		N	N	N	-	-	-
Salinity (%)	%	0.5	1	-	-	2	-
Taste		N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature (C)	°C	-	Normal +2°C	▯@	Normal +2°C	-	-
Turbidity (NTU)	NTU	5	50	50	-	-	-
Faecal Coliform **	counts/100mL	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	counts/100mL	100	5000	5000	50000	50000	>50000

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter presents the methodology adopted in this study. This chapter is presented in the following manner: sample collection is presented first, followed by material used, properties of soil, water quality parameter, adsorption and filtration test using activated carbon (AC). The methodology flowchart of this study is summarised in Figure 3.1.

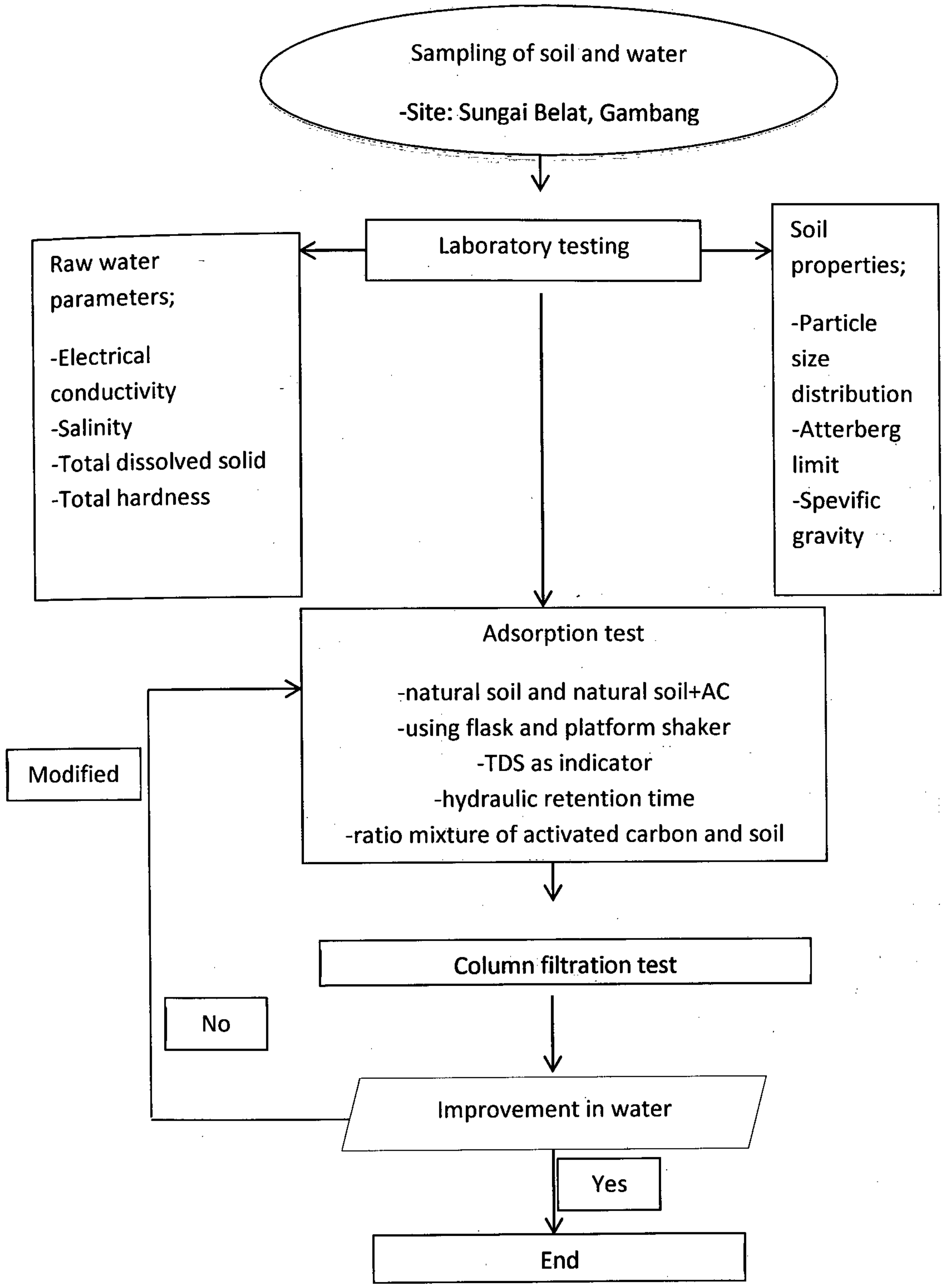

Figure 3.1 Flow chart of the experiment