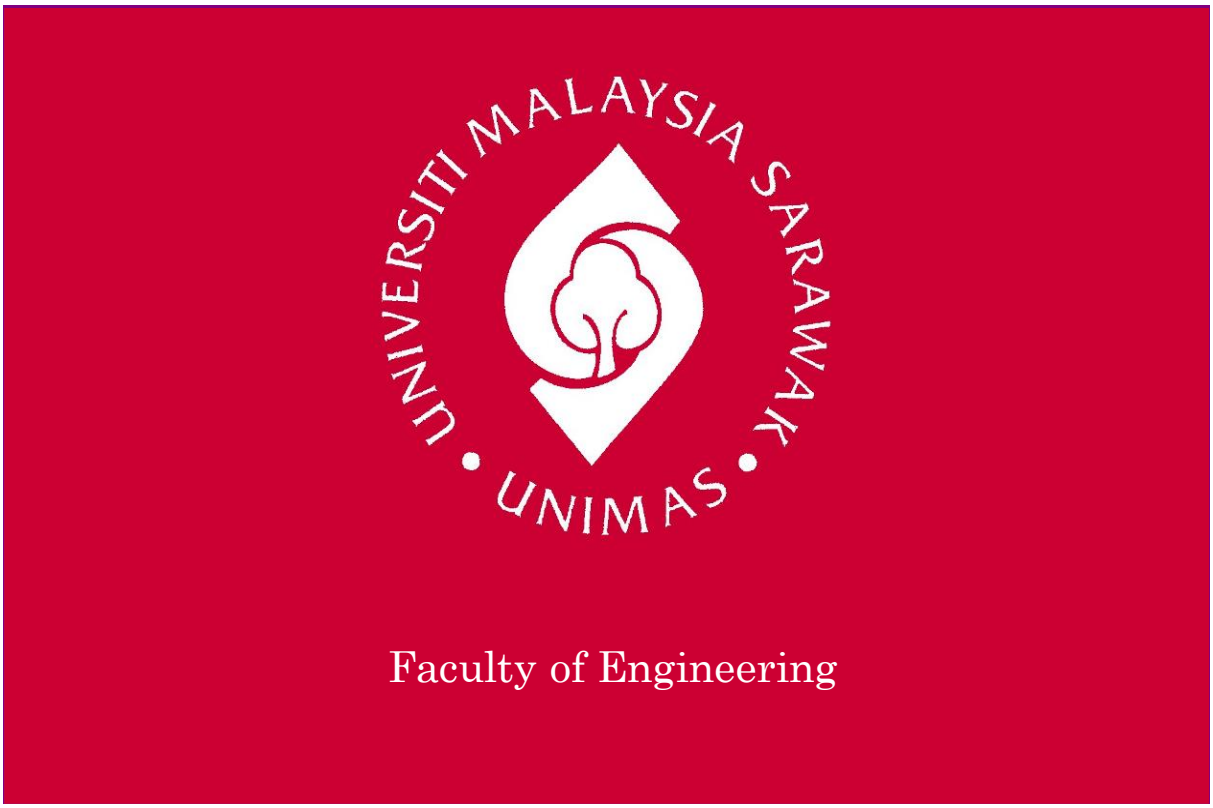

DEVELOPMENT OF WATER FILTRATION SYSTEM CONFIGURATION FOR RURAL SCHOOL IN SARAWAK

Alick Davidson anak Elciana

Bachelor of Engineering with Honours

(Chemical Engineering)

2020

UNIVERSITI MALAYSIA SARAWAK

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(Final Year Project Supervisor)

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DEVELOPMENT OF WATER FILTRATION SYSTEM CONFIGURATION FOR RURAL SCHOOL IN SARAWAK

ALICK DAVIDSON ANAK ELCIANA

A thesis is submitted in partial fulfillment
of requirements for the degree of
Bachelor of Engineering with Honours
(Chemical Engineering)

Faculty of Engineering
Universiti Malaysia Sarawak

2020

Dedicated to my beloved parents, family and friends, who always bestow me sustainable motivations and encouragements

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ABSTRACT

The rapid growth of population and urbanization lead to increasing industrialization and agricultural activities. The revolution in these aspects leading to the contamination of natural sources of water due to human interference activities. Toxic pollutants contaminate the available water sources such as rainwater. Therefore, this leading to the shortage of freshwater supply for bathing, cooking and drinking. In order to fulfil the demand for water supply, this sources of water should undergo light pre-treatment using pressurize water filtration system. The water parameters such as pH, turbidity, total suspended solids, biochemical oxygen demand, chemical oxygen demand and heavy metal concentration will be measured before treatment to get the information on the pollution level in the water sources. Then, the water parameters will be assessed after the filtration process in order to get the effective configuration of the filtration system in terms of number of cycle in series to treat the polluted water to comply with raw water supply standard in accordance to Ministry of Health Malaysia.

ABSTRAK

Kadar pertumbuhan populasi dan pembandaran menyebabkan peningkatan kegiatan perindustrian. Revolusi yang berlaku dalam aspek ini akan menyebabkan pencemaran sumber air semula jadi disebabkan oleh kegiatan manusia yang tidak bertanggungjawab. Sumber air sedia ada seperti air hujan telah dicemari dengan sisa-sisa pencemar toksik. Oleh sebab itu, berlaku kekurangan bekalan untuk bekalan air bersih untuk mandi, makan dan minum. Oleh itu, bagi memenuhi keperluan untuk bekalan air bersih, sumber-sumber air ini seharusnya menjalani proses rawatan ringan seperti sistem penapisan air bertekanan. Parameter air seperti pH, tahap kekeruhan, jumlah pepejal terampai, permintaan oksigen biokimia, permintaan oksigen kimia dan kandungan logam berat dalam air akan diukur sebelum proses penapisan untuk mengetahui tahap pencemaran air tersebut. Kemudian, parameter air itu akan diukur sekali lagi selepas proses penapisan untuk mendapatkan maklumat mengenai kecekapan sistem penapisan air tersebut sekaligus mendapatkan konfigurasi sistem penapisan air yang berkesan dari segi bilangan kitaran penapisan dalam konfigurasi selari untuk merawat air tercemar agar mematuhi standard bekalan air mentah Kementerian Kesihatan Malaysia.

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LIST OF ABBREVIATIONS

AC	-	Activated Carbon
BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
DO	-	Dissolved Oxygen
DOE	-	Department of Environment
E-coli	-	*Escherichia coli*
PPE	-	Personal Protective Equipment
RM	-	Ringgit Malaysia
RWHS	-	Rainwater Harvesting System
TDS	-	Total Dissolved Solids
TSS	-	Total Suspended Solids
UNIMAS	-	Universiti Malaysia Sarwak
USA	-	United States of America
VOC	-	Volatile Organic Compound
WWF	-	World Wide Fund

LIST OF NOMENCLATURE

kg	-	Kilogram
mg/L	-	Milligram per litre
NTU	-	Nephelometric Turbidity Units
$\mu S cm^{-1}$	-	Microsiemens per centimetre
FTU	-	Formazin Turbidity Units

CHAPTER 1

INTRODUCTION

1.1. Background of Study

The rapid growth of population and urbanization together with industrialization evolution demands for more water supply especially for drinking, cooking, bathing and any other household usage. Industrial activities need water as the supply for process and manufacturing or for cooling process to occur. However, due to human interference and industrialization is one of it, the available water sources had contaminated with pollutants that can give adverse effects to the health and ecological. Five water sources that are usually used for utilities in everyday life are river water, mountain water, groundwater, rainwater and lake water will be assessed its physicochemical properties in order to gather information on the level of pollution and factors affecting it. The focus of water source in this research work is rainwater.

The water sample from rainwater will be collected and assessed accordingly to the water parameters such as pH, turbidity, TSS, BOD, COD, Iron (Fe) and Manganese (Mn) concentration in the water. Such information is very useful to determine the type of pre-treatment used, which is direct filtration. The mass of filter media such as silica sand, activated carbon and zeolite to filter the polluted water was given as in Table 1.1 and the number of cycle in series for the filtration process will remain unknown until the treated water is comply with the raw water quality standard. The usage of zeolite and AC is due to their excellent adsorption capability especially to remove toxic contaminants. Silica sand in the other hand is low cost. From Table 1.1, the most bottom part of the filter tank will be filled with 9kg of silica sand of 0.6mm that covers 20% of the total media space, followed by 31.5kg of silica

sand 2.3mm that covers 70% of the total media space. Next is AC layer that covers 5% of total media space (2.25kg) and the same mass for zeolite on the most top layer of the media. Therefore, the total mass of media inside the filter tank is 45kg that covers 80% of the total space inside the filter tank. 20% of the space on the very top of the filter tank is intentionally remained empty. The mass of every filter media as in Table 1.1 is used along the experimental work without changing it.

Table 1.1: Filter Media Mass Used in the Filtration System

Filter Media	Percentage (%)	Mass (kg)
Zeolite	5	2.25
AC	5	2.25
Silica sand 2.3mm	70	31.50
Silica sand 0.6mm	20	9.00
TOTAL	100	45.00

After the treatment process, the physicochemical properties of water will be check again to ensure the efficiency of the system and most importantly to know the effective number of filtration cycles to treat water by complying with the raw water supply standard. Lastly, there will be analysis of the result of the water physicochemical properties that will be discussed further in Chapter 4: Results and Discussion.

1.2. Problem Statement

The limited availability of freshwater supply leading to increasing demand for treated water to be used for potable usage. This limitation is due to the increasing population, rapid urbanization and industrial together with agricultural activities that lead to the pollution of water sources. Besides that, scarcity of treated water for potable use is also due to treated water also being use for non-potable purposes.

The most abundant water source for residence in rural area is rainwater. Rainwater that being collected using rooftop in rainwater harvesting system (RWHS) is contaminated due to roof catchment system. Toxic gases also dissolved in the rainwater leading to the degradation of the quality of rainwater. When the rainwater falls into river basin, the river basin is contaminated with eroded soil due to development and agricultural activities nearby. The situation become worse during

rainy season because the amount of eroded soil will be increased that leads to brownish colour of water. The brownish colour of water has high turbidity and suspended solids. Industrial activities nearby the water source, which is river basin will release small amount of heavy metal waste such as iron and manganese that will accumulated within a long period and become carcinogenic if consumed. The pH of water will decrease due to agricultural and household waste release. Due to high amount of suspended solids in the water source, eventually the BOD and COD will also increase. Therefore, an efficient pre-treatment with effective number of treatment cycle is needed for the freshwater management principle in order to remove the contaminants and brings back the clean water supply.

1.3. Objectives

There are three objectives formulated for this study in order to solve the problem arises in the problem statement. The objectives are:

i. To study the water quality parameters for rainwater source that falls into the river basin and factors affecting it;
ii. To treat the contaminated rainwater source that contained eroded soil in the river basin by filtration and comply with the raw water supply standard; and
iii. To find the effective number of filtration cycle to treat the contaminated rainwater source to comply with raw water supply standard.

1.4. Scope of Study

The scope of this study encompasses research on effective number of filtration cycle to filter the contaminated of rainwater source that contained eroded soil when falls into the river basin. The source of collecting water sample is carried out at the Department of Chemical Engineering and Energy Sustainability, Faculty of Engineering, UNIMAS. The water is then mixed with clay soil in order to immitate the real case situation in Ulu Balingian and Balleh in Sarawak. The water will be treated using simple pressurize water filtration system with filter media such as silica sand, activated carbon (AC) and zeolite. The flow of the water into the filter tank is upflow. The parameters involved in this study will be pH, turbidity, TSS, BOD,

COD, Iron and Manganese. The experimental work will be carried out at Unit Operations Lab (carry out filtration), Analytical Chemistry Lab (carry out heavy metal concentration test) and Basic Chemistry Lab (to conduct other physicochemical properties test of the water), Department of Chemical Engineering and Energy Sustainability. The experimental data will be discussed thoroughly to investigate the effective number of filtration cycle in series configuration to treat the contaminated rainwater with eroded soil.

1.5. Research Gap

The research gap of this study is that this study will provide the effective number of filtration cycle in series configuration to treat the contaminated rainwater with eroded soil. Furthermore, the catchment for rainwater collection for this study will be using direct catchment as many literatures were using rooftop catchment that will wash away the dirt particles from the roof and decrease the purity of rainwater. The rainwater will be intentionally contaminated with clay soil in order to follow the real case situation in Ulu Balingian and Balleh that has brownish water due to rainy season that caused soil erosion.

1.6. Summary

In this chapter, the general overview of this study was mention. The main objective of this study is to find the suitable and effective number of filtration cycle in series configuration in order to treat the polluted rainwater with eroded soil until it comply with the raw water supply standard.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter gives an overview on the conditions of five water sources in Malaysia and particularly Sarawak. All the five water sources namely river water, mountain water, groundwater, rainwater and lake water are very essential for potable used and need to be treat due to its polluted condition. The focus of this research is on contaminated of rainwater source with eroded soil when falls into river basin. The type of treatment introduce is pressurize water filtration system using multi-media such as silica sand, activated carbon and zeolite. The characteristic of the pressurize water filtration system is discuss in this chapter together with the effectiveness of each filter media. Besides that, the most important part is the assessment of the physicochemical properties of the water sources before treatment will provide information on the level of pollution of the rainwater source contained eroded soil while the assessment of water parameters after filtration will provide information on the filter efficiency. The effective number of filtration cycle will be recorded as if the treated water comply with the raw water quality standard.

2.2. Sources of Water in Sarawak

The increasing in the number of population resulted from a very rapid urbanization process in Sarawak had led to increasing demand for water supply either for raw water supply or drinking water supply every year. According to Mahyan and Selaman (2016), the existing water resources in Sarawak are surface water, groundwater and rainwater. Surface waters are water on the Earth's surface such as

streams like rivers, lakes and reservoirs and wetlands. Lake water is in the category of surface water as it is located within or nearer a river basin although lake has its own basin. Therefore, the water quality standard for lake water will follow the water quality standard for river water as stated by Huang et. al (2015) since the lake water does not has its own quality standards. Surface water is the main water resources in Sarawak, followed by groundwater and lake water. Rainwater in the other hand is the alternative supply of water sources especially in rural areas in Sarawak as mentioned by Mahyan and Selaman. Surface water especially river water was used for domestic purposes, agricultural activities, inland transport system and industrial usage as clarified by Isyiaka and Juahir (2015).

2.2.1. River Water

River water in Sarawak provides continuous water supply as it dominates the majority of area in Sarawak. As an addition, Sarawak rivers also provides hydroelectric power (Bakun dam, Murum dam and Batang Ai), irrigation and rich soil. According to WWF Malaysia (2014), rivers in Sarawak especially the 560-km Batang Rajang provides natural habitat to marine species and acts as an economic source to the local people. These has been proved in the statement by WWF Malaysia stated that Sarawak's rivers became the habitat for the world's second smallest freshwater fish namely *Paedocypris micromegthes*. In addition, rivers in Sarawak also become the source to harvest 387 tonnes of fish and crustaceans worth RM2.299 million in 2011. Despite of all the specialities provided by the river water, the human interference activities had cause the degradation of its water quality. There were many factors affecting the decreasing quality of river water in Sarawak. By considering the main biggest river, which is Batang Rajang, it has low dissolved oxygen (DO) level due to the impact of of the releasing of Bakun dam water that has low DO level as stated by Ling et. al (2017). Ling et. al (2016) in the Sains Malaysiana journal mentioned that the amount of DO decreased as the depth of Bakun dam increased because oxygen that dissolved being used to decompose organic matter at the bottom and it is not replaceable due to stratification that gives