APPROVAL

I hereby declare that I have read this report and in my opinion, this report is sufficient in terms of scope and quality for the award of Bachelor of Engineering in Mechanical Engineering.

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DESIGN AND DEVELOPMENT OF PORTABLE WATER TREATMENT SYSTEM

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This report is presented in partial fulfilment of the requirement for the

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DECLARATION

I declare that this report entitles "Design and Development of Portable Water Treatment System" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in the candidates of any degree.

Signature : ……

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Date : 16 May 2018

DEDICATION

This report work is dedicated to my beloved father and mother, Mr. Othman Bin Molok and Madam Normah Binti Ismail whose have been a continual source of encouragement and support to overcome the challenges in engineering school and student life.. I am grateful for having you in my life. This work is also dedicated to my friends who have support and always help me. Without whose helpful support, it would not have been possible for me to complete this report.

ABSTRACT

Nowadays, many people suffer the lack of access for a clean drinking water. This problem also may cause to the death. It is happened because they do not have a proper water treatment system. In fact, current water treatment system comes in big scale of size and cannot be transported to the needed place. Therefore, the purpose of this project is to design and develop a portable water treatment system. This project will design a portable water treatment system that will work as well as any other current water treatment system. The outcomes of this project also will fulfil other requirement needed by the people such as reasonable price and easy to handle. A detail study on current water treatment system are made to develop and design the portable water treatment system that will produce a clean drinking water that is in line with the established standard of Water Quality Standard by the Ministry of Health Malaysia (MOH). The chemical dosing involve in the water treatment also must satisfy the guideline from the MOH. The final design of the water treatment system has been prove success as it has pass the analysis process. The final design also has follows all the guideline and requirement. A further study for the dosing process has been assign in order to improve the effectiveness of the final design.

ABSTRAK

Pada masa kini, ramai orang mengalami kekurangan akses untuk air minuman yang bersih. Masalah ini juga boleh menyebabkan kematian. Ia berlaku kerana mereka tidak mempunyai sistem rawatan air yang betul. Malah, sistem rawatan air semasa, datang dalam saiz yang besar dan tidak boleh diangkut ke tempat yang diperlukan. Oleh itu, tujuan projek ini adalah untuk merekabentuk dan membangun sistem rawatan air mudah alih. Projek ini akan merekabentuk sistem rawatan air mudah alih yang akan berfungsi sebaik sistem rawatan air semasa yang lain. Hasil projek ini juga akan memenuhi keperluan lain yang diperlukan oleh pengguna seperti harga yang wajar dan mudah diuruskan. Satu kajian terperinci mengenai sistem rawatan air semasa dibuat untuk membangun dan merekabentuk sistem rawatan air mudah alih yang akan menghasilkan air bersih yang sejajar dengan Standard Kualiti Air yang ditetapkan oleh Kementerian Kesihatan Malaysia (KKM). Dos kimia yang terlibat dalam rawatan air juga mesti memenuhi garis panduan dari KKM. Reka bentuk terakhir sistem rawatan air telah membuktikan ianya berjaya kerana ia telah lulus proses analisis. Reka bentuk akhir juga telah mengikuti semua garis panduan dan keperluan. Satu kajian lanjut untuk proses dos telah diutarakan untuk meningkatkan keberkesanan reka bentuk tersebut.

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SUBSCRIPT	DEFINITION
PAC	Poly Aluminium Chloride
MOH	Ministry of Health
HOQ	House of Quality
PDS	Product Design Specification
ANSI	American National Standards Institute
CATIA	Computer-Aided Three-Dimensional Interactive Application
FEA	Finite Element Analysis
BOM	Bill of Material

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The idea of invention the portable water treatment system comes from the flood that struck Malaysia every year when the monsoon season is happening. The flood will cause the lack of clean drinking water access as the surrounding sources of water are contaminated. During that situation, the access of clean drinking water not only become important but also the needed of clean drinking water increasing compare to the normal situation. The lack of clean drinking water in other countries also brings lead into this creation.

Red Cross (2005) stated that over 1.1 billion people lack access to safe drinking water. It causes over 2.2 million people die from unclean drinking water every year. From these deaths, 90 percent of them are children under five years old. Moreover, 4500-6000 children die from water related diseases as reported by British Broadcasting News.

Nowadays, there are many water treatment processes include reverse osmosis water treatment plant, ultraviolet purification system, household water purifiers and desalination plants. All these products and systems quite expensive and required a specialist to run and control the process. Moreover, the size and the complexity of the systems will limit the portability.

This project will bring into an invention of portable water treatment system that is easy and simple to handle.

1.2 Problem Statement

Water is a substance that is essential for life, yet 1/6 of the global population lacks access to clean drinking water. We are facing a global water crisis. In fact, providing access to a clean drinking water has even identified as one of the 14 grand challenges that our planet is facing. For example in India of Africa, some of the people are drinking the water from a stagnant pool that is surely dirty and contaminated. In Malaysia, majority of the residents can get an access to the clean drinking water supply. Only a small percentage of the resident who lives in an inland having a difficulty to get a clean drinking water access. However, when the Monsoon season arrive, which is usually from November to March, some places like the East Coast states, will experience floods. This is when the lake or river water becomes quick source for drinking water.

For the water treatment system, the current product or the current system comes in big scale of size and some of them needs a big source of current supply to run the system. As a result, the user will have a limitation, as the product only can be use at the particular area. Moreover, the current water treatment systems are expensive. Finally yet importantly, the current water treatment systems are complex to handle and difficult to understand.

1.3 Objective

To design a portable water treatment system.

1.4 Scope of Project

The scopes of this project are:

i. The target water for this water treatment system is the flood in Malaysia residential.
ii. The water treatment system must be portable.
iii. The output water must meet the Drinking Water Quality Standard by MOH.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section explain about the Literature Review of the study based on the journal, books and internet. That information can be achieve through the website and the library. There is a summary of the information or any related knowledge, which can guide and lead the study case.

2.2 Aeration

Generally, aeration is a process of mixing or circulated air with liquid. This method propose was to increase the oxygen saturation of the water. This process bring the liquid and air closely contact by exposing drops or thin sheet. This aeration process consist two method to collect the oxygen into the system. There is passing the liquid through air such as fountains, paddle wheels or cascades. Secondly, the passing air through the liquid such as venture tube or compress air. The first method is absorption of oxygen when the water coming out of the fountain and return back into the tank. Next, the second method is, there is tube of ceramic and combine with the diffuser in purpose to dispersion the fine air or gas bubble into liquid. In this case, there is small bubble produce in the tank and supply the oxygen into the system. Then, let the air producing arise through the water. Besides, the more exposed gas to the liquid will increase the efficiency of the gas transfer. According to Kossay K. Al-Ahmady, (2006) [1], aeration system determine the effect of coverage area of diffusers and the percentage of oxygen absorption. This aeration process is a sub process of producing a clean water. In other words, this aeration is a part of treatment required to produce the clean water. The other name of this process also known as aerification process. This stage would the important roles, as it was an effective method to reduce the contaminants. This method is treated domestic waste by remove the nutrients and the odour issues without producing other environmental problems.

The both processes and procedure are producing the desired same results [2]. Next, there is two main physical process of the system that is scrubbing action and oxidation of certain gases. The function of the scrubbing action is to mix the water and air together. Therefore, the process can be faster as the scrubbing action physically remove the gases from the any solution in water. This situation enhance them to escape into surrounding air. As this process need only the oxygen gases, the scrubbing action can remove the carbon dioxide and hydrogen sulphide. Indirectly, it remove the water from taste and odour problem. Meanwhile, the oxidation process is the phase of removal of certain mineral and gases from the water. Then, the process produced the unwanted material in the water. The suspended material can be remove by the filtration process. In holistic, the efficiency of the aeration process depending on the amount of the surfaces contact between the water and air.

2.3 Coagulation and Flocculation

Coagulation and flocculation is the stage of remove turbidity, bacteria, taste and odour. The treatment involved typically for surfaces water. Generally, those treatment are used to separate and easier to remove the suspended solid substances from water. The objectives in this phase is to change the surface change of the particles. The suspended solid in the water are having the same charge and make them repel each other when they in closed position. That situation lead them come close together after the violation. Therefore, the particles can combine completely and stick together forming the large particles. Then suspended substances will remain in suspension and will not stick together. Those particles will settle by the gravity. The particles produced called floc.

This treatment consist several steps, and should run in succession. This way allowed the particles to collide each other then become floc. Both process are related and need to be complete as the process to remove the suspended solid [3]. Then, the sedimentation phase can run successfully. The flocculation stage is synonym with the mixing stage. The stage is undergo the mixing of chemical to increase the size of the particle by make them collide each other. The differences size of the particles is from sub microscopic micro floc to visible particles. The collision occur make them to bond and stick then increase in size. The floc will continue to build, as there is still have collision on the system. Next, the macro flocs produced with high molecular weight polymers and it may use to help bridge and strengthen

the floc. Finally, the water is ready for the next stage once the floc reached it optimum strength and size.

Next, this treatment has their own coagulant reagents. The commonly used for this phase is metal coagulations. The metal coagulation have divided into two categories. The categories based on aluminium and another based on iron. The aluminium based coagulant most widely used and probably known as aluminium sulphate [4]. The aluminium sulphate called “alum” was been used for the water treatment for long decades ago. It made up from the reaction of bauxite ores and sulphuric acid. Any kind of the product produced from “alum” is acidic. It made up as a liquid and mainly used industry. This application of metal coagulations is widely spread because the relatively save the cost. In addition, it is simpler application route to apply.

Besides, there is another coagulant reagent that produce according there are many chemical coagulant that used in water purification releasing harmful substances. This study focusing on rural area as that place becoming major focus. Cactus trees seen as a suitable reagent coagulant and the objectives of the study to identify and analyse the coagulant activity of cactus powder using the jar test [4, 5].

2.3.1 Jar Test

The jar testing is a method of simulating a scale of water treatment process. This test providing a reasonable system of the way a chemical treatment will operate. Besides, it helps the researcher to identify which treatment chemical can work the best with their raw water. There is different value of coagulant use and it cannot be same with the other researcher. This due to the raw water came from different way and sources. The jar test carried as a pilot-scale test of the chemical treatment that used in a particular water plant. It is simulates the coagulation and flocculation process for producing water treatment.

The jar testing needs some adjustment of the amount of chemical treatment and the sequence of the raw water. The best way to achieve the optimum value, the jar test need to run for several beaker in the same time, refer Figure 2.1. There is a proper procedure can be run to achieve the best result of the jar test. The following procedure below uses the aluminium sulphate as the coagulant material.

Figure 2.1: The Jar Test Machine. Taken from "Coagulation and Flocculation." *Introduction to Potable Water Treatment Processes*, Mar. 2009, pp. 26–42., doi:10.1002/9781444305470.ch3.[3]

Procedures

1. Prepare the six-gang jar tester and the chemical (aluminium sulphate) for coagulation reagent.
2. Add 1000 millilitre (mL) water into each of the jar beakers of 1000 millilitre (mL) graduated cylinder.
3. Alkalinity the raw water before the start the mixing phase.
4. Prepare the stock solution by dissolving 10 ppm of alum into 1L raw water.
5. Repeated the same procedure and add another 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm for every beaker provided.
6. After dosing each breaker, turn on the stirrer to stir the substance in certain period.
7. Observe the particles inside the breaker and make the comparison of the colour and substances contain.

2.3.2 Formula to Calculate the Coagulant Dosing

Example:

- From the jar test, the chosen value is 30 ppm
- Flowrate raw water: 4.545^3m/hr
- Specific Gravity coagulant: Standard Gravity PAC=1.31

$$\text{Formula} = \frac{\text{Dos Optimum (ppm) x Flowrate Raw Water } (\text{m}^3/\text{hr})}{\text{1000 x Standard Gravity}}$$

$$= \frac{30 \text{ ppm x } 4.545^3/\text{hr}}{1000 \text{ x } 1.31}$$

$$= 104.0 \text{ L/h}$$

2.4 Sedimentation

Sedimentation is another physical water treatment process that removes suspended solid from water by the gravity. Settling by gravity is the most extensively applied for remove the suspended solid from water and wastewater. The solid substance produced by the turbulence movement may be discard naturally by sedimentation process. This process required for high turbidity water that detention time about two to four hour [7]. The particles settle from the suspension become sediment and in water treatment process, it called as sludge. This phase of treatment functional as to reduce the concentration of the particles in suspension before or after the coagulant phase. In this study, the sedimentation treatment was applied after the coagulant as a purpose to reduce the concentration of solid substances in suspension. Therefore, the next phase can function more efficiently.

In general, there is two aspects concern to clarify the water. It is the flow pattern through the tank and the settling characteristics of the particles. Firstly, the flow pattern need to clarify based on the configuration of the tank and the parameter involves such as water flow rate, solid concentration and temperature. The second part is about the characteristic of the particles that concern about shape, size and interaction of water through buoyancy and drag force. Next, there are several types of sedimentation tanks in the water treatment which influents certain parameter [8]. The common types of sedimentation tanks are horizontal

flow tanks, radial flow tanks, inclined settling and ballasted sedimentation. Those types consist different parameter as it influences the sedimentation process.

The horizontal flow tanks are the simplest tanks of sedimentation is the water treatment. This treatment is to fill tank or jar with water. Then, leave the water for a long enough time to make the particles to settle and remove the resulting water without the sediment. This way of practice was rarely used in this particular area. Generally, this simplest method is use rectangular tank at ended outlet with the horizontal flow. The water with the particles in suspension will be introduced at the end of the tank and the water flows oppositely to the end of the tank settlement. Clearly, this parameter used to achieve a large proportion of the settling particles manage. Then, reach the tank floor before the water is remove out from the tank. The flow is such horizontal flow tanks and built with a floor that sloping down to the inlet end to the hopper. Then, the tank is combine with the hydraulic to scrape all the sediment from the inlet end to the outlet end. This action makes the water flow uniformly and more fluent.

Next, the radial flow tanks. This tanks are circular in shape with the inlet at the centre and the peripheral outlet. This tanks need to concern about the shape and design as to support uniform distribution of flow blow to the whole tank. Then, the sediment will scrape to a central to discard. Sometimes, the circular tanks need additional features in the middle for flocculation. Then, ballasted sedimentation is the differences between the particles and water produced by coagulation and flocs. Generally, they produced in very small size and they settle slowly.

The inclined settling was the most frequently used in the industry. This settling tank size is governed by the time to be allowed for particles easy to settle trough the depth of water. Normally, the inclined settling constructed with light material which can easily positioned in the tank. The flow can be co-current, cross-flow or counter flow. In the co-current arrangement, the flow moves towards downward between the plate and the direction of settlement particles. The counter-current arrangement is the water flows upward between the plates against the direction of the settlement particles. Lastly, there is water flow cross the plate at the right angle towards the direction of particles settlement. There is need to maximise the distribution flow of water within and between the plate to maximise the efficiency of the particle removal. Besides, the inclined tube can use in the same arrangement

except the cross flow arrangement. The tube modules can be constructed in variety ways since the cross-sectional shape of the tube can perform various forms.

2.5 Filtration

In this section describe the next stage of the standard water treatment process. The water treatment may slightly different depending on the technology and the water sources of the plant. The principles are normally the same for all the process. This process used to treat and filter the particles that are too small. These small particles were escaped from the sedimentation process. According to (Devadas, 1984) the provision of quality and good sanitation of water services is vital for the protection of human resources.

Slow sand filtration process is the process of physical filtration of particles or biological removal of any organics in the upper biologically layer of the sand bed called as biofilm. It been identified by technology for drinking water treatment in rural area. This process has been suggested to recognize as a technology for removing water borne pathogens and remove the turbidity. Based on several research and investigation, there is material and method concern on this process. This phase of the process played an important role to make sure the hygiene and safe water supply guaranteed.

The materials concern in this phase is the filter basin. The filter basin can be constructed using various of materials such as earthen berm construction or concrete. Besides, the selected material influences by the size of the filter basin and the sources of raw water. The turbidity test is used for different sources of raw water with high turbidity. The test functional to determine the efficiency of the slow sand filter and reduce the turbidity. Normally, the small size of filter basin can be constructed from polyethylene or fiberglass [12]. Those materials provide uniform flow rate. The gravel coarse functional to make the under drain medium. It is important to measure the grain and sorted through mechanical sieves. This action to prevent the clogging and make the flow smoothly. Therefore, it is important to have the effective size to produce the uniform coefficient. The inlet or outlet flow is controlled by slow sand filter. The flow can be either constant or declining rate. Finally, the outlet to drain is the treated water.

Next, the method of the operation of the slow sand filter undergo the formation of gelatinous layer. The layer also called as hypogeal layer that formed in the first 10 to 20 days