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Portable Treatment System to Treat Cafeteria Sullage Water Using Effective Microorganism and Biomedia

Muhammad Zahid Mohammad Isa[1], Zarizi Awang[1]*

[1]Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600, Pagoh Muar, Johor Darul Takzim, Malaysia.

*Corresponding Author Designation

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Abstract: This study investigates portable water treatment in small scale size according to the design in the previous research that can solve the main problem of water pollution faced by UTHM Kampus Pagoh cafeteria. The objectives of this study are to design and produce a portable water treatment system using effective microbioorganism and biomedia to reduce contamination of sullage water and to analyze and make a comparative study with other designs to treat sullage water focusing on UTHM Kampus Pagoh cafeteria. To produce portable water treatment, a do-it-yourself (DIY) tank from polypropylene container box with volume of 151 L was designed, incorporating two types of biological treatments, namely effective microorganism and biomedia. This study also reviewed and compares the analysis results of biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solid of water treatment from previous studies. At the end of this study, the expected results obtained were comparable with results from the previous studies. As a recommendation, actual laboratory tests must be conducted for future work to obtain accurate data for the parameters analyzed .

Keywords: Sullage Water, Water Treatment, Effective Microorganism, Biomedia.

1. Introduction

Sullage or known as "grey water" is one of the main sources of pollution released into the rivers from residential and commercial areas without proper control. This sullage originates from mainly kitchen sinks, washing machines, bathrooms, restaurants, wet markets and car washing centers [1]. This study addresses an effective strategy for controlling the pollution at the source. The pollution must be eliminated in any case to protect our water resources or to maintain the parameter of the water quality. Therefore, various wastewater treatment methods have been introduced [2], including the physical method, chemical method, biological method as well as thermal method. Moreover, some studies have used effective microorganisms (EM) for wastewater treatment. Diverse methods of microorganisms have been employed in the last 50 years to promote medical technologies, human and animal health,

*Corresponding author: azarizi@uthm.edu.my

food processing, food safety and quality, genetic engineering, environment protection, biotechnology for agriculture and municipal waste treatment which exhibit impressive track record [3]. Microorganisms comprise lactic acid bacteria, yeast and photosynthetic bacteria [4]. Significantly, the EM is able to increase the quality of wastewater and suitable for treatment .

Besides EM, another biological treatment involved in this study was biomedia. It can be used to develop the workforce for future river purification and restoration plan [5]. Biofilm support media, a unique design that employs a medium to support large quantities of biomass by natural connection, has become a promising alternative for successful remediation of various conventional activated sludge treatment technologies for industrial effluents [6]. The hybrid system has been proved to be effective in reducing the chemical oxygen demand (COD) and ammoniacal nitrogen (AN) below the discharged limit [7].

1.1 Problem Statement

This study focuses on the problem faced by UTHM Kampus Pagoh cafeteria, where this non-point source of sullage wastewater was highly untreated and contributed to high pollutant to the watercourse. Without proper control, it can affect the human health and environment. Therefore, alternative methods need to be developed to solve the wastewater issue from the source. Based on previous studies, the design of water treatment system is large in size and not in a portable form which experiences difficulties in maintenance. To overcome this problem, a small scale and portable type of treatment tank has been proposed.

1.2 Objectives

The main purpose of this study is to investigate and recommend suitable method to treat sullage water using biological treatment with EM and biomedia in the treatment system. The objectives for this study project are as follows:

i. To design and produce portable treatment system using EM and biomedia to reduce contamination of sullage water;
ii. To analyze and make comparative study with other designs for sullage water treatment

2. Materials and Methods

The materials and methods section describes all the necessary information required to obtain the results of the study.

2.1 Materials

The portable tank for sullage water treatment was separated into three parts. The first part of the tank functioned to trap all the large solids from the kitchen waste. The sullage water flowed into the second part of the tank which trapped small solid before the water flowed through the third part of the tank. The third part of the tank is the important part for this study. This part contained EM, biomedia and aeration. The tank was designed based on the designated area to install and maintain the treatment system. The dimension of the treatment system was 0.74 m x 0.47 m x 0.435 m, equivalent to 151 L volume of water.

Table 1: List of materials used for portable treatment system

Description	Picture	Quantity
Polpropylene (PP) storage box (0.74 m x 0.47 m x 0.435 m)		1 unit
Pipe connectors: i. 90° PVC 25 mm ii. 'T' PVC 25 mm iii. PVC ball valve PVC 25 mm iv. PVC tank connector 25 mm v. PVC pipe 25 mm	 (i)  (ii)  (iii)  (iv)  (v)	i. 3 units ii. 3 units iii. 1 unit iv. 5 units v. 5 meters
Air pump		1 unit
Air bubble stone 1' ½''		2 units
PVC pipe cement		1 unit
Clear silicone sealant		1 unit
Plastic sheet (40" x 50")		2 units
Foralastre circle cutter		1 unit
Bio ball (38.1 mm x 31.75 mm)		800 pcs
EM 1		15 mL

2.2 Methods

The methodology started with the process of finding reference material or information related to this study. The references and information were retrieved from the most up-to-date and appropriate sources for review. To ensure the quality of this study, the process of identifying related sources of reference and information is crucial. Figure 1 illustrates the methodology flow chart for this study.

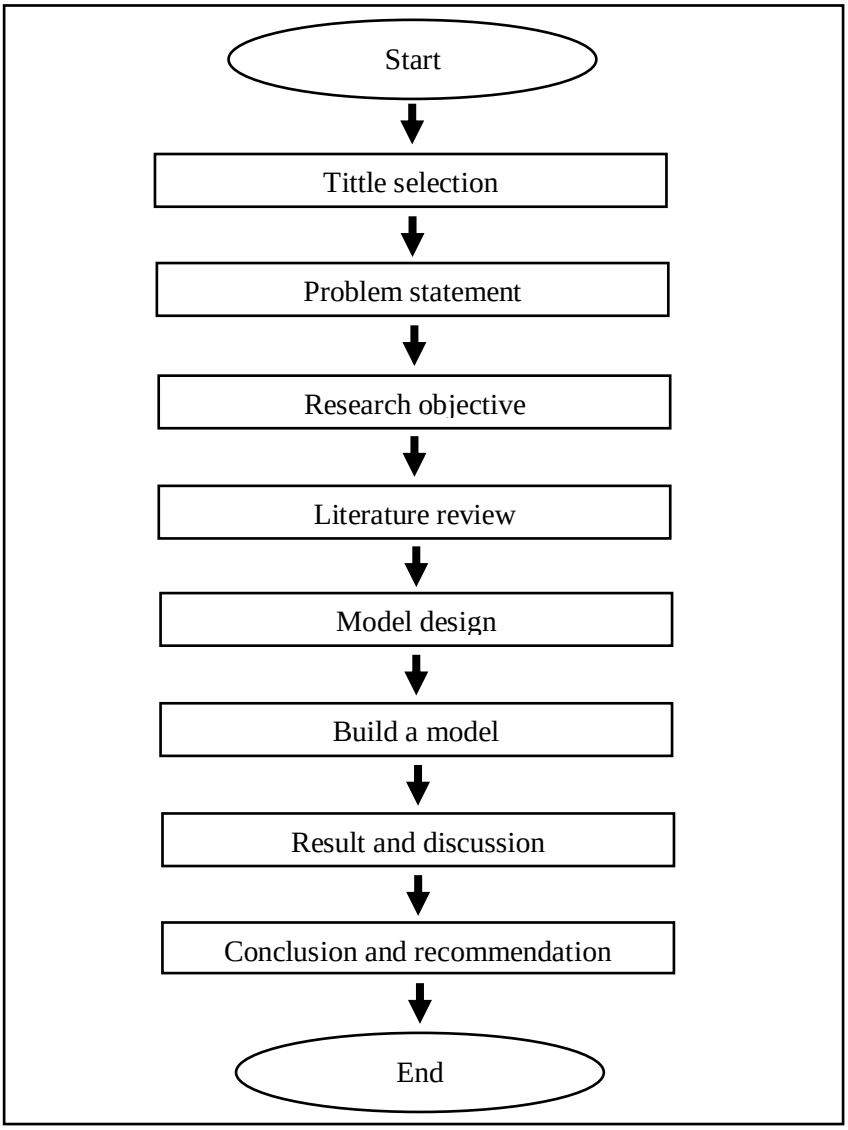

Figure 1: Flow chart of Methodology

The portable treatment system was built using appropriate and easily available materials which can be carried out by anyone, as demonstrated in Figure 2. This system is a small scale whose volume of water is 151 L with 800 pieces of bioball, aeration by using air pump and Effective Microorganisms.

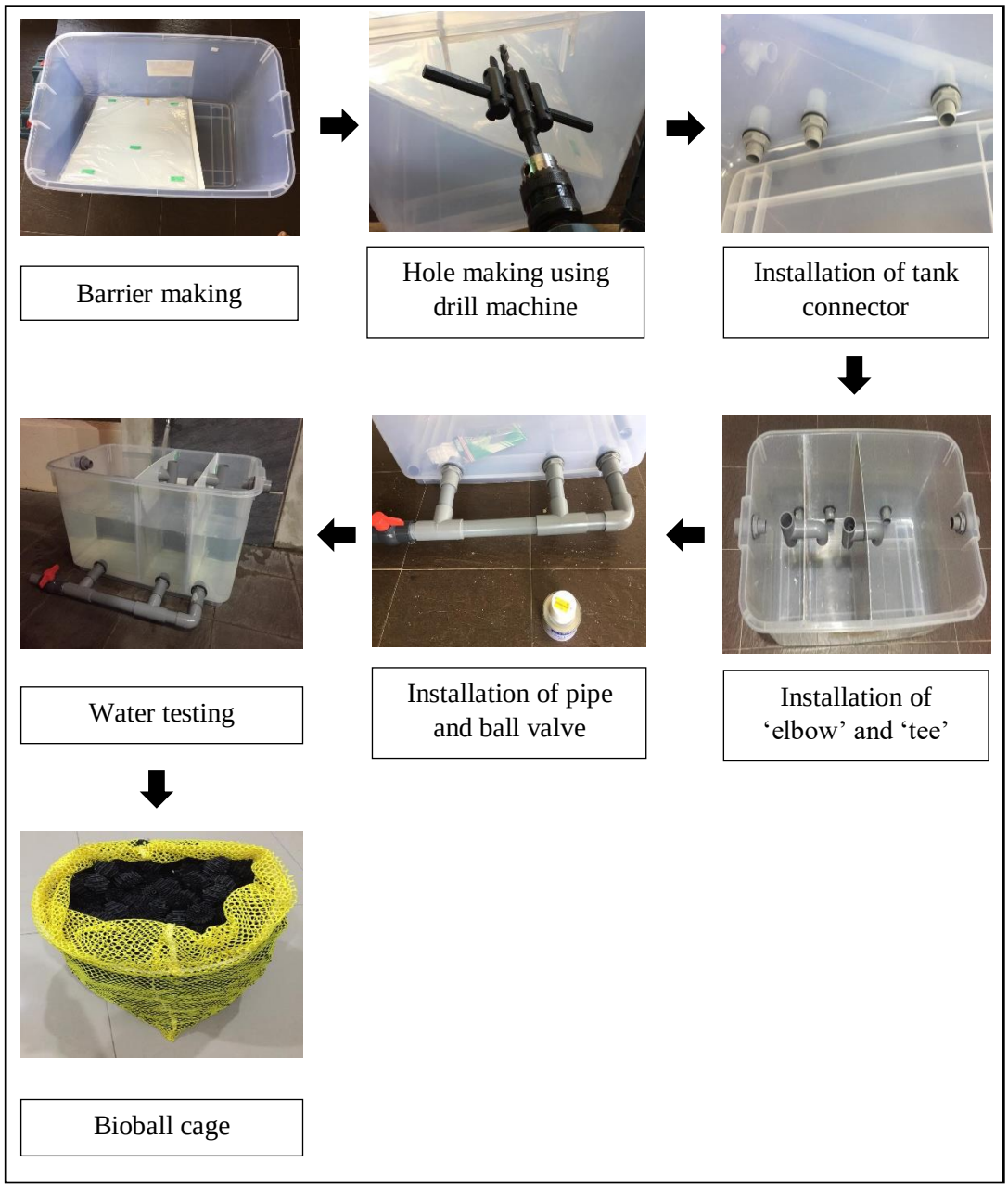

Figure 2: Flow chart to produce treatment system

2.3 Equations

The design of portable treatment involves water volume calculation to influence hydraulic retention time so that the sullage water can be treated more effectively. The measurement was 0.74 m in length, 0.47 m in width and 0.435 m in depth and tank volume was calculated by Equation 1.

$$Volume = Length\ x\ Width\ x\ Depth \qquad \text{Eq. 1}$$

$$151{,}293{,}000\ mm^3 = 740\ mm\ x\ 470\ mm\ x\ 435\ mm$$

The volume of water calculated in millimeter cube was converted into liter unit by using the following equation:

$$1\ Liter = 1{,}000{,}000\ mm^3 \quad \text{Eq. 2}$$

$$151\ Liter = \frac{151{,}293{,}000}{1{,}000{,}000}$$

The hydraulic retention time (HRT) of an aeration tank is determined by dividing the volume of the tank (m^3) with the flow rate ($m^3/hour$) as shown in Equation 3. The flow rate through the tank must be expressed as meter cubic per hour (m^3/hour).

$$HRT\ (hours) = \frac{Area\ x\ depth\ (m^3)}{(m^3/hour)} \quad \text{Eq. 3}$$

$$HRT\ (hours) = \frac{0.151}{0.54} = 0.27\ Hour$$

3. Results and Discussion

These comparative data will assist in drawing conclusion to obtain information related to better effluent compact treatment system. The characteristics of effluent parameters being focused were suspended solid, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Numerous researches on sullage water have been conducted because the discharge of sullage water is one of the sources entering streams, lakes and other water bodies which could cause environmental problem known as eutrophication.

3.1 Results

Four previous studies were examined for this review based on data comparison. of their BOD and COD values using EM and biomedia. All the data are shown in Table 2.

Table 2: Comparative data based on previous studies

Types of treatment	Researcher	Parameter (optimum time selected)	Removal effectiveness (%)
Effective Microorganisms (EM)	EMRO Japan [8]	BOD	90.45
		COD	90.13
		Suspended solid	86.80
	Namsivayam *et al.* [4]	BOD	68.00
		COD	34.00
		Suspended solid	-
Bioball	Filliazati *et al.* [10]	BOD	68.98
		COD	-
		Suspended solid	-
	Chen & Lo [9]	BOD	87.00
		COD	84.00
		Suspended solid	86.00

Based on comparison, it was found that the effectiveness of removal using EM was in the range of 68.0 -90.0 % for BOD and 34.0 -90.0 % for COD. The suspended solid can be removed effectively by 86 % as reported by [8]. Using bio ball, the BOD was effectively removed ranging from 68.0 -87.0 %, while COD and suspended solid were effectively removed more than 80.0 %.

3.2 Discussions

The hydraulic retention time or HRT of the tank refers to the amount of time in hours for wastewater to pass through the tank. According to [7], COD concentration in the range of 100-200 mg/L can be obtained with 4 hours HRT. To obtain 90.0 % removal, the HRT is recommended to be more than 3

hours. For this portable treatment tank, the flow rate of sink tap was 0.15 liter/second with HRT of 0.27 hour. Therefore, it is anticipated that this portable treatment system is able to remove up to 90.0 % water contamination such as BOD, COD and suspended solid in shorter retention time using hybrid treatment medium. This system will integrate aeration system, EM and bioball as accelerator to reduce contamination from sullage water. Figure 3 shows three-dimensional (3D) of side view of portable treatment tank using Sketchup, while Figure 4 displays the portable treatment system produced.

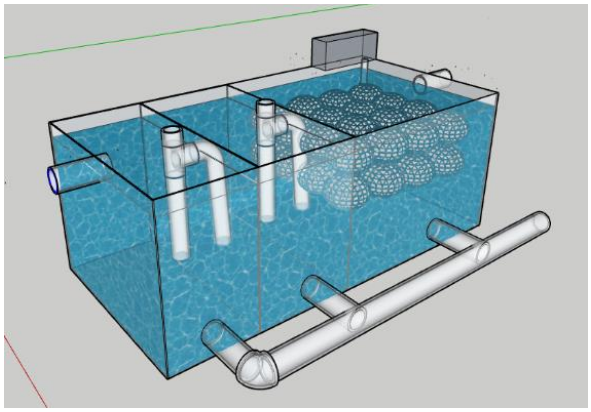

Figure 3: Three-dimensional (3D) of side view of portable treatment tank using Sketchup

Figure 4: Portable treatment system

Table 3 shows the expected result that will be obtained using this portable treatment system. Considering the media filter used was similar to those of previous studies with short HRT (0.27 hour), the expected removal effectiveness of BOD, COD and suspended solid should be able to reach 70.0 % to 90.0 %.

Table 3: Expected results using a portable treatment system

Name of treatment	Parameter	Removal effectiveness (%)
Portable treatment system	BOD	70 - 90
	COD	70 - 90
	Suspended solid	70 - 90

According to [8], Pardos Chicken Magdalena restaurant has improved its operational effectiveness in reducing the time to clean tanks and keeping the workers' health in good condition, as well as reducing exposure to cleaning chemicals after using EM. The dilution of EM was 1:10,000. The effectiveness of EM was evaluated based on reduction in BOD, COD, total solids, and fats and oils. It was reported that EM was the best product to control water pollution originated from kitchen. The percentages of contamination removal after using EM were 90.0 % for BOD, 90.0 % for COD, 86.0 %

for total solids, 95.0 % for fats and oils. According to [8], EM shows the best performance as agent in biological treatment system which is economic-friendly to all users.

Another agent of biological treatment system with good performance is biomedia which ican be applied with low cost [9]. According to [9], the percentages of contamination removal after using bioball were 87.0 % for BOD, 84.0 % for COD and 86.0 % for suspended solid.Thus, it can be inferred that bioball can be effectively applied to control water pollution from restaurant.

4. Conclusion

In conclusion, the objectives of this study were achieved. The portable treatment system was successfully designed and used EM and biomedia to reduce the contamination of sullage water. The second objective for this study is to analyze and make comparative study with other designs for treating sullage water. Based on previous studies, EM and bioball have higher potential of up to 90.0 % to reduce contamination of sullage water.

The use of portable wastewater system seems to be a promising contribution towards sustainability. Nevertheless, this study should be extended to field investigation to understand more on the EM and biomedia behaviour as filter media.

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