IMPROVING QUAL NGAI BELAT USING ACTIVATED CARBON IN RIVERBANK FILTRATION METHOD: A LABORATORY TESTING

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ABSTRACT

Water is indeed important in our daily lives. Demand for good quality of water happened to increase due to an increase in population, rapid urbanization, industrial expansion and climate change. One of the main sources of water comes from surface water such as rivers, lakes and ponds. River water quality is an important parameter that must be preserved and monitored. In order to improve the quality of the water, water treatment has to be conducted. Water from rivers is commonly treated conventionally using chemicals for removal of suspended solids and other contaminants. One of the alternative ways to improve the water quality from rivers is by using Riverbank Filtration (RBF) method. It is used as an alternative for an efficient and economical drinking-water treatment technology. The efficiency of RBF system depends heavily on the type and properties of soil resides in the riverbank. Thus, the efficiency might vary and some modification may be required in achieving reasonable treatment ability. In this study, soil from Sungai Belat riverbank was considered and the effectiveness in improving the quality and appearance of water sample was investigated. In addition, AC mixture was also used to modify the soil. Several tests, namely adsorption test and filtration test was conducted in the laboratory to determine the effectiveness of both material as RBF media. In this study, four parameters are considered which are turbidity, colour, total suspended solid (TSS) and total dissolved solid (TDS) and then be compared with Interim National Water Quality Standard (INWQS). Laboratory investigation indicated that, the overall results shows that the type of soil is poorly graded sand with clay (silty clay) (SP-SC). The initial parameter of the river water falls under class II in INWQS where further water treatment is needed. The final results for the water quality parameters by natural soil are: Turbidity; 2.75 NTU, Colour; 38 PtCo, TSS; 0 mg/L and TDS; 117.26 mg/L. While the final results for the water quality parameters by modified soil with AC are Turbidity; 7.06 NTU, Colour; 73.8 PtCo, TSS; 17 mg/L and TDS; 111.2 mg/L. Although the value for turbidity and colour is slightly higher than the maximum value in INWQS, all other parameters are in the range of class I where no further treatment is needed. The quality and appearance of the river water was improved after filtering and thus the natural soil and modified soil with AC can be used as filtration media in the construction of RBF system in treating Sungai Belat.

ABSTRAK

Air amat penting dalam kehidupan seharian kita. Permintaan untuk kualiti air yang baik meningkat berikutan peningkatan penduduk, perbandaran yang pesat, perkembangan industri dan perubahan iklim. Salah satu daripada sumber utama air datang dari permukaan air seperti sungai, tasik dan kolam. Kualiti air sungai adalah satu parameter penting yang perlu dipelihara dan dipantau. Dalam usaha untuk meningkatkan kualiti air, rawatan air perlu dijalankan. Air dari sungai biasanya dirawat secara konvensional menggunakan bahan kimia untuk penyingkiran pepejal terampai dan bahan pencemar lain. Salah satu cara alternatif untuk meningkatkan kualiti air dari sungai-sungai adalah dengan menggunakan kaedah tapisan tebing sungai (RBF). Ia digunakan sebagai alternatif untuk teknologi rawatan minum air yang cekap dan ekonomik. Kecekapan sistem RBF bergantung kepada jenis dan jenis tanah tinggal di tepi sungai. Oleh itu, kecekapan mungkin berbeza-beza dan beberapa pengubahsuaian yang diperlukan dalam mencapai keupayaan rawatan berpatutan. Dalam kajian ini, tanah dari tebing Sungai Belat diambil dan keberkesanan dalam meningkatkan kualiti dan rupa sampel air telah dikaji. Tambahan pula, campuran AC juga telah digunakan untuk mengubah suai tanah. Beberapa ujian, iaitu ujian penjerapan dan penapisan ujian telah dijalankan di makmal untuk menentukan keberkesanan kedua-dua bahan media RBF. Dalam kajian ini, empat parameter telah digunakan iaitu kekeruhan, warna, jumlah pepejal terampai (TSS) dan jumlah pepejal terlarut (TDS) dan kemudian dibandingkan dengan INWQS. Ujian Makmal menunjukkan bahawa, keputusan keseluruhan menunjukkan jenis tanah telah digredkan sebagai pasir dengan tanah liat (tanah liat berkelodak) (SP-SC). Parameter awal air sungai jatuh di bawah kelas II dalam INWQS di mana rawatan air lanjut diperlukan. Keputusan akhir bagi parameter kualiti air dengan tanah semula jadi adalah: kekeruhan; 2.75 NTU, Warna; 38 PtCo, TSS; 0 mg/L dan TDS; 117.26 mg/L. Keputusan akhir bagi parameter kualiti air dengan tanah diubahsuai dan AC adalah kekeruhan; 7.06 NTU, Warna; 73.8 PtCo, TSS; 17 mg / L dan TDS; 111.2 mg / L. Walaupun nilai untuk kekeruhan dan warna adalah lebih tinggi sedikit daripada nilai maksimum dalam INWQS, semua parameter yang lain adalah dalam lingkungan kelas I dimana tiada rawatan lanjut diperlukan. Kualiti dan rupa air sungai itu baik selepas penapisan dan dengan itu tanah semula jadi dan tanah diubahsuai dengan AC boleh digunakan sebagai media penapisan dalam pembinaan sistem RBF dalam merawat Sungai Belat.

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LIST OF SYMBOLS

D_{10}	Effective Size
C_U	Uniformity Coefficient
C_C	Coefficient of Gradation
S_0	Sorting Coefficient

LIST OF ABBREVIATIONS

RBF	Riverbank Filtration
AC	Activated Carbon
TSS	Total Suspended Solid
TDS	Total Dissolved Solid
INWQS	Interim National Water Quality Standard
MHM	Ministry of Health Malaysia
ASTM	American Society for Testing and Materials
AASHTO	American Association and State Highway and Transportation Officials
USCS	Unified Soil Classification System

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, it takes so much water to produce anything in our daily lives. Unfortunately, demand for good supply of clean water happened to increase due to an increase in population, rapid urbanization, industrial expansion and climate change. As the source of available water is limited but demand increasing rapidly, Malaysia is facing water problems (Chan, 2006). Currently, there are about 80 clean basins, 59 slightly polluted whereas 7 basins are severely polluted. Several requirements for drinking water quality standard are the water must be clear and does not have objectionable taste, colour and odour. Therefore, water treatment is necessary in order to provide potable water that is safe to drink, pleasant in appearance, taste and odour and cost effective to produce (Ministry of Health Malaysia, 2000).

According to the Safe Drinking Water Formulation, most water treatment plants use combination of coagulation, sedimentation, filtration and disinfection processes to provide clean, safe drinking water to the public. A combination of coagulation,

sedimentation and filtration is the most widely applied water treatment technology, and has been used since the early 20th century.

In order to obtain a sustainable water treatment system, RBF is used for treatment of river water.RBF is a system that consists of extracting water from rivers by pumping wells located in the adjacent alluvial aquifer. Alluvial aquifers are widely used as a groundwater source in many countries. By pumping wells located in an alluvial plain hydraulically connected to a river it is possible to get a hydraulic gradient so that surface water is forced to flow through the bed and the banks of the river (Marcela, 2011).

Most RBF system is constructed in alluvial aquifers located along river-banks. These aquifers can consist of a variety of deposits ranging from sand, sand and gravel, to large cobbles and boulders. The efficiency of RBF system depends heavily on the type and properties of soil resides in the riverbank. Thus, the efficiency might vary from one location to another location and some modification maybe required in achieving reasonable treatment ability. In this study, soil from Sungai Belat riverbank was considered and the effectiveness in improving the quality and appearance of water sample was investigated. Furthermore, AC mixture was also used to modify the soil. Several tests, namely adsorption test and filtration test was conducted in the laboratory to determine the effectiveness of both material as RBF media.

1.2 PROBLEM STATEMENT

Conventional water treatment consists of several processes that require the usage of chemicals. This treatment are often very expensive to construct and operate thus the use of RBF may be considered as an efficient and economical drinking-water treatment technology. However, riverbank material and it nature soil may not be suitable to treat water until standard water quality achieved. Therefore, some modification may be required by mixing other material to improve the performance of RBF.

1.3 OBJECTIVES

The main objectives of this study are:

i. To determine the effectiveness of nature soil as filtration media.

ii. To study the effectiveness of AC as an artificial barrier in improving the quality and appearance of the water.

iii. To compare the changes in water parameter before and after using activated carbon.

1.4 SCOPE OF STUDY

This study involved investigating the performances of soil obtained from Sungai Belat riverbank in treating water. This study also focused in improving the river water by modified soil with Activated Carbon (AC) as the modified barrier at the riverbank. All tests were conducted under laboratory condition. The soil properties and the water quality parameters considered in this study were:

i Soil Properties

- Specific gravity
- Particle size distribution
- Liquid limit
- Plastic limit
- Hygroscopic water content

ii Water Quality Parameters

- Turbidity
- Colour
- Total Suspended Solid (TSS)
- Total Dissolved Solid (TDS)

1.5 THESIS LAYOUT

This thesis consists of five chapters. The first chapter explained about the sources and demand of drinking water in Malaysia as well as the needs of good quality of water in our daily lives. It also brief about the water treatment used in this research which is RBF. This chapter stated clearly the objectives as it will be the guidance along the process in completing this research. This chapter also state problem statements that explain the causes why this study should be conducted and followed by the scope of study which elaborate the specific point of this research.

Chapter 2 briefly explained about all the important aspects of RBF, the purpose, advantages and disadvantages of RBF. This chapter also stated the properties of AC as the artificial barrier in RBF and the use of AC in water treatment.

Chapter 3 which is research methodology discusses the detail of the properties of soil and water quality parameters used in this study. 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 detailed of experimental set-up followed by the procedure of this study also included in this chapter.

Chapter 4 briefly stated the results and discussions of this study. This chapter will be helpful in determining the efficiency of the natural soil and AC in removing the turbidity, colour, TSS and TDS in Sungai Belat. This chapter also indicates the water quality parameters and the differences of the river water before and after treatment.

The conclusions and recommendations have been made based on the results in the previous chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describes a general overview on water supply in Malaysia, water treatment techniques, artificial barrier and water quality standard. This chapter also briefly describes about riverbank filtration system and activated carbon as the artificial barrier.

2.2 WATER SUPPLY

Water is available in abundance all around the world. Lack of clean water causes more death in the world than war. About 1 out of every 6 people living today do not have enough access to water, and more than double that number lack basic sanitation for which water is needed. For example, they need the water to satisfy their basic needs of drinking, cooking, washing and bathing (National Academy of Engineering, 2012). According to the Jabatan Bekalan Air Malaysia, they constantly struggled to make sure

that they will provide sufficient, safe, quality and reliable water supply for the whole nation to satisfy the needs of the people and nation.

2.2.1 Water Demand

Nowadays, so much water is used on daily basis (i.e. agriculture, industry, household). The Government's long term objectives for the water industry are to identity and develop enough water resources for all users, preserve and protect the quantity and quality of existing resources as well as to identify and conserve potential water sources to meet the future needs. (Hasnul, 2012). Unfortunately, demand of good quality of water happened due to population explosion, rapid urbanization, industrial expansion and climate change. As the total quantity of available water is limited but demand increasing rapidly, Malaysia is facing water problems (Chan, 2006).

2.2.2 Water Sources

Based on the World Wide Fun for Nature (WWF) in Malaysia, about 97% of raw water supplies are from agricultural, domestic and industrial needs. Most of the water supply in Malaysia comes from rivers and streams. Malaysia has 189 river basins where 89 in Peninsular Malaysia, 78 in Sabah and 22 in Sarawak. Other sources originate from ground water, seawater and rainfall. Groundwater contributes to only 1% of water required (Azrina et al., 2011).

2.3 WATER TREATMENT TECHNIQUES

According to the Water Environment Partnership in Asia (WEPA), 80 river basins (55%) were clean, 59 (40%) slightly polluted and 7 (5%) were polluted. It shows that there are still a lot of polluted river in Malaysia do not achieved the water quality standard. Some of the requirements for water quality standard for drinking water are the water must be clear and does not have objectionable taste, colour and odour (Ministry of Health Malaysia). Hence, water treatment is indeed important in order to provide potable water that is safe to drink, pleasant in appearance, taste and odour and cost effective to produce. There are different types of water treatment had been conducted all around the world especially Malaysia. Some of them are conventional water treatment and riverbank filtration system.

2.3.1 Conventional Water Treatment

Figure 2.1 shows the path that water takes from the intake of the water treatment plant (from the freshwater source) to the storage tank, from which it is pumped to homes, businesses, and industries. According to the Safe Drinking Water Formulation, most of the water treatment plants use a combination of coagulation, sedimentation, filtration and disinfection to provide clean, safe drinking water to the public. A combination of coagulation, sedimentation and filtration is the most widely applied water treatment technology, and has been used since the early 20th century.

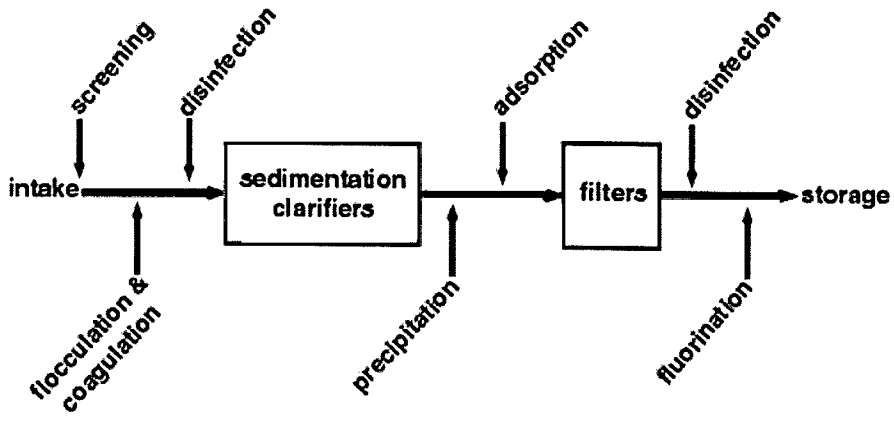

Figure 2.1: Conventional Water Treatment Process

Source: Casiday (2008)

2.3.2 Riverbank Filtration (RBF)

Figure 2.2 describes the flow of the water during the RBF process. RBF is a process during which surface water is subjected to sub surface flow prior to extraction from wells (Weiss et al., 2003). During the underground passage, a series of physical, chemical, and biological processes take place, improving the quality of the surface water, substituting or reducing conventional drinking water treatment. During RBF process, a reduction in the concentration of pollutants is achieved between the surface water and groundwater. There are two different types of RBF. It can be designed either vertically as the most common practice especially for the extraction of low water quantities or horizontally for higher extraction rates. (Jaramillo, 2011). In Malaysia, there are certain states planned to implement the RBF system. Perak is looking forward at expanding the RBF project to extract underground water in all districts specifically in Larut, Matang, Selama and Krian (NST, 2013).

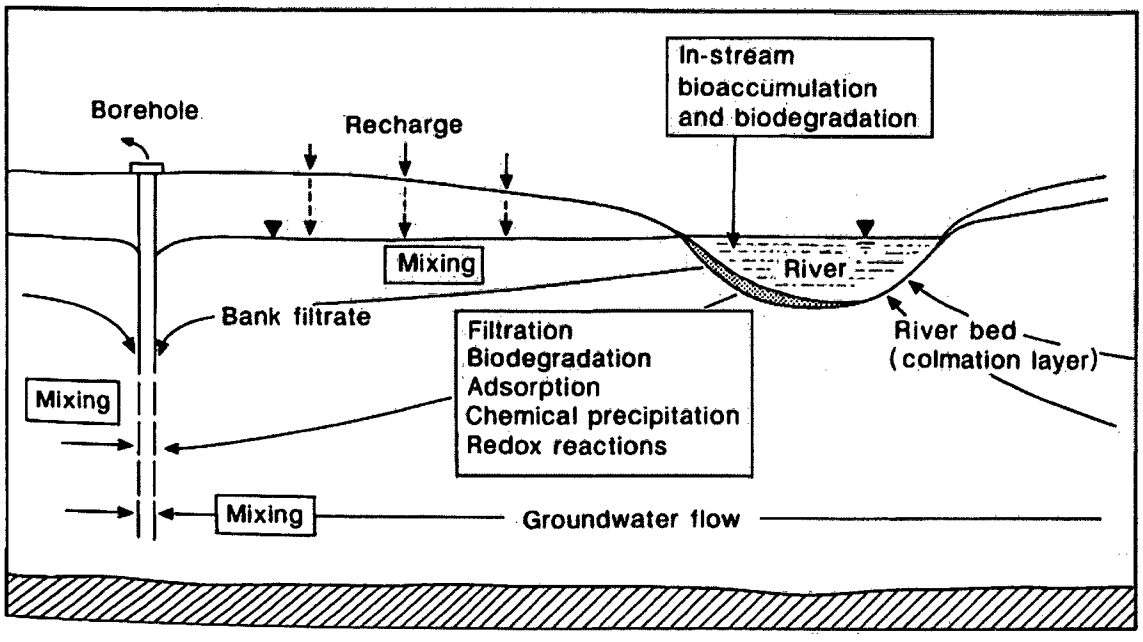

Figure 2.2: Riverbank filtration (RBF) process

Source: Hiscock & Grischek (2002)

2.3.2.1 Purpose of RBF

The main purpose of RBF is clear improvement in water quality in comparison to the direct use of raw water for drinking water (Michael, 2006). In order to improve the quality of the surface water, RBF is suggested as it contains a lot of advantages rather than disadvantages.

2.3.2.2 Advantages of RBF

By comparing RBF with conventional water treatment, there are a lot of advantages can be seen. For example, RBF do not use any chemical substances to purify the water. It can also reduce some of the process involved in the conventional water treatment such as coagulation, flocculation and sedimentation. Therefore, less data are needed for RBF system. The RBF system 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 pollutants. (Jaramillo, 2011).

2.3.2.3 Disadvantages of RBF

The RBF system condition may vary according to the river water and groundwater quality itself. Another disadvantages associated with RBF is the obstruction or clogging of the porous media. There are four types of clogging: mechanical, physical, biological, and chemical. The clogging prevents the water from making its way to the aquifer. (Jaramillo, 2011). Another disadvantage of RBF is the type of soil use at the riverbank. The efficiency of the soil may vary according to its condition. Thus, if the soil is not favourable modification has to be conducted to the soil.

2.4 MODIFIED BARRIER

Most RBF system is constructed in alluvial aquifers located along river-banks. These aquifers can consist of a variety of deposits ranging from sand, sand and gravel, to large cobbles and boulders. Ideal conditions typically include coarse-grained, permeable water bearing deposits that are hydraulically connected with riverbed materials. These deposits are found in deep and wide valleys or in narrow and shallow valleys. RBF systems in deep and wide valleys may have a wider range of options since wells (vertical and horizontal collector wells) can be placed at greater depths which can provide higher capacities and can be placed further away from the river to increase the degree of filtration.of large or small scale RBF. The production well will be constructed to collect the water from RBF and the number of production wells will be based on population demand. Typical aquifers used for RBF consist of alluvial sand and gravel deposits with a hydraulic conductivity greater than approximately 10 m/day (Nordin et al., 2013).

2.4.1 Properties of AC

AC is a natural material obtained from bituminous coal, lignite, wood and coconut shell which activated by steam or other method. The quality and use of AC is evaluated on a number of criteria depends on their intended use. The density of AC depends on the volume of adsorption process. The greater the particle sizes of an AC, the greater the access to surface area, and the faster the rate of adsorption by the material. The physical size of the carbon can significantly impact its resistance to flow within a system. When the size of AC is smaller, the resistance to flow and the adsorption is greater (Desilva, 2000). The biggest application of AC is in the purification of water as well as the artificial barrier in RBF (Cabot, 2013).

2.4.2 The use of AC in Water Treatment

AC filter is one of the well established treatment techniques and is primarily functions to remove taste and odour (Water Treatment Engineering and Research Group, 2010). Nowadays, AC filters have been used to remove some of the contaminants that have been discovered in water supplies. According to (Zhang, 2008), AC is used in drinking water treatment for the removal of synthetic organic compounds (SOC_S), disinfection by products (DBP_S) and undesirable taste and odour. The chemical and physical properties of AC are different depends on the nature of raw material used, the nature of the activating agent and the conditions of the activation process. In addition, AC is recommended as a good option for the removal of some pharmaceuticals and endocrine disrupting compounds in drinking water treatment (Yu, 2007).

2.5 WATER QUALITY STANDARD

Water quality standard is indeed important in order to ensure all the treated water complies with standard. Clear and does not have objectionable taste, colour and odour is one of the most important aspects in drinking water. It must be free from all harmful organisms, chemical substances and pleasant to drink (MHM, 2004). The quality and appearance of the water are measured and classified based on INWQS to identify the effects of AC as the artificial barrier on the water quality condition (Fawaz et al.,2013).

2.5.1 Interim National Water Quality Standard (INWQS)

The National Water Quality Standards, which is applied to surface water, contain standard values of 72 parameters in 6 water use classes. The goal is not to meet the standards of the certain water class in all surface waters, but to improve water quality gradually in order to meet the standards of the better water class than the actual. In my cases, there are certain parameters that are related to the appearance of the water such as colour, turbidity, TSS and TDS.