EFFECTIVENESS OF I M IN REMOVAL OF
ORGANIC CC RIVER USING
ACTIVA TESTING

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ABSTRACT

Riverbank filtration (RBF) is a water treatment technology that consists of an extraction well installed adjacent to an alluvial aquifer. This aquifer, acts as a filtration medium for filtering contaminants from the extracted water. During the underground passage, a series of physical, chemical, and biological process take place, improving the quality of the surface water, substituting or reducing conventional drinking water treatment. The use of RBF, which utilizes the riverbank for extraction and filtration of rivers, may be considered as a cheaper alternative. RBF system have been shown to effectively remove pollutants such as, particulate matters, organic compounds, microbes and a large number of chemical micro pollutants. Activated carbon (AC) adsorption has long being recognised as one of the most effective technologies at removing natural organic matter from water in drinking water treatment plants. In this study the effectiveness of using activated carbon as a filtration media when it mixed with natural soil are analyzed. Apart from that, the water quality parameters were tested to compare the value of before and after filtration process. The results for the percentages removal of the parameter in terms of water quality for nature soil are: BOD_5 at 20°C 10%; COD 81%; TOC 0%; Total nitrogen 0 %; Total phosphorus 63 % while the percentages removal of the parameter in terms of water quality for nature soil + AC are: BOD_5 at 20°C 5%; COD 100%; TOC 0%; Total nitrogen 0%; Total phosphorus 49%. Although not all the value of parameter was decreases but some of parameter do decreases in value which it can be considered that the water become clean than before undergoes filtration process. The design of this experiment clearly shows that modification of soil by mixing AC can be used as filtration media in RBF system.

ABSTRAK

Riverbank penapisan (RBF) adalah teknologi rawatan air yang terdiri daripada pengekstrakan juga dipasang bersebelahan dengan akuifer aluvium. Akuifer ini, bertindak sebagai medium penapisan untuk menapis bahan cemar dari air yang diekstrak. Semasa laluan bawah tanah, satu siri fizikal, kimia, dan proses biologi berlaku, meningkatkan kualiti air permukaan, menggantikan atau mengurangkan konvensional rawatan air minuman. Penggunaan RBF yang menggunakan tebing sungai untuk pengekstrakan dan penapisan sungai-sungai, boleh dianggap sebagai alternatif yang lebih murah. Sistem RBF telah ditunjukkan untuk menghapuskan bahan pencemar seperti, zarah, sebatian organik, mikrob dan sejumlah besar bahan pencemar mikro kimia dengan berkesan. Karbon teraktif (AC) penjerapan telah lama diiktiraf sebagai salah satu teknologi yang paling berkesan untuk menghapuskan bahan organik semula jadi daripada air di minum loji rawatan air. Dalam kajian ini, keberkesanan penggunaan karbon teraktif sebagai media penapisan apabila ia bercampur dengan tanah semula jadi dianalisis. Selain itu, parameter kualiti air telah diuji untuk membandingkan nilai sebelum dan selepas proses penapisan. Keputusan bagi penyingkiran peratusan yang parameter dari segi kualiti air untuk tanah sifat adalah: BOD5 pada 20oC 10%; COD 81%; TOC 0%; Jumlah nitrogen 0%; Jumlah fosforus 63% manakala peratusan penyingkiran bagi parameter dari segi kualiti air untuk tanah sifat + AC adalah: BOD5 pada 20oC 5%; COD 100%; TOC 0%; Jumlah nitrogen 0%; Jumlah fosforus 49%. Walaupun tidak semua nilai parameter mengalami penurunan tetapi beberapa parameter yang berkurangan dalam nilai yang ia boleh dianggap bahawa air menjadi bersih daripada sebelum melalui proses penapisan. Reka bentuk eksperimen ini jelas menunjukkan bahawa pengubahsuaian tanah dengan mencampurkan AC boleh digunakan sebagai media penapisan dalam sistem RBF

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LIST OF ABBREVIATIONS

RBF	Riverbank Filtration
AC	Activated Carbon
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TOC	Total Organic Carbon
ASTM	American Society for Testing and Materials
AASHTO	American Association and State Highway and Transportation Officials
USCS	Unified Soil Classification Standard

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Water is the most important element in the world which made up about 70 percents of Earth's surface. The oceans hold for about 96.5 percent of all Earth's water. In fact, water also exists as water vapour in rivers and lakes, in the ground as soil, moisture and also in aquifers (Gleick, 1993). Thus, for a general livelihood and the support of life style for example agricultural activities, human must depend upon the remaining 0.62 percent which can be found in freshwater lakes, rivers, and groundwater supplies (Howard, 1985).

Although supply water is abundant or substantial, it is estimated that 1 billion people still lack access to safe drinking water while in the developing world the cost of building and maintaining conventional water and waste water treatment can be prohibitive (Claire and Janet, 2011). Many water treatment facilities use filtration system to remove particulate matter from water (EPA, 1974). In addition, these systems utilize chemicals to treat the water and inevitably increases the operation cost.

The use of riverbank filtration system (RBF), which utilizes the riverbank for extraction and filtration of rivers, may be considered as a cheaper alternative. RBF system consists of an extraction well installed adjacent to an alluvial aquifer. This aquifer, acts as a filtration medium for filtering contaminants from the extracted water (Kumar *et al.*, 2009; Jaramillo, 2011). RBF have been shown to effectively remove pollutants such as, particulate matters, organic compounds, microbes and a large number of chemical micro pollutants (Kuehn *et al.*, 2000).

The aim of this study is to study the effectiveness of natural soil before and after alteration and compare the changes of water quality parameter before and after filtration process.

1.2 PROBLEM STATEMENT

The natural purification of polluted river water through riverbank filtration could be one of the alternatives to eliminate organic, microbial and other pollutants. Riverbank filtration system (RBF) can be used as the method in treating the surface water but the effectiveness of RBF system depends entirely on the properties of the soil which resides in the riverbanks. If the soil properties are not favorable, thus some modification is required in order to increase the treatment efficiency of the RBF system.

1.3 OBJECTIVES

The objectives of this study are:

i. To study the effectiveness of natural soil as filtration media
ii. To analyse the effectiveness of natural soil with activated carbon mixture in removing organic contaminants using riverbank filtration system.
iii. To compare the changes in water parameter before and after using activated carbon.

1.4 SCOPE OF STUDY

This study is focus on properties of natural soil and the water quality parameters before and after using RBF system. This study also focuses on removing the organic contaminants of Sungai Belat river water by using the mixture of natural soil and activated carbon as the filtration media. The test was conducted in Soil Mechanics & Geotechnical and Environmental Engineering Laboratory, Faculty of Civil Engineering & Earth Resources, Universiti Malaysia Pahang (UMP). The soil properties and water quality parameters used to analyses are:

i. Soil properties
   - Sieve analysis
   - Specific gravity
   - Atterberg limits

ii. Water quality parameters
   - Biochemical oxygen demand (BOD)
   - Chemical oxygen demand (COD)
   - Total organic carbon (TOC)
   - Total nitrogen
   - Total phosphorus

1.5 SIGNIFICANCE OF STUDY

This study will be helpful in determining and evaluate the effectiveness of natural soil with activated carbon mixture in removing Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Total organic carbon (TOC), Total phosphorus and Total nitrogen by using RBF system.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explain the elements involve in this study with any related issues in a more detailed approach. The overview from previous researcher and journal on this topic of study are included. A clearer understanding on the research objectives, problem statement and the significant of the study are provided in this chapter.

2.2 WATER SUPPLY

Good quality water is essential for all living beings. Even modern technologies could not change our dependency on water. We are more concern about this natural resource when it becomes too little, too much or too dirty. Until recently, the quantity of water was not an issue in the country, except in the dry regions of the Peninsula. Sabah and Sarawak did not face any serious shortage of raw water yet. (National Water Resources Study 2000 – 2050) stated that majority of the potable water is tapped from the rivers, which are fed by the rain.

2.2.1 Water Demand

Water demand can be categorized as domestic and non domestic water. It is driven by non potable use, the potable requirements or biological need for example drinking water, water contained in beverages and naturally bound in food. It was representing a very small proportion of the total, being essentially around 2 litres per head per day, irrespective of the socio-economic level or geographical location of the community (Bradley, 2004).

2.2.2 Water Sources

Freshwater is maybe the most essential resources for people and all other living animals on earth. In our living, it rotates around water, and sufficient clean water is crucial for our solid living and in addition the wellbeing of nature. Malaysia gains abundant rainfall averaging 3000 mm yearly that helps an expected twelve-month water resources of in the range of 900 billion cubic metres. In the percentages of 97 % of our raw water supply for agricultural, domestic and industrial need are inferred from surface water sources essential from rivers. Malaysia has 189 river basins which are 89 in Peninsular Malaysia, 78 in Sabah and 22 in Sarawak (WWF, 2012).

For a general livelihood and the support of life style for example agricultural activities, human must depend upon the remaining 0.62 percent of water which can be found in freshwater lakes, rivers, and groundwater supplies (Howard *et al.*, 1985).

2.3 WATER TREATMENT TECHNIQUE

The primary purpose of water treatment is to provide drinking water to consumer that is free of waterborne pathogens. Because no single treatment process can be expected to remove all of the different types of pathogens that can be found in water (under all conditions), multiple barriers are desirable. Multiple barriers will also ensure additional safety in the case that a single treatment step is not working optimally (Stanfield *et al.*, 2002).

2.3.1 Conventional Water Treatment

Coagulation-flocculation followed by sedimentation, filtration, and disinfection often by chlorination is used worldwide in the water treatment industry before distributing treated water to consumers.

2.3.2 Riverbank Filtration System (RBF)

RBF is a pre treatment technique in which water is withdrawn from one or more wells near rivers (within 10 to 100 meters). By pumping a RBF well, river is induced to flow trough porous riverbed sediments. As the raw surface water passes through the sediments beneath the river and travels towards the RBF well, dissolved and suspended contaminants, as well as pathogens are removed or significantly reduced in number due to combination of physical, chemical and biological processes (Hubbs *et al.*, 2004).

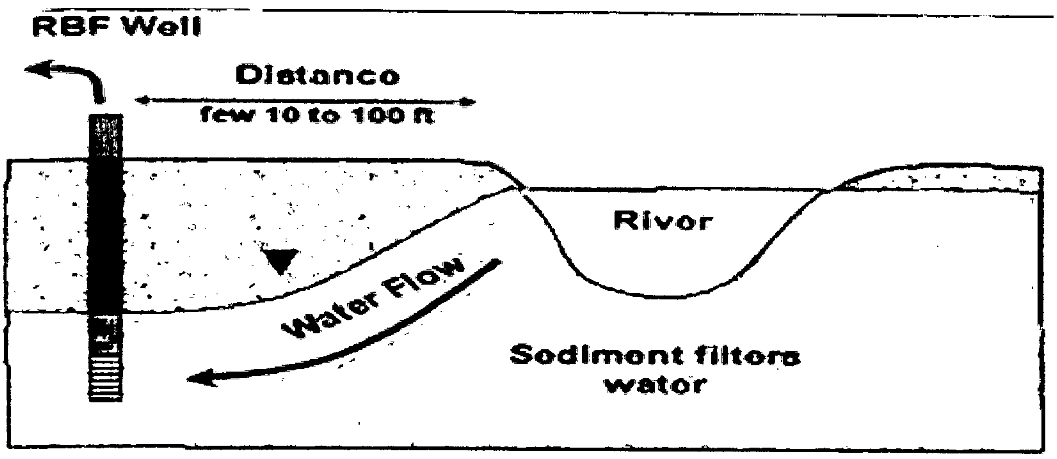

Figure 2.1: Riverbank Filtration System (Hubbs *et al.*, 2004)

2.4 RIVERBANK FILTRATION (RBF)

2.4.1 Purpose of RBF

The purpose of riverbank filtration was to effectively remove pollutants like particulate matter, manmade or natural organic compounds, bacteria, protozoa, algae, viruses, disinfectant by product precursors and a large number of chemical micro pollutants (Kuhn and Muller, 2000). The filtration system widely used as a groundwater source due to their high production potential, proximity to demand areas, their ease and extraction in economy (Doussan *et al.*, 1998). Other purpose was to reduce the level of pollution in accomplished by a various process include physical filtration, microbial degradation, ion exchange, precipitation, adsorption and dilution (Wang *et al.*, 2002).

2.4.2 Advantages of RBF

In Jordan, Zarqa River installed RBF since 2006 and it was already cleared that the RBF has significantly improved the water quality and local farmers have begun using RBF water for agricultural purpose (Boving *et al.*, 2009). RBF also contribute an inexpensive means in order to remove the large amount of contaminants and improve the quality of water to be delivered for domestic used for example removal of turbidity, microbes and natural organic matter (Schubert, 2004). RBF has been used in Europe for about 100 years, and it is recently widely accepted as treatment technology preceding more advanced pre-treatment operations (Schmidt & Ray, 2002). RBF supplies 75 % of water supply to the German capital of Berlin (Hiscock, 2005). In the Netherlands, RBF offers for about 7 % (80 Mm^3/a) of the national drinking water supply in 26 well fields (Stuyfzand *et al*, 2004).

2.4.3 Disadvantages of RBF

Riverbank filtration does not have the ability in order to remove certain biological, inorganic and organic contaminants in the limitations associated with the hydrology and dynamics river and groundwater where this should take as the first view as RBF is considered as a pre-treatment solution (Schubert *et al.*, 2002). Fluctuations in the river stage alter water saturation; biofilms content, geochemistry and even the structure of the RBF affect the performance of the treatment. This variation can affect the flow and transport characteristics of the whole system because the unsaturated region, that does not have the same removal potential as the saturated zone could be infiltrated by river water during an increased stage of water level therefore the filtered water obtained will have poorer quality (Schubert *et al*, 2000).

2.5 ACTIVATED CARBON (AC)

Activated carbon was well known adsorbent that can be used efficiently for removal of a broad spectrum of pollutants from air, soil and liquids. Adsorbents are usually porous solids, and adsorption occurs mainly on the pore wall inside particles. AC is more efficient adsorbent for elimination of many pollutants (organic, inorganic and biological) of concern in water and wastewater treatment (Ansari *et al.*, 2009).

2.5.1 Application of AC

Activated carbon has been widely used in the treatment of drinking water to remove unpleasant tastes and odours (Reasoner *et al*, 1985). Activated carbon (AC) adsorption is highly effective for the removal of organic compounds (Yangyang *et al.*, 2013).

Activated carbon adsorption has long being recognised as one of the most effective technologies at removing organic matter from water in drinking water treatment plants (Emelko *et al.*,2006; Simpson, 2008). The removal of organic matter by AC basically takes place via adsorption of soluble compounds and filtration of particulate solids (Simpson, 2008; Buchanan *et al.*, 2008; Putz *et al.;* 2005).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The purpose of this study is to examine the effectiveness of activated carbon toward the quality and improvement of existing riverbank filtration. The four purposes of this chapter are to describe the research methodology of this study, explain the sample selection, describe the procedure used in running the experiment and collecting the data, and provide an explanation of the statistical procedures used to analyze the data.

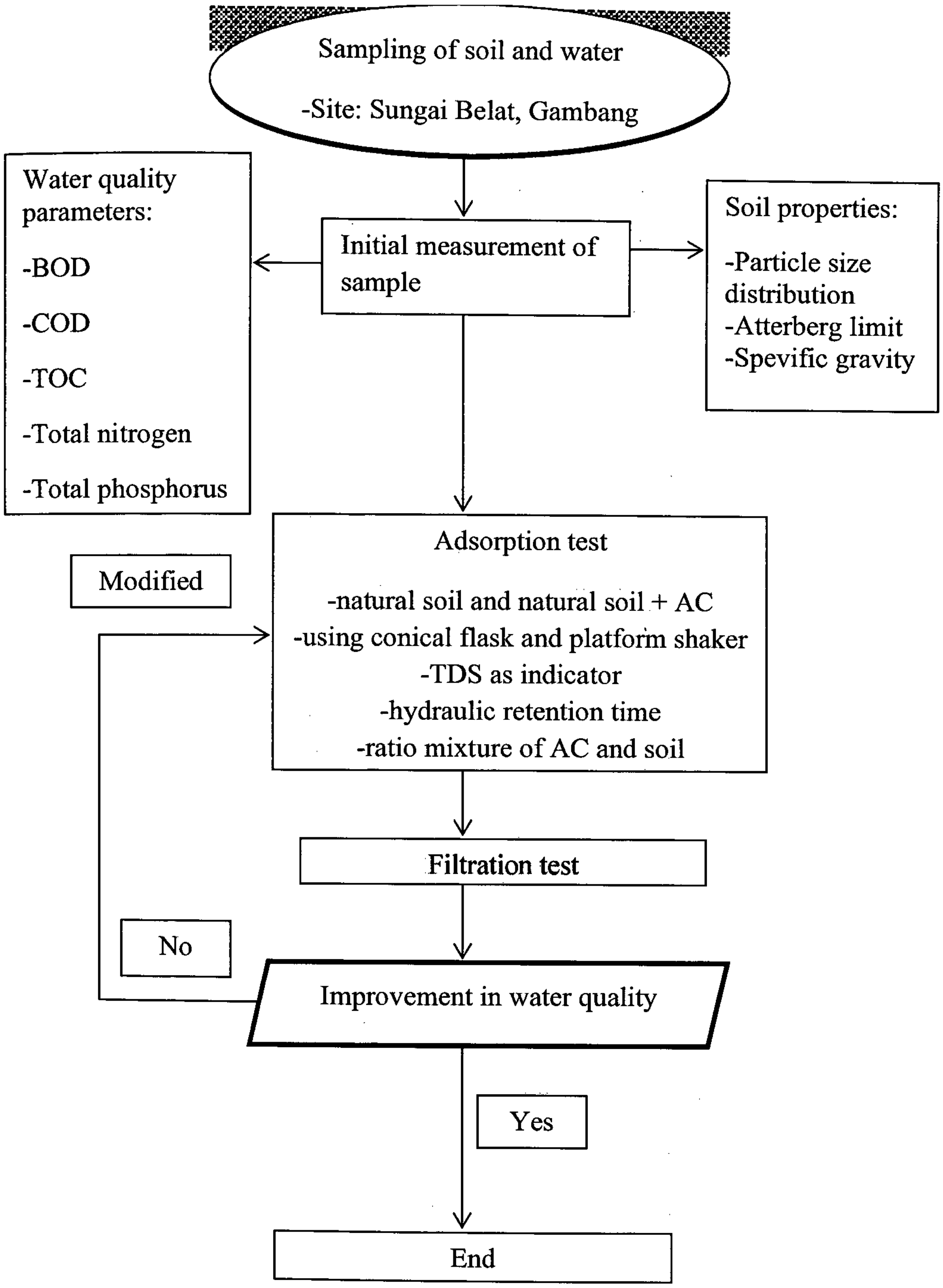

Figure 3.1: Experiment flowchart

3.2 SOIL AND WATER SAMPLING

The site that considered in this study located at Sungai Belat, Gambang. Water sample of 20 litres was collected using a hand ladle as shown in Figure 3.2. The sample is then kept in a 20 litres high density polyethylene (HDPE) container. The sample is then kept in a chilled room at 4 °C and about 10 kg of disturbed soil sample was collected from the surface of riverbank using a hand shovel as shown in Figure 3.3. The sample is then placed in sealed bags and kept in an air tight container.

Figure 3.2: Water sampling

Figure 3.3: Soil sampling

3.3 SELECTION OF MATERIAL

Activated carbon was selected to study it effectiveness in improving the quality of RBF system. In this study, AC used was produced from pyrolysis of Kenaf fibre at 2200 ^{0}C. The AC was crushed into powder form prior to being tested as shown in Figure 3.4.

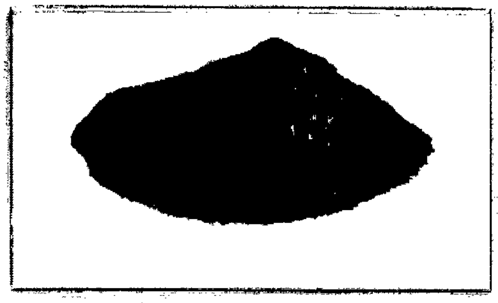

Figure 3.4: Activated carbon

3.4 PROPERTIES OF SOIL

In this section, the soil was analysing through the laboratory testing to determine it properties and the type of the soil.

3.4.1 Particle Size Distribution

This method describes the procedure for determining the relationship between the particle size distribution of fine and coarse aggregates and fine grained soils. The complete procedure for this test is outlined in BS: 1377 (1990). The apparatus used is shown in Figure 3.5.

Figure 3.5: Mechanical sieve shaker

3.4.2 Specific Gravity

The specific gravity test is made on the portion of soil which passes the No 2.00 mm sieve. The definition of specific gravity is the ratio of the weight in air of a given volume of a material at a stated temperature to the weight in air of an equal volume of distilled water. The reference used is BS: 1377 (1990) standard procedure and apparatus used shown in Figure 3.6.