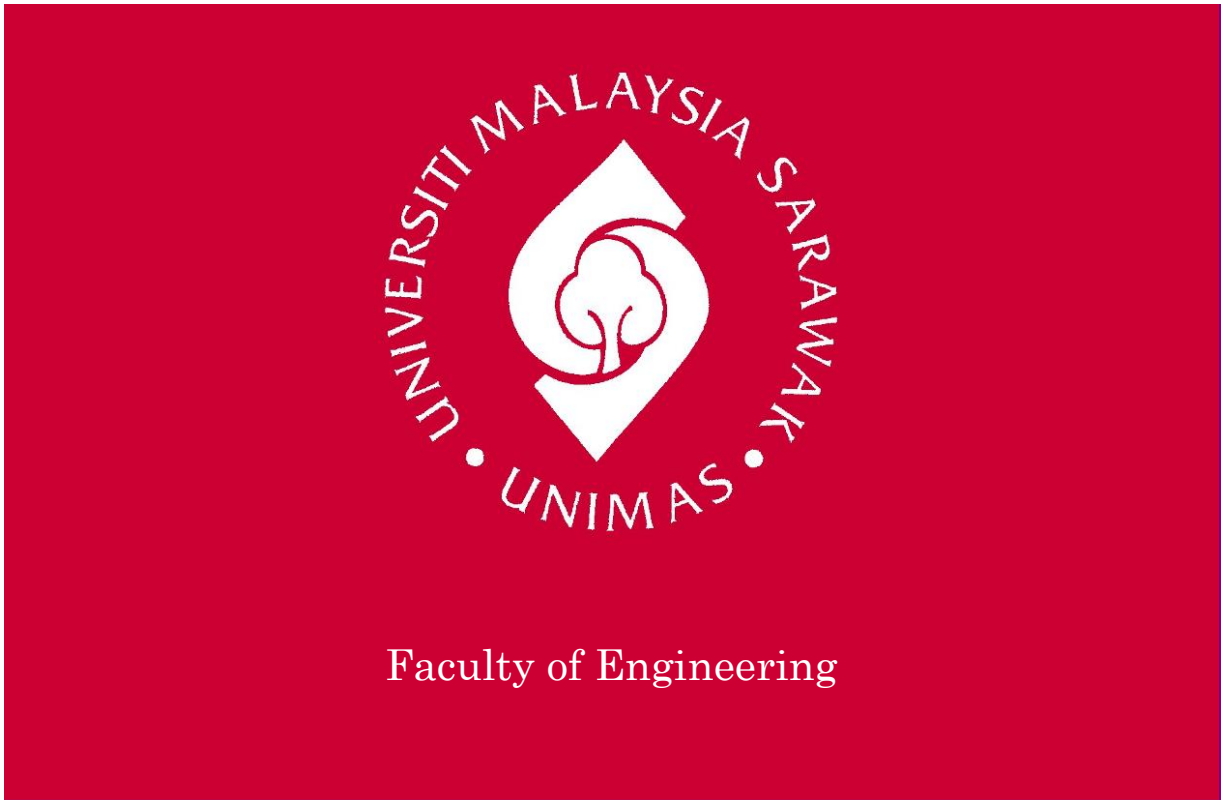

STUDY OF THE INFLUENCE OF FILTER MEDIA RECYCLABILITY ON THE QUALITY OF TREATED WATER

Benedict Anak Jerry

Bachelor of Engineering (Chemical Engineering)

with Honours

2022

UNIVERSITI MALAYSIA SARAWAK

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STUDY OF THE INFLUENCE OF FILTER MEDIA RECYCLABILITY ON THE QUALITY OF TREATED WATER

BENEDICT ANAK JERRY

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering (Hons)
Chemical Engineering

Faculty of Engineering
Universiti Malaysia Sarawak

2022

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

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ABSTRACT

Population growth, urbanization, industry, and irrigation agriculture have all caused the rise in the need for treated water resources. In addition, there is a shortage of treated water for potable water use where treated water is also used for non-drinking purposes. Most water sources in Sarawak are severely affected due to aquaculture, household sewage, and fertilizers from agricultural activities, all of which contribute to the increase in solid waste and suspended chemicals. These factors have contributed to the reduction of river water quality in Malaysia, especially in Sarawak. The presence of contaminants in water leads to the critical need for an efficient water filtration process. The project studies the water quality parameters of different water sources such as rivers, lakes, rainwaters, etc. The water quality parameters can be categorized mainly into three main categories which are physical (turbidity), chemical (pH, hardness, BOD, COD, TSS, iron concentration, copper concentration, and manganese concentration), and biological (E. coli) properties. The separate filter media filtration system was used to study the media performance. It was found out that the silica sand 0.6mm media were effective for turbidity, TSS, hardness, and BOD reduction. Apart from that, the activated carbon was efficient for E. coli treatment, whereas the zeolite media was better in pH and COD removal. On the other hand, most filter media managed to treat a water sample to comply with the raw water quality standard after the first cycle except for COD and BOD treatment. Lastly, this study shows the operating conditions and the quality of treated water for all media have a very high negative correlation, where the overall water quality decreases as the filtration cycle increases. Therefore, the improvement of the existing filter media must be implemented by studying the appropriate water treatment cycle process to improve the quality of treated water in meeting the requirement set by the Department of Environment Malaysia.

Keywords: water filtration system, filter media, water quality, water treatment cycle

ABSTRAK

Pertumbuhan penduduk, pembandaran, perindustrian, dan pertanian pengairan semuanya telah menyebabkan peningkatan dalam keperluan sumber air bersih terawat. Selain itu, terdapat kekurangan air terawat untuk kegunaan air minuman di mana air terawat juga digunakan untuk tujuan yang lain. Kebanyakan sumber air di Sarawak terjejas teruk disebabkan oleh akuakultur, kumbahan isi rumah, dan baja daripada aktiviti pertanian, yang semuanya menyumbang kepada peningkatan sisa pepejal dan bahan kimia terampai. Faktor-faktor ini telah menyumbang kepada penurunan kualiti air sungai di Malaysia khususnya di Sarawak. Kehadiran bahan cemar dalam air membawa kepada keperluan kritikal proses penapisan air yang cekap. Projek ini mengkaji parameter kualiti air bagi sumber air yang berbeza seperti sungai, tasik, air hujan dan lain-lain. Parameter kualiti air boleh diklasifikasikan kepada tiga kategori utama iaitu fizikal (kekeruhan), kimia (pH, kekerasan, BOD, COD, TSS, kepekatan besi, kepekatan kuprum, dan kepekatan mangan), dan sifat biologi (E. coli). Sistem penapisan media penapis berasingan telah digunakan untuk mengkaji prestasi media. Telah didapati bahawa media pasir silika 0.6mm berkesan untuk kekeruhan, TSS, kekerasan, dan pengurangan BOD. Selain itu, karbon teraktif adalah cekap untuk rawatan E. coli, manakala media zeolit lebih baik dalam penyingkiran pH dan COD. Sebaliknya, kebanyakan media penapis berjaya merawat sampel air untuk mematuhi piawaian kualiti air mentah selepas kitaran pertama kecuali rawatan COD dan BOD. Akhir sekali, kajian ini menunjukkan keadaan operasi dan kualiti air terawat untuk semua media mempunyai korelasi negatif yang sangat tinggi, di mana kualiti air keseluruhan menurun apabila kitaran penapisan meningkat.Oleh itu, penambahbaikan media penapis sedia ada perlu dilaksanakan dengan mengkaji proses kitaran rawatan air yang sesuai bagi meningkatkan kualiti air terawat dalam memenuhi keperluan yang ditetapkan oleh Kementerian Kesihatan Malaysia.

Kata kunci: sistem penapisan air, media penapis, kualiti air, kitaran rawatan air

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LIST OF ABBREVIATIONS

Ag_2SO_4	-	Silver Sulphate
As	-	Arsenic
BOD	-	Biological Oxygen Demand
CDOM	-	Coloured Dissolved Organic Material
CFU	-	Colony Forming Units
CO_2	-	Carbon Dioxide
CO_3^{2-}	-	Carbonate
COD	-	Chemical Oxygen Demand
Cu	-	Copper
DO	-	Dissolved Oxygen
DOE	-	Department of Environment
E. Coli	-	Escherichia Coli
EDI	-	Electrodeionization
EPA	-	Environmental Protection Agency
FAAS	-	Flame Atomic Absorption Spectroscopy
Fe	-	Iron
HCO_3^-	-	Bicarbonate
H_2SO_4	-	Hydrogen Sulphate
$K_2Cr_2O_7$	-	Potassium Dichromate
Mn	-	Manganese
MOH	-	Ministry of Health
NH_3^-	-	Ammoniacal Nitrogen
NH_4^+	-	Ammonium Ion
NTU	-	Nephelometric Turbidity Unit
NQWS	-	National Water Quality Standards
O_2	-	Oxygen
ppm	-	part per million
RSF	-	Rapid Sand Filtration

SDI	-	Silt Density Index
SS	-	Suspended Solid
SSF	-	Slow Sand Filtration
TDS	-	Total Dissolved Solid
TSS	-	Total Suspended Solid
UNIMAS	-	Universiti Malaysia Sarawak
UV	-	Ultraviolet

LIST OF NOMENCLATURE

^{o}C	-	Centigrade
%	-	Percentage
cm	-	centimetre
g	-	gram
km^2	-	square kilometers
m	-	meter
mg/L	-	milligram per liter
mg/LN	-	milligram per liter nitrite
mL	-	milliliter
mm^3	-	cubic millimeters
MPN/100 mL	-	Most Probable Number per hundred milliliters
nm	-	nanometer

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Safe water supply is essential to the preservation of human life and support conditions of neighbourhood orders. Drinking water treatment is a confusing issue, and the treatment chain includes a couple of cycles, which vary depending upon the establishment, the ejection centres on debasements and the costs identified with them. In 1854, it was tracked down that a cholera pandemic spread through water. The scene had all the earmarks of being less genuine in areas where sand channels were presented (Ighalo & Adeniyi, 2020). This exposure provoked governments to present common water treatments like sand filtration and chlorination, and thus the vitally informal law of public water. From here on out, among water treatment chains, filtration has set up the point of convergence of drinking water treatment alongside sterilization for significantly longer than a century.

Water filtration is an obstacle for presumably the most broadly perceived issues experienced in the water supply industry, concealing, turbidity, and damaging microorganisms being the crucial ones among them. Filtration expects a huge part of the multi-obstacle approach used for the ejection of microorganisms (Hluštík & Novotný, 2018). The presence of suspended solids and any particulate matter forms the resistance of most microorganisms to disinfection. In like manner, a low atom departure execution by granular filtration can reduce cleansing capability. Henceforth, researchers have been pursuing dealing with the viability of the filtration estimates which are at present used. A couple of systems have been taken. From one perspective, filtration has revolved around crafted by more effective conventional media. Various changes have been performed on determining the effective water treatment cycle, pulling out from the standard granular media filtration towards the utilization of films and strands (Yu et al., 2019).

Usage of treated water is searched for where unequivocal issues related to the unrefined water make its allure and are more affordable, which game plans have wound up being insufficient. Without a doubt, quick granular filtration is often continued as a roughing

treatment to ensure the ejection of poisons that could risk the uprightness of the films. Mostly, filtration uses granular media for designing filtration systems, similar to sand, in either fast or slow channels, dependent upon the stream rate applied (Tan et al., 2017). In addition, twofold media arrangements, recollecting a layer of anthracite at the top part and an additional third thick layer of rock at the bottom part, have been commonly used. While these courses of action are still extensively used all over the world, the effect of rapid development has caused them to be reliable and effective with continuous changes to the authorization. A general push towards higher efficiencies also provokes an examination concerning distinctively producing the expected results. This raises the impact of channel media recyclability on regarded water quality, as the channel media recyclability can expand the productivity of the filtration cycle by making it savvier and asset touchy (Dong et al., 2017). As the interest in the water continuously rises, this will undoubtedly turn out to be more significant for the different water treatment processes, which makes this review a significant piece of the course of progress.

1.2 Problem Statement

Population growth, urbanization, industry, and irrigation agriculture have all caused the rise in the need for treated water resources. In addition, there is a shortage of treated water for potable water use, where treated water is also used for non-drinking purposes. Most rivers in Malaysia, especially in Sarawak, are severely affected because of aquaculture, household sewage, and fertilizers from agricultural activities, all of which contribute to the increase in solid waste and suspended chemicals. These factors have contributed to the reduction and aggravation of river water quality in Sarawak. This has made it increasingly difficult to use water directly for daily uses, such as sanitation, drinking, and agricultural purposes. In addition, rain in Sarawak may also contain sulphur dioxide and nitrogen oxides, which can cause acid rain. This is another issue that affects the quality of river water in the state. The increase in pollution that leads to acid rain will then increase the pH level of the water and make it unsuitable for drinking or direct use. Water treatment plants need to be developed to allow water to be treated so that it is safe to drink and use for daily activities. Those living in rural areas may have difficulty gaining clean water because of the long distance from their homes and the difficulty of distributing treated water from water treatment plants. The solution to this problem is to use rainwater sources, which are one of the most accessible water sources, especially in rural areas, and affordable as it is free to use. However, most of the stagnant and stored rainwater piles have come into contact with the rooftop. The unsanitary condition of the

rooftop caused the water used to be slightly contaminated. From that, the water may pick up soluble and insoluble contaminants. Therefore, the improvement of the existing filter media must be implemented by studying the water treatment cycle process to improve the quality of treated water.

1.3 Objectives

Three objectives have been developed for this study to answer the problem stated in the problem statement. The objectives are:

i. To set up the experimental procedure to meet the project objective
ii. To evaluate the influence of the filter media recyclability on the quality of treated water
iii. To formulate the correlations between the operating conditions and the quality of treated water

1.4 Scope of Study

This study includes treating a water sample (river/soil water) by using a separate media filtration system. The water sample collection process will be done at the Department of Chemical Engineering and Sustainability Engineering UNIMAS, Faculty of Engineering. Then, the collected water sample will be mixed with soil in the laboratory to simulate the actual state of river water in Sarawak. The water will go through a treatment phase using a filtration system that contains several filter materials. Some important parameters analyzed in this study are pH, turbidity, BOD, COD, hardness, amount of suspended solid, metallic elements, and E Coli. created on water quality metrics. This step is very important to verify that the water quality parameters are successfully treated by following the prescribed water quality standards set by the Ministry of Health Malaysia. The experiments will be conducted at the UNIMAS Fluid Mechanics Laboratory, Analytical Chemistry Laboratory and Basic Chemistry Laboratory. Each experimental finding will be carefully examined and that information will improve a filtration system that can treat the water accordingly in meeting the raw water quality set by the Ministry of Health Malaysia. This also allows the filtration system to be used for non-potable purposes while being ecologically friendly. Finally, a few suggestions to improve the efficiency of the system will be made.

1.5 Research Gap

This study is to identify water quality analysis for rainwater falling into river basins. Water quality parameters for rainwater were pH, turbidity, BOD, COD, TSS, iron (Fe) concentration, copper (Cu) concentration, manganese (Mn) concentration, E. coli, and hardness. Rainwater will be mixed with soil to simulate the actual state of rainwater flowing into the Sarawak River, causing soil erosion. Eroded soils are the variable that influences the quality and appearance of precipitation that falls into river basins. A separate media filtration system will treat rainwater samples. The main purpose of the rainwater treatment process is to reduce the turbidity of rain contaminated with brown eroded soil. Finally, the experimental results will be extensively analyzed and reviewed to determine the number of effective filtration cycles that can successfully treat a water sample that complies with raw water quality standards set by the Department of Environment and Ministry of Health, Malaysia.

1.6 Summary

To conclude, the goals of this study are to conduct an experiment that can provide the influence of the filter media recyclability on the quality of treated water and to correlate the operating condition with the quality of treated water. With the goals, a few factors, such as water sources, filtration system, filter media, and water quality parameters, need to be studied.